

Educational Exhibits Chosen by the Annual Meeting Committee

In advance of the upcoming [Society of Interventional Radiology Annual Scientific Meeting](#) in Phoenix, the SIR Annual Meeting Committee wishes to highlight the educational exhibits that will be presented. The exhibits were chosen using blinded review. Authors are congratulated for their contributions.



Gloria Salazar, MD, FSIR

Chair, 2023 Annual Meeting Scientific Program

Bulent Arslan, MD, FSIR

Vice Chair, 2023 Annual Meeting Scientific Program

Educational Exhibits

Abstract No. 700

Endovascular Management of Unused Fenestrations or Branches in Fenestrated/Branching Aortic Endograft

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LEARNING OBJECTIVES: Endovascular management of unused fenestrations and branches in custom aortic endografts.

BACKGROUND: Fenestrated and branched aortic endografts (F/B EVAR) are now widely used as the main treatment option for a variety of aneurysmal aortic pathology from atherosclerotic degenerative aneurysm to chronic aortic dissection. The majority of these endografts are custom grafts where the F/B are designed according to the patient's anatomy. In most cases, all the fenestration or branches are used during the procedure, connecting to the target arteries. However, in some clinical scenarios, not all the F/B are used. These include failed cannulation of target artery, interval occlusion of target artery during graft manufacturing, or in the case of the "off-the-shelf" devices; the target vessel is already occluded and hence the branch is no longer needed. Leaving these unused fenestrations or branches patent without occluding them will lead to an endoleak.

CLINICAL FINDINGS/PROCEDURE DETAILS: Branch Device. There are several manufacturers of branch devices but for illustration purpose we are using Cook Medical t-Branch device. For Cook Medical t-Branch,

there are two different side branch diameters, 8 mm for the celiac and superior mesenteric artery (SMA) and 6 mm for the renal arteries. These branches could be blocked by a variety of devices including Amplatzer Vascular Plug, MVP microvascular plug (Medtronic), or extending the branch with a balloon expandable stent graft followed by a vascular plug.

Fenestrated Endograft. The majority of the fenestrations are 6 or 8 mm in diameter. If there is sufficient length between the fenestrations, an aortic cuff could be placed covering the fenestration without interfering with other fenestration or branches. Patent Ductus Arteriosus Amplatzer Duct Occluder or Amplatzer Muscular Ventricular Septal Defect are other alternatives. Finally, deploying a balloon expandable stent graft in the fenestration to increase the length for placement of a vascular plug/coil in the stent graft. Limitations of each technique will be illustrated in the presentations.

CONCLUSION AND/OR TEACHING POINTS: As Fenestrated and branch devices are used more frequently for the treatment of aortic aneurysms, interventionalists should be familiar with endovascular options for the management of unused fenestration or branches. This presentation illustrates the technical aspect and appropriate devices for occlusion of these unused branches or fenestration.

Abstract No. 701

Withdrawn

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*An underline under an author's name designates the presenting author.

All tables are labeled by abstract number.

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Abstract No. 702**Percutaneous Vascular Closure Device-Related Complications with Emphasis on Delayed Malfunction**

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LEARNING OBJECTIVES: (1) To review the differing types of percutaneous vascular closure devices available, their indications, mechanism of action, and technical considerations to ensure proper deployment. (2) To illustrate, through case-based review, the complications related to vascular closure device failure, with emphasis on delayed device malfunction. (3) To propose a simplified algorithmic approach to managing closure device-related complications.

BACKGROUND: Percutaneous vascular closure devices (VCDs) have become increasingly used with improved patient comfort and reduced time to hemostasis compared with manual compression following percutaneous arteriotomy. However, VCDs carry an additional inherent subset of complications related to foreign body deployment, deployment failure, and device malfunction. Device malfunctions typically occur within the peri-procedural period but can be delayed to 30 days post-procedure, after which patients may have already been discharged home. These complications are not benign and may cause major vascular complications leading to permanent adverse sequelae and largely affect patients' quality of life and mobility.

CLINICAL FINDINGS/PROCEDURE DETAILS: Main types of VCDs include collagen-, sealant-, suture-, and clip-based devices. VCD-related complications include hematoma, active bleeding, arteriovenous fistula (AVF) formation, pseudoaneurysm, acute limb ischemia, infection, and deployment failure. Device malfunction typically occur in the peri-operative period but can extend to 30 days post-procedure, by which time collagen and sealant-based plugs are resorbed. Treatment of these complications include conservative management, percutaneous intervention, and surgical repair.

Cases of VCD-related complications will be discussed. A delayed malfunction of suture-based VCD following endovascular stent graft exclusion of femoral-femoral AVF with resulting pseudoaneurysm which required open surgical repair. A 7-day delayed malfunction of collagen-based VCD following embolization for a large retroperitoneal hematoma with resulting pseudoaneurysm necessitating open surgical repair, complicated by rebleeding with surgical re-exploration, sartorius myoplasty, and prolonged negative pressure wound therapy of the groin.

CONCLUSION AND/OR TEACHING POINTS: Late vascular complications at the site of arteriotomy or continued blood loss despite transfusion of blood products should raise a high index of suspicion for delayed malfunction of VCDs. It is prudent for interventionalists to be aware of these complications and direct appropriate management.

Abstract No. 703**Alternative Access Sites: Transvisceral Arterial Interventions**

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LEARNING OBJECTIVES: To review indications and rationale for performing transvisceral arterial intervention. We illustrate three cases of transsplenic or transhepatic arterial access. Each case highlights the anatomy and benefits for these access techniques.

BACKGROUND: Femoral and radial access are conventional access sites for performing splenic or hepatic arterial interventions. However, traditional access may not work when faced with certain barriers. In these cases, transsplenic or transhepatic arterial access may be attempted to perform the intervention.

CLINICAL FINDINGS/PROCEDURE DETAILS:

1. A patient with a deceased donor liver transplant presented with evidence of splenic artery steal syndrome. Traditional endovascular splenic embolization was not possible due to previous splenic artery ligation. Transsplenic arterial access was gained with a 21-gauge needle and microsystem. Splenic embolization of the mid and lower poles was performed using particles and coils. Transsplenic arterial access was closed using Gelfoam pledgets.
2. A patient with history of deceased donor liver transplant presented with a hepatic artery pseudoaneurysm after stenting of a hepatic artery stenosis. Covered stent placement to treat the pseudoaneurysm via transarterial access was not possible due to vessel tortuosity and prior stenting. Transhepatic access into a right hepatic artery branch was performed and the transhepatic wire was snared from the left radial artery access for through-and-through access. A covered stent was successfully deployed transhepatically to cover the pseudoaneurysm. The transhepatic access was closed using coils and thick Gelfoam.
3. A patient with a 3-cm splenic artery aneurysm presented for embolization. Tortuosity of the splenic artery proximal to the aneurysm prevented antegrade stent deployment. Percutaneous access of the intraparenchymal splenic artery was obtained and a wire was advanced through the aneurysm to the proximal splenic artery. The wire was snared from brachial access to obtain through-and-through access. Stents were then deployed over the wire to span the aneurysm neck. Stent assisted coiling was performed for packing. A coil was deployed through the microcatheter to close the splenic arterial access site after removal of the wire. Final arteriogram demonstrated flow to the upper pole of the spleen and occlusion of the aneurysm.

CONCLUSION AND/OR TEACHING POINTS: Transsplenic and transhepatic arterial access are potential alternatives when barriers are present to traditional arterial access and are beneficial to be familiar with.

Abstract No. 704

Techniques of Below-the-Ankle Revascularization

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LEARNING OBJECTIVES: To describe clinical indications for and outcomes of below-the-ankle (BTA) arterial revascularization. To illustrate case-based techniques for BTA arterial revascularizations. To discuss post-procedure end points, management, and follow up after BTA interventions.

BACKGROUND: Peripheral artery disease comprises a range of diseases with the most severe presentation being clinical limb ischemia (CLI). Those with CLI have one-year rates of amputation or mortality exceeding 50%, with the global incidence of major amputations between 120–500 million per year. Arterial revascularization has been shown to improve limb salvage rates. While below-the-knee (BTK) techniques have been increasingly used by the interventional community, complete revascularization of the foot may be limited by more distal “below-the-ankle” (BTA) disease, requiring more complex BTA and pedal revascularization strategies. These techniques require special consideration of particular tools and familiarity with anatomy of the foot. The purpose of this exhibit is to review the anatomy, indications, techniques, and outcomes of BTA arterial revascularization.

CLINICAL FINDINGS/PROCEDURE DETAILS: In this review, we will detail the relevant anatomy and work-up of the patient presenting for potential BTA intervention. An emphasis on pedal anatomy and procedural planning, including the WI-FI classification system, will be reviewed. Various techniques of BTA revascularization will be illustrated through case-based examples, focusing on endovascular tool selection, access techniques, pedal loop reconstruction, anatomic and physiologic end-points, and alternative treatment options such as deep venous arterialization. Post-procedure monitoring with perfusion and hemodynamic diagnostics and clinical outcomes will be discussed.

CONCLUSION AND/OR TEACHING POINTS: Despite advancements in BTK interventions, BTA disease continues to pose a significant barrier to revascularization of the distal lower extremity. Various BTA revascularization techniques are safe and effective at improving perfusion and wound healing compared with BTK intervention alone. As interventional radiologists’ role in treating critical limb ischemia increases, so must their expertise in treating BTA disease to ensure optimal limb salvage outcomes.

Abstract No. 705

Below-the-Ankle Intervention: Vascular Anatomy and How We Do It

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LEARNING OBJECTIVES: To illustrate the below-the-ankle (BTA) vascular anatomy. To review the available devices and procedural steps in BTA interventions. To summarize the recent outcome data on BTA interventions in managing patients with chronic limb ischemia (CLI).

BACKGROUND: CLI is an increasingly prevalent disease, and is associated with significant morbidity and mortality. The presence of BTA lesions play a major role in the preservation of ankle joint and avoidance of major amputation. Therefore, BTA lesions should be addressed when necessary to preserve limb functionality and to reduce patient morbidity and mortality.

The goal of distal infrapopliteal disease management is to establish in-line arterial flow directly to the distal wound bed. Due to the challenging anatomy, endovascular therapy is preferred over surgical revascularization. Recent data have suggested that BTA interventions carried survival benefits related to the preservation of ankle joints and improved wound healing; therefore, it has become an important adjunct tool for managing complex CLI patients. BTA interventions are technically challenging, and there is a paucity of reports on the techniques and approaches. We aim to illustrate the anatomical and technical aspects of BTA intervention, as well as recent outcome data.

CLINICAL FINDINGS/PROCEDURE DETAILS: In this educational exhibit, we will (1) provide a pictorial review of detailed BTA anatomy, including the pedal arch, dorsalis pedis, plantar arteries and the major tributaries; (2) present diagrams as well as angiography images in various obliquities to best demonstrate the said vascular anatomy; (3) detail our technical approach to BTA interventions, including the access sheath, access technique/location, common crossing and working wires, common support catheters, balloons (plain and specialty balloons), lithotripsy devices, and atherectomy devices; and (4) summarize the most recent literature on BTA outcomes, including the recent Liberty 360 trial.

CONCLUSION AND/OR TEACHING POINTS: BTA interventions have become a critical tool in managing complex CLI patients. Practitioners should be familiar with the basic BTA vascular anatomy to provide targeted therapy. Knowledge of the available wires, catheters, and specialty devices, as well as technical approaches, can better prepare clinicians in managing this complex condition.

Abstract No. 706

Endovascular Treatment of Extremity Frostbite

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LEARNING OBJECTIVES: Familiarize the Society of Interventional Radiology with initial evaluation and management of frostbite injury. Present several cases of extremity thrombolysis in the setting of frostbite injury. Review the current evidence for endovascular management of extremity frostbite injuries.

BACKGROUND: Severe frostbite injury causes ischemia and can lead to significant morbidity resulting from tissue loss and amputation.

Though randomized, prospective trials are lacking, there is a growing body of evidence supporting endovascular thrombolysis in the management of frostbite injuries. Depending on the location of vascular and interventional radiology training, it is likely that the majority of graduating vascular and interventional radiologists have no experience in assessing a patient with frostbite. We hope to familiarize vascular and interventional radiologists with the literature supporting the endovascular management of frostbite and share our local protocols which can be adapted to other institutions.

CLINICAL FINDINGS/PROCEDURE DETAILS: (1) Review frostbite injury classification systems. (2) Outline our institutional workflow for endovascular management of frostbite injuries including pre-procedural work-up, procedural details including our thrombolysis infusion protocol, and roles of collaborating services. (3) Evaluate the literature comparing varied thrombolysis regimens and their efficacy. (4) Present several cases of endovascular treatment of frostbite injuries including photos and angiographic images.

CONCLUSION AND/OR TEACHING POINTS: All vascular and interventional radiologists should have the technical skills to perform extremity thrombolysis in the setting of severe frostbite injury. Learning to classify and evaluate frostbite injuries is imperative if participating in the care of these patients. An institutional algorithm can be helpful in the management of uncommonly encountered injuries such as severe frostbite.

Abstract No. 707

An Atlas of Prostatic Artery Anatomy

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LEARNING OBJECTIVES: To present a pictorial atlas of prostatic artery anatomy relevant to prostatic artery embolization. This includes a review of common classification systems, such as Yamaki Branching Classification and Carnevale Classification, as well as dangerous anastomoses, collateral identification, and clinically important vascular variants.

BACKGROUND: Benign prostatic hyperplasia (BPH) affects 80% of men by age 80. The often-associated lower urinary tract symptoms (LUTS) can greatly decrease quality of life. Prostatic artery embolization (PAE), among other minimally invasive surgical techniques (MISTs), is an effective treatment performed by interventional radiologists that has been shown to improve LUTS and reduce prostatic volume. Although understanding prostatic artery anatomy is key for intervention, arterial anatomy is highly varied among individuals. Multiple systems of classifying arterial anatomy by number, origin, anastomoses, incidence of atherosclerosis, branching, and type have been attempted. In this educational exhibit, we seek to provide an atlas of prostatic artery anatomy.

CLINICAL FINDINGS/PROCEDURE DETAILS: This exhibit will (1) provide a pictorial review of prostatic artery anatomy and classifications by Carnevale et al. and Yamaki et al; (2) describe the frequency of the previously classified variants based on current literature; (3) describe the vascular navigation involved in PAE; (4) identify and describe dangerous anastomoses and collaterals; and (5) identify and describe clinically important vascular variants, including blood supply, size, and vascular compartmentalization.

CONCLUSION AND/OR TEACHING POINTS: Knowledge of prostatic artery anatomy and its variants is critical to performing successful PAE. PAE is an important therapy for BPH performed by interventional radiologists. Highlighting key imaging findings of PA anatomy variations can help an interventional radiologist determine a procedural approach or alternative therapy option. The atlas of PA anatomy presented here exhibits important PA anatomy variations essential to successful MIST, which can greatly improve a patient's quality of life.

Abstract No. 708

Updates in Catheter-Directed Therapy for Pulmonary Embolism, A Review of New Devices and Guidelines

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LEARNING OBJECTIVES: (1) Differentiate classifications of pulmonary embolism (PE). (2) Detail an updated review of various options involving catheter-directed therapy of pulmonary embolism. (3) Highlight the latest devices in use of treating PE including advantages and disadvantages of each option. (4) Compare and contrast societal guidelines in treatment of PE.

BACKGROUND: Acute PE is estimated to account for 100,000 deaths per year in the United States alone. Management of acute PE can depend on several factors including a patient's hemodynamic stability and bleeding risk. When hemodynamic instability persists despite first line thrombolysis treatment and/or patient has moderate to high bleeding risk, catheter-directed therapy (CDT) is an effective strategy for PE. CDT can involve clot dissolution or mechanical removal. Clot dissolution involves use of pressurized saline or ultrasound. Mechanical removal involves rotational devices, suction, or embolectomy. We present an overview of recent advancements in PE treatment including INARI, AlphaVac, AngioVac, AngioJet, and Penumbra Lightning 12 as well as technical pearls in the use of these devices. In addition, we review American College of Chest Physicians (CHEST), Society of Interventional Radiology (SIR), American College of Cardiology (ACC), and European Society of Cardiology (ESC) guidelines in treatment of PE.

CLINICAL FINDINGS/PROCEDURE DETAILS: This exhibit will (1) define low risk, submassive, and massive pulmonary embolism; (2) discuss the device specifications of INARI, AlphaVac, AngioVac, AngioJet, and Penumbra Lightning 12 in a graphical format; (3) differentiate technical considerations related to the use of each device and highlight situational advantages and disadvantages of each device; and (4) discuss

updated societal guidelines related in the treatment of submassive and massive pulmonary embolism including CHEST, SIR, ACC, and ESC.

CONCLUSION AND/OR TEACHING POINTS: Treatment options for pulmonary embolism depend on several factors including status of right ventricular function, hemodynamic stability, and biomarkers. Guidelines offer varied recommendations on when to use catheter-directed therapy for treatment of PE. This educational exhibit serves to highlight risk stratifying patients with PE, current devices used in treating PE, as well as updated guidelines from relevant societies.

Abstract No. 709

Beyond Acute Pulmonary Embolism: Removal of Chronic Thrombus with Catheter-Directed Mechanical Pulmonary Thrombectomy

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LEARNING OBJECTIVES: (1) Review current guidelines and literature of treatment of pulmonary emboli. (2) Describe the pathogenesis and chronological transformation of thrombus. (3) Discuss the potential future role of mechanical thrombectomy in the treatment of chronic pulmonary emboli.

BACKGROUND: Catheter-directed pulmonary mechanical thrombectomy has emerged in recent years as an effective and safe therapy for intermediate-risk acute pulmonary embolism (PE). The technique has demonstrated comparable reduction in right heart strain compared with catheter-directed thrombolysis as well as lower rates of major bleeding events compared with both catheter-directed and systemic thrombolysis. However, robust research directly comparing various PE treatments is largely lacking. Among potentially important yet largely unexplored difference is the relative effectiveness of mechanical thrombectomy in removing nonacute thrombus when compared with other therapies.

Histologically, thrombus undergoes chronological, structural transformation through multiple stages. This is largely related to changes in numerous factors at the cellular level including fibrin, pro-collagen, collagen IV, and other cellular components. This structural transformation represents a continuous spectrum; all stages are thought to be simultaneously present to varying degrees within any given thrombus. And thus, given this heterogeneity, the effectiveness of thrombolysis and anticoagulation is thought to be inherently limited.

CLINICAL FINDINGS/PROCEDURE DETAILS: Histopathologic analysis was performed on clot specimens from 7 patients who underwent catheter-directed mechanical pulmonary thrombectomy for acute, intermediate-risk PE at a single institution. All procedures were performed by an interventional radiologist and histopathologic analysis was performed by a clinical pathologist. To date, preliminary histopathologic analyses demonstrate evidence of late-stage thrombus at the cellular level within the aspirate.

CONCLUSION AND/OR TEACHING POINTS: Our observational study thus far demonstrates evidence of late-stage thrombus within aspirate from pulmonary mechanical thrombectomy. This finding raises the question of whether mechanical thrombectomy treatment for PE might be of better therapeutic value compared with other therapies. Studies comparing the long-term outcomes of mechanical thrombectomy versus other therapies for PE are of significant need. We plan to continue assessing our growing cohort for features of chronicity within aspirated clot from mechanical thrombectomy for PE.

Abstract No. 710

Infraclavicular Brachial Plexus Block for Endovascular Arteriovenous Fistula Creation

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LEARNING OBJECTIVES: Describe the technique of infraclavicular brachial plexus block (IBPB) for endovascular arteriovenous fistula (AVF) creations, mechanism of action, reported efficacies, complication rates, and limitations.

BACKGROUND: Intra-operative ultrasound BPB is regarded as the gold-standard method for providing anesthesia for creating AVF for hemodialysis access. Blind techniques and neurostimulation associated with a high complication incidence, were previously used. Many block approaches have emerged, including axillary, supraclavicular and infraclavicular. This review discusses IBPB for endovascular AVF creation, the mechanism of action, reported efficacies, complication rates, and limitations.

CLINICAL FINDINGS/PROCEDURE DETAILS: The exhibit will (1) highlight the technique, vascular, and iatrogenic complications reported for this procedure; (2) provide an honorable mention of the efficacy and limitations of the procedure in comparison with other types of BPB, mainly to understand if one could be used rather than the other for local causes; and (3) present the current literature on the use of IBPB for endovascular AVF creation, the study limitations, and future research considerations.

CONCLUSION AND/OR TEACHING POINTS: An interventional radiologist performing IBPB, particularly for endovascular AVF creation, requires in depth understanding of the technique, associated adverse events and limitations, and patient discomfort and satisfaction with this procedure. This exhibit reviews the literature on this procedure. It highlights the need for future studies to be conducted while ensuring satisfactory anesthesia and postoperative analgesia are established to increase the available data on the procedure performed for practice improvement.

Abstract No. 711**Transradial Approach for Dialysis Access Interventions**

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LEARNING OBJECTIVES: (1) Review transradial artery access (TRA) for upper extremity arteriovenous fistula and graft (AVF/AVG) interventions. (2) Provide case-based techniques for TRA hemodialysis (HD) access interventions. (3) Identify advantages, disadvantages, pitfalls, and tips of TRA access for HD access interventions.

BACKGROUND: HD is preferably performed via an upper extremity AVF or AVG. HD access failure is a major cause of morbidity in patients with end-stage renal disease and percutaneous interventions are a mainstay of access repair. Traditionally, endovascular interventions of HD access are performed via direct puncture of the AVF or AVG, though other techniques have been described. TRA for HD access interventions is an increasingly recognized option that may improve ergonomics, procedure time, and access site complications. This abstract will review techniques of TRA for HD access interventions through various case-based examples.

CLINICAL FINDINGS/PROCEDURE DETAILS: *Technique:* Techniques of TRA access unique to HD interventions will be described, including patient selection and pre-procedure ultrasound to ensure TRA will be feasible and effective. Guidelines regarding radial sheath sizing and dual access techniques for larger bore devices will be discussed. Operator and patient positioning to improve ergonomics and decrease radiation dose during HD interventions will be illustrated.

Advantages of TRA: TRA enables evaluation and treatment of the entire HD circuit from arterial inflow to right atrium without need for multiple access sites. Mechanical thrombectomy may be performed with single TR sheath with potential for improved mechanical advantage and optimal evaluation of completion flow dynamics to predict immediate success. Decreased access site complications relative to other upper extremity access sites i.e., brachial access.

Disadvantages of TRA and alternative strategies: Sheath size options for radial access are more limited. Circuit configuration must be well delineated prior to TRA. Complications associated with TRA including hand ischemia.

Case illustrations will be provided, including thrombectomy, percutaneous AVF interventions, central venous outflow obstruction and inflow insufficiency.

CONCLUSION AND/OR TEACHING POINTS: TRA for HD access interventions is a technique that may identify and treat lesions from a single puncture site, predict procedural success with intra-procedural monitoring, improve ergonomics and reduce radiation. Techniques and pitfalls unique to TRA must be understood by the interventionalist to ensure safe and effective therapies.

Abstract No. 712**Complications with Percutaneous Endovascular Arteriovenous Fistula Creation and Management**

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LEARNING OBJECTIVES: 1. To familiarize the various immediate and delayed complications associated with percutaneous endovascular fistula (pAVF) creation, including radiofrequency and thermal technologies. 2. To understand the pathophysiology of these complications and identify the associated risk factors. 3. To provide a comprehensive review of the literature pertinent to complications. 4. To identify strategies to minimize complications and provide a guide to its management

BACKGROUND: Arteriovenous fistula creation remain the preferred vascular access for hemodialysis. pAVF creation trends higher rates of success with creation, patency, usability, and lower maturation time compared with surgical fistula (sAVF) creation. Even though this technique is minimally invasive, complications have been reported. This exhibit provides a comprehensive pictorial review of most of the complications reported during creation, assisted maturation and during long-term follow up. Insight into the risk factors and pathophysiology can provide a guide to minimize complications, aid the management and improve outcomes.

CLINICAL FINDINGS/PROCEDURE DETAILS: The exhibit will provide relative anatomy of the upper extremity vessels for better understanding of the potential sites for complications. The exhibit will categorize the complications as below and provide management of individual complications, literature review and overall strategies to minimize complications.

1. Immediate:
 - a. Sedation (respiratory depression)
 - b. Supraclavicular nerve block (phrenic nerve palsy, pneumothorax, nerve injury, local anesthetic systemic toxicity)
 - c. Creation/assisted maturation (arterial/ venous hematoma, creation site vs access site pseudoaneurysm, non-targeted embolization, closure device related, dissection)
2. Delayed: Post procedural (hematoma, arterial/venous pseudoaneurysm, dialysis associated steal syndrome, thrombosis, infection, ischemic monomelic neuropathy, venous hypertension)

CONCLUSION AND/OR TEACHING POINTS: pAVF creation is a safe procedure and has lower complications (1.5%–9.3%) versus sAVF (4.5%–26%). Identification of potential risk factors before creation and implementing select strategies during creation, can aid in minimizing complications. The most common complications of pAVF include hematoma and pseudoaneurysm formation. In suitable cases, arterial wrist access provides better hemostasis over brachial access. In general low complications are reported with the use of thermal resistance anastomosis device.

Abstract No. 713

BAM! A Pictorial Essay of Early Dialysis Access Interventions

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LEARNING OBJECTIVES: Explained in Background.

BACKGROUND: A hemodialysis (HD) arteriovenous fistula (AVF) is an iatrogenic shunt between an artery and vein created surgically or endovascularly in dialysis patients. A mature AVF allows for high flow hemodialysis without the need for placement of a tunneled catheter. In this pictorial essay, we will address Kidney Disease Outcomes Quality Initiative recommendations for “fistula first” and the importance of moving from catheter-based dialysis to arm access as soon as possible. More specifically we will present common causes for delayed AVF maturity and the interventions available to treat them.

Complications over the lifetime of an AVF include aneurysm, pseudoaneurysm, stenosis, and thrombosis. Of these, stenosis is a common pre-existing or early cause of delayed maturation. We will highlight cases of inflow venous stenosis secondary to post-surgical scarring, venous valves, intramuscular course of veins in upper arm and shoulder, and prior subclavian and IJ catheters. Additionally, examples of poor maturity secondary to anatomic variations or the presence of multiple venous side branches will be presented.

Having identified the common causes for delayed maturity for AVFs, we will also highlight appropriate interventions with examples of balloon-assisted maturation (BAM) and venous side branch embolization/ligation. This educational presentation is designed for the practitioner seeking to improve early outcomes for their dialysis patient population by understanding the common causes of delayed maturity for an AVF and how to improve outcomes with early intervention.

CLINICAL FINDINGS/PROCEDURE DETAILS: We'll highlight cases of inflow venous stenosis, along with examples of appropriate interventions such as BAM.

CONCLUSION AND/OR TEACHING POINTS: (1) Inflow venous stenosis from post-surgical scarring: scarring in the lumen of vessels occludes flow. (2) Stenosis secondary to venous valves: the cephalic arch has at least twice as many valves compared with any similar portion of the cephalic vein leading to turbulent and sometimes occlusive blood flow. (3) Stenosis secondary to intramuscular course of veins in upper arm and shoulder: muscular compression of vessels occludes flow. (4) Stenosis secondary to prior subclavian and IJ catheters: stenosis is a well-known complication of central venous catheterization. (5) Anatomic variations: a single channel that joins the axillary vein to form the subclavian vein is the most common variant of the cephalic arch; a bifid arch may also be encountered. (6) Poor maturity secondary to multiple venous side branches: side branches divert flow from main AVF channel, delaying its maturation.

Abstract No. 714

Safety and Efficacy of Thrombectomy Using Vascular Snare for the Chronic Organized Thrombi in Patients with Thrombosed Native Hemodialysis Fistula

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PURPOSE: To evaluate the safety and efficacy of the thrombectomy using a vascular snare for the chronic organized thrombi in patients with thrombosed native hemodialysis fistula (AVF).

MATERIALS AND METHODS: The electronic medical records of the patients who underwent recanalization for thrombosed AVF from January 2019 to June 2022. During the study period, a total of 20 native fistulas (14 brachiocephalic, 5 radiocephalic, and 1 radiobasilic) were treated using a vascular snare in 19 patients. Characteristics of the AVF, endovascular procedures, technical and clinical results, and complications were evaluated.

RESULTS: Total thrombosis was observed in 13 fistulas. Aneurysmal changes were found in 15 fistulas. Thrombectomy using a vascular snare was initiated in 5 fistulas or followed insufficient thrombectomy with a rotational percutaneous thrombectomy device (PTD) in 15. Additional aspiration and adjunctive balloon angioplasty were performed in all procedures. Thrombolysis was performed in 6 hours before thrombectomy procedure in one fistula. Mean procedure time except thrombolysis was 79 minutes (SD 31.5). Technical and clinical success rates were 90% (18/20) and 95% (19/20), respectively. Massive pulmonary embolism requiring emergent cardiopulmonary resuscitation was occurred in one patient, resulted in the failure of hemodialysis with AVF.

CONCLUSION: The use of a vascular snare was safe and highly effective for the removal of chronic organized thrombi in the recanalization procedures of thrombosed AVF.

Abstract No. 715

The Utilization of Ultrasound in the Creation and Maturation of Percutaneous Arteriovenous Fistula: A Pictorial Essay

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LEARNING OBJECTIVES: (1) Discuss clinical indications and patient selection for percutaneous arteriovenous fistula (AVF) creation. (2) Discuss AVF maturation techniques in the setting of low flow volumes. (3) Outline U/S findings required for creation and maturation of percutaneous AVF.

BACKGROUND: Historically, patients with end stage renal disease requiring hemodialysis (HD) underwent surgical creation of AVFs. Although surgical AVF creation is a quick outpatient procedure, many fistulas require numerous interventions and prolonged time to maturation, with potential avoidable complications. Recent techniques such as percutaneous AVF creation has been shown to be effective and safe in establishing HD access.

CLINICAL FINDINGS/PROCEDURE DETAILS: Potential candidates undergo sonographic vascular mapping. Images must reveal a radial artery at least 2 mm with a feasible communicating vein within 1 mm of the radial artery (e.g., antecubital perforator vein), also measuring ≥ 2 mm. Next, percutaneous endovascular AVF is created using a designated AVF vascular access system (e.g., Ellipsys) with radiofrequency ablation between the artery and vein, followed by balloon angioplasty of the arterial anastomotic site. During AVF creation, sonography including intravenous ultrasound (IVUS), is used to evaluate goal flow volume of ≥ 250 mL/min. Later, ultrasound (U/S) is used to assess volume flow rates of ≥ 350 mL/min at 1 week and ≥ 500 mL/min at 3 weeks.

To aid in the maturation process, angiography is performed to identify potential complications preventing successful maturation, most commonly stenosis. If stenosis is revealed at the time of angiography, U/S may be concurrently used to obtain inflow and outflow volumes followed by balloon angioplasty to achieve reduction in stenosis within the arterial anastomosis, antecubital perforator vein, and/or basilic outflow vein. Furthermore, to aid in AVF maturation, competing collateral outflow vessels are sometimes banded or coil embolized to increase flow volume through the primary outflow vein. A successful fistula demonstrates ≥ 600 mL min flow volume, is located within 6 mm of the skin, and is 6 mm in diameter, all of which can easily be received using U/S.

CONCLUSION AND/OR TEACHING POINTS: Percutaneous AVFs offer a viable alternative to surgical AVF creation and have been shown to decrease overall maturation time, maturation interventions, and complications. The utilization of U/S is vital to the patient selection process with performing vein mapping, creation of percutaneous AVF, calculating flow volumes, assessment of AVF maturation, and long-term AVF success with fistula flow volume monitoring and patency.

Abstract No. 716

Middle Meningeal Artery Embolization for the Treatment of Chronic Subdural Hematomas: A Case Series

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LEARNING OBJECTIVES: (1) Retrospectively analyze the efficacy, complication rate and recurrence rate of middle meningeal artery (MMA) embolization for treatment of chronic subdural hematoma (cSDH) in 19 patients who underwent the procedure at our institution. (2) Discuss relevant technical and anatomic considerations for MMA embolization. (3) Review current literature on outcomes of cSDH treatment with surgery versus MMA embolization.

BACKGROUND: cSDH is a common traumatic disease among the elderly associated with high morbidity. Surgical evacuation is the standard of treatment but is associated with significant morbidity and up to 9% complication rate and 28% recurrence rate. cSDH evolves from prior acute subdural hemorrhage, in which inflammation and angiogenesis involved in the healing process further generate vascularized neomembrane and chronic fluid exudation. The MMA supplies these

frangible neovessels as it traverses the dura and has been reported to be enlarged in patients with cSDH. Although techniques vary across institutions, 200- to 300- μ m microparticles are usually injected into the target MMA until stasis is achieved on angiogram.

CLINICAL FINDINGS/PROCEDURE DETAILS: Retrospective analysis of treatment outcome was performed on 19 patients who underwent MMA embolization for cSDH treatment since 2019 at our institution. There were 0 complications and 3 recurrent subdural hematomas (15%) that required either surgery or repeat MMA embolization. Complete resolution of cSDH was achieved in 10 patients (50%), with average duration to achieve resolution 7.7 months. 12 patients had midline shift prior to the procedure and 8 patients achieved complete resolution post-procedure (67%). The longest recurrence-free duration within this patient cohort was 3 years. The average percent reduction in hematoma size was 12% at 1 to 3 days, 9% at 2 to 3 weeks, 39% at 1 to 2 months, and 77% at 3 to 4 months. Careful review of MMA anatomy on angiogram is required to successfully embolize all sources to the cSDH while avoiding important arterial anastomoses and cranial nerves.

CONCLUSION AND/OR TEACHING POINTS: MMA embolization for cSDH was associated with no complications, low recurrence rate and reliable hematoma size reduction in this case series. Especially among high-risk surgical patients, MMA embolization should be considered a reliable alternative therapy for cSDH management.

Abstract No. 717

Embolization for the Treatment of Symptomatic Hemorrhoids: A Primer for the Interventional Radiologist

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LEARNING OBJECTIVES: Review the anatomy and characteristics of hemorrhoids. Review the variable superior, middle and inferior rectal artery anatomy. Review treatments of hemorrhoids including band ligation, excision, and embolization. Review current guidelines for hemorrhoid artery embolization. Review technique, advantages, and disadvantages of the “emborrhoid” technique

BACKGROUND: Hemorrhoids are a bothersome clinical condition commonly affecting patients aged 45–65. They occur most commonly in men, and have associations with diet and bathroom habits. Hemorrhoids can result in pain, bleeding, and aesthetic concerns for patients. Hemorrhoids gain greater clinical significance when they become ulcerated or incarcerated putting patients at risk of infection. Internal hemorrhoids are further classified into four grades based on extent of prolapse, bleeding, and reducibility. The goal of this educational abstract is to review hemorrhoid characteristics, discuss treatment options, and highlight the relatively new procedure of a hemorrhoid artery embolization.

CLINICAL FINDINGS/PROCEDURE DETAILS: Twelve current clinical studies published on hemorrhoid embolization were analyzed and were found to come primarily from Europe, used coils and/or microspheres,

had 1 to 12 months of follow-up, and had an average cohort of 25 patients treated. There are five described anatomical variations of the SRA, MRA, and IRA important to consider if planning an emborrhoid procedure. Complications and limitations of the emborrhoid technique will be discussed. Considerations regarding embolic used will also be addressed, in addition to possible future use of liquid embolics to ensure distal penetration.

CONCLUSION AND/OR TEACHING POINTS: Hemorrhoids are a common and morbid condition affecting much of the population. Hemorrhoids have become a clinical focus for interventional radiologists since the advent of the emborrhoid technique as an alternative to invasive surgical removal. Evidence for the efficacy of hemorrhoid artery embolization compared with other treatments is currently limited. Randomized controlled trials with longer patient follow-up are necessary to further establish this novel technique.

Abstract No. 718

Withdrawn

Abstract No. 719

Radiation Dose Reduction in Prostate Artery Embolization Using Advanced Imaging Guidance

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PURPOSE: Prostate artery embolization (PAE) has the potential for significant radiation exposure. This study evaluated the dose reduction associated with a standardized procedural workflow and advanced guidance software and compared this with other commonly performed procedures in interventional radiology.

MATERIALS AND METHODS: IRB-approved single institution retrospective study of all patients undergoing PAE from 2017 to 2022 for hematuria or lower urinary tract symptoms (LUTS) secondary to benign prostatic hypertrophy (BPH) ($n = 143$), with a comparison cohort of patients receiving primary transjugular intrahepatic portosystemic shunts (TIPS, $n = 50$) or radioembolization (TARE, $n = 50$). Patients receiving PAE were separated into two cohorts based on the implementation of a previously reported procedural workflow and the use of advanced planning software.

RESULTS: There was a greater than 3-fold reduction in radiation exposure (dose area product) in patients who underwent the standardized workflow with advanced planning software compared with those who did not (71.7 vs. 236.4 Gy-cm²; $P < 0.0001$). There were also reductions in total contrast used (104.1 vs. 136.2 mL; $P = 0.021$) and failure rates (0% vs. 10.5%; $P = 0.025$). Despite more patients requiring protective embolization in the advanced protocol, suggesting greater complexity of cases, there was no difference in fluoroscopy time (50 v 48.5 min; $P = 0.657$). PAE also resulted in significantly lower dose compared with primary TIPS and TARE (71.7 vs. 204.6 vs 284.3, respectively; $P < 0.0001$), even when accounting for body mass index.

CONCLUSION: Advanced imaging guidance and a standard workflow can lead to substantial reductions in radiation dose, contrast utilization, and failure rates for prostate artery embolization. The reduction was realized shortly after implementation of these techniques, which supports ease of use and fluid incorporation into existing clinical practices. The radiation dose achieved is significantly lower than other commonly performed interventional radiology procedures, which should obviate concerns of referring providers about the risk of radiation exposure.

Abstract No. 720

“Hit Below the Waist”: A Primer for Trainees and Interventional Radiologists Managing Lower Extremity Vascular Trauma

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LEARNING OBJECTIVES: (1) 1. To classify common vascular injuries encountered in blunt and penetrating lower extremity trauma. (2) To outline endovascular and open treatment options for vascular trauma to the lower extremity. (3) To provide interprofessional team strategies for improving care and outcomes in patients with lower extremity vascular extremity trauma.

BACKGROUND: Lower extremity vascular injury in trauma patients is rare, but can cause significant morbidity and mortality if not treated promptly. Injuries to the vascular system of the lower extremity may be caused by three forms: blunt, penetrating, or a combination of the two. Historically, vascular injuries have been treated with open surgery because of the morbidity and mortality associated with them. Considering growing endovascular techniques, patients who have sustained lower extremity trauma may not be required to undergo operative treatment if they are appropriate candidates for endovascular treatment. Both the Western Trauma Association (WTA) and the Eastern Association for the Surgery of Trauma (EAST) provide recommendations on the management of vascular injuries. It is important to note that some vascular injuries are more appropriate for endovascular interventions while others are more suitable for surgical repair. With this exhibit, trainees and interventional radiologists will learn how to effectively manage lower extremity trauma and how to determine whether a patient is a candidate for endovascular repair.

CLINICAL FINDINGS/PROCEDURE DETAILS: (1) Overview of mechanisms of injury of the lower extremity that may result in vascular injuries. (2) Review of WTA and EAST Classifications of Vascular Injury and management recommendations. (3) Endovascular techniques for the treatment of lower extremity posttraumatic vascular injury. (4) Interprofessional team strategies to improve care and outcomes for patients with vascular extremity trauma to the lower extremities.

CONCLUSION AND/OR TEACHING POINTS: Interventional radiologists will continue to play an important and increasing role as endovascular treatments become more accepted in the interdisciplinary treatment paradigm for lower extremity vascular injury.

Abstract No. 721

Interventional Radiology's Role in the Treatment of Adhesive Capsulitis

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LEARNING OBJECTIVES: (1) Understand the pathophysiology of adhesive capsulitis and its implications for trans-arterial embolization (TAE). (2) Review the procedural details of TAE for adhesive capsulitis. (3) Summarize the current literature on the safety and efficacy of TAE for adhesive capsulitis.

BACKGROUND: Adhesive capsulitis is a shoulder condition characterized by shoulder pain and loss of both passive and active range of motion that affects 3% to 5% of the population. Patients are typically offered conservative treatment options including physical therapy, NSAIDs, or intra-articular corticosteroids. Operative management for cases refractory to conservative therapy includes manipulation under anesthesia and arthroscopic capsulotomy. Recent clinical trials have investigated the use of TAE for the treatment of adhesive capsulitis.

CLINICAL FINDINGS/PROCEDURE DETAILS: (1) Review the pathogenesis of adhesive capsulitis. (2) Discuss the effect of TAE on the pathophysiology of adhesive capsulitis and its therapeutic role. (3) Outline the procedural details. (4) Showcase pathological findings on angiograms. (5) Review the current literature on TAE for adhesive capsulitis with a focus on the efficacy and safety profile.

CONCLUSION AND/OR TEACHING POINTS: Recent clinical trials have shown TAE to be both safe and efficacious for treating adhesive capsulitis resistant to conservative therapies. In this educational exhibit, we discuss the pathophysiology of the disease and the role of TAE.

Abstract No. 722

Low-Flow Vascular Malformations of the Head and Neck: A Pictorial Review and Survival Guide for Challenging Cases

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LEARNING OBJECTIVES: Understand the nuances and imaging findings of the diagnosis and treatment of challenging low-flow vascular malformations of the head and neck.

Understand how multidisciplinary care between otolaryngology (ENT) and interventional radiology (IR) can provide the most effective collaborative care to these patients.

BACKGROUND: The International Society for the Study of Vascular Anomalies (ISSVA) classifies low-flow vascular malformations as

lymphatic and venous malformations, many of which occur in the head and neck. Clinical diagnosis of these vascular lesions is aided by several imaging modalities such as US and magnetic resonance imaging which provide findings that are characteristic of each vascular malformation. Following diagnosis, interventional radiologists and otolaryngologists may offer several treatment options in tandem or together aimed at reducing the progression of and preventing further complications of low-flow malformations.

CLINICAL FINDINGS/PROCEDURE DETAILS: This exhibit will first review the imaging characteristics for the diagnosis of low-flow vascular malformations. Next, several cases of various low-flow malformations of the head, neck, and orbit will be presented with treatment strategies that best detail the collaborative work between ENT and IR. The discussion on treatment options will focus on the indications for several sclerosants and novel therapeutics, and how these treatments can be used in conjunction with surgical intervention with special attention paid to indications to appropriate treatment, diagnostic and treatment pitfalls, technical considerations, and clinical follow-up.

CONCLUSION AND/OR TEACHING POINTS: The collaborative work of interventional radiologists and otolaryngologists plays an important role in the management of low-flow vascular malformations of the head and neck by providing imaging expertise and offering multidisciplinary treatment options.

Abstract No. 723

Angiography in the Setting of Extracorporeal Membrane Oxygenation (ECMO): What an Interventional Radiologist Needs to Know

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LEARNING OBJECTIVES: (1) Understand the differences in extracorporeal membrane oxygenation (ECMO) circuit types and cannulation access sites. (2) Review the physiologic differences and impact of ECMO on catheter angiography. (3) Tips and tricks to optimize clinical and procedural success.

BACKGROUND: There are two types of ECMO circuits: venovenous (VV) and venoarterial (VA). VV ECMO withdraws venous blood and subsequently returns oxygenated blood to the venous system. In contrast, VA ECMO withdraws venous blood and returns oxygenated blood to the arterial system. VA ECMO can be further classified into central and peripheral based on the arterial cannulation site. In central VA ECMO, there is direct cannulation of the ascending aorta and blood flow follows the native antegrade pathway. However, in peripheral VA ECMO, which is more commonly used, a peripheral artery is cannulated and blood flows retrograde within the thoracic aorta.

The most common venous access sites include the femoral and internal jugular veins. The most common peripheral arterial access sites include the femoral artery, occasionally carotid, subclavian, or axillary. Often, these critically ill patients require additional arterial or venous access points for monitoring lines or other mechanical cardiac support devices such as Impella or intra-aortic balloon pump.

While on ECMO, anticoagulation is used to prevent thrombotic complications. However, sustained anticoagulation combined with acquired coagulopathy in critically ill patients leads to significant risk for bleeding events. Due to limited arterial access site availability in combination with the non-physiologic blood patterns, angiography on ECMO patients can be challenging.

CLINICAL FINDINGS/PROCEDURE DETAILS: This exhibit will review the role and challenges of angiography in critically ill patients on ECMO. This will start with reviewing ECMO itself including indication, cannulation access sites, blood flow patterns, and bleeding complications. The challenges in work-up and management of bleeding complications will be discussed including the role and limitations of diagnostic imaging. Finally, angiography itself will be discussed in detail including technical and diagnostic challenges in the setting of limited access point availability and non-physiologic blood flow. Various angiographic pictures of patients on ECMO will be provided.

CONCLUSION AND/OR TEACHING POINTS: Patients on ECMO can have non-physiologic blood flow. Work-up and management of these patients can be difficult and pose clinical and procedural challenges. Understanding all this is important to optimize procedural and clinical success, ultimately improving patient care.

Abstract No. 724

Pictorial Review of the Endovascular Treatment of Pulmonary Arteriovenous Malformation

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LEARNING OBJECTIVES: (1) Review the etiology, classification, and clinical presentation of pulmonary arteriovenous malformations (PAVMs). (2) Compare the different types of endovascular devices used to treat PAVMs. (3) Review the most recent literature on the treatment of PAVMs.

BACKGROUND: PAVMs are rare direct pulmonary artery-to-vein connections without intervening capillary beds, leading to right-to-left shunting or hemorrhage. Most PAVMs are congenital, approximately 70% to 90% of patients have hereditary hemorrhagic telangiectasia. Acquired PAVMs commonly happen in the setting of cirrhosis, trauma, post-surgical, and others. Patients with PAVMs are usually asymptomatic but can present with dyspnea and fatigue. Complications of PAVMs include paradoxical embolization, leading to stroke, transient ischemic attack, or brain abscess. We will provide a pictorial review of the different types of PAVMs.

CLINICAL FINDINGS/PROCEDURE DETAILS: Endovascular tools used to treat PAVMs include detachable balloons, coils, or plugs. Traditionally, the distal aspect of the feeding artery beyond significant branches supplying the lung yet proximal to the venous sac is embolized. However, most recent meta-analysis and systematic review showed that venous sac embolization with or without feeding artery embolization is superior when compared with feeding artery embolization alone in the management of PAVMs. We will provide pictorial case examples from the literature and institutional experience to help show the different embolization methods. This will include an introduction to the different

catheters designed to access the pulmonary circulation and help sub-select vessels. In addition, we will also demonstrate how to deploy the different embolic devices.

CONCLUSION AND/OR TEACHING POINTS: Most recent literature showed that venous sac embolization with or without feeding artery embolization is more efficacious than feeding artery embolization alone. Currently, vascular plug embolization is being used more as an endovascular therapy, which shows greater promise due to lower rates of recanalization. Further literature has complicated the effect of embolics in PAVMs. There are still many questions unanswered for PAVM treatment, including the goals of therapy, implications of persistence and which technique is superior, etc. We hope to highlight and provide the most up-to-date technical and procedural aspects of PAVM embolization in an easy-to-read pictorial format.

Abstract No. 725

Medical Management of Patients with Osteoarthritis (OA) Prior to Genicular Artery Embolization (GAE)

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LEARNING OBJECTIVES: (1) Understand the pathophysiology of osteoarthritis (OA). (2) Review the current treatment algorithm used for OA including lifestyle modifications, pharmacologic options, intra-articular injections, regenerative therapies, genicular artery embolization (GAE), and surgical interventions. (3) Discuss the growing use, indications, contraindications, and potential complications of GAE for the treatment of OA.

BACKGROUND: Osteoarthritis is a non-inflammatory degenerative disorder of the synovial joints. It typically presents with joint pain, stiffness, and locomotor restriction, making it a leading cause of impaired function and disability. The joint-specific management of OA includes nonpharmacologic lifestyle modifications, pharmacologic options, intra-articular injections, regenerative therapies, genicular artery embolization (GAE), and surgical options with the primary goal being to minimize pain, optimize function, and modify the process of joint damage. Specifically, the severity of disease and the patient's comorbidities must be considered when constructing a treatment plan. For example, mild knee OA treatment should focus on nonpharmacologic lifestyle modifications whereas moderate to severe cases may require adjunct therapies such as NSAIDs, Duloxetine, intra-articular glucocorticoids, and as a last resort, surgery. Although end-stage knee OA can be treated with total knee arthroplasty, conservative treatment for patients who are not surgical candidates or for those who want to delay surgery is a challenge. GAE may serve to narrow this gap. In one single-arm trial of GAE, 68% of subjects continued to have marked symptomatic improvement at 12 months post treatment. Vascular interventional radiologists should be made aware of this novel treatment modality for the treatment of refractory OA.

CLINICAL FINDINGS/PROCEDURE DETAILS: In this exhibit, we begin by highlighting the pathophysiology of OA and its debilitating effects on the patient and their quality of life. We continue by detailing the

current treatment guidelines used for the management of OA. We will then discuss specifically GAE, a promising approach for the treatment of moderate to severe knee OA.

CONCLUSION AND/OR TEACHING POINTS: OA is a complicated, multifactorial disease process that can greatly impair the function of one's life. There are a variety of treatment algorithms that may be used based on severity of disease. Typically a combination of therapeutic approaches must be used for the proper management of OA. Specifically, Vascular interventional radiologists can perform GAE for refractory, symptomatic patients.

Abstract No. 726

Who Would Benefit from Percutaneous Cholangioscopes-Assisted Laser Incision of Hepaticojejunostomy Stenosis?

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LEARNING OBJECTIVES: (1) To review clinical indications and contraindications of percutaneous cholangioscopes-assisted laser incision of biliary anastomotic stenosis. (2) To describe the technical details and considerations of the percutaneous laser incision of biliary stenosis. (3) To provide a pictorial review of cases who would benefit the most from percutaneous laser incision of biliary stenosis.

BACKGROUND: Patients who undergo Roux-en-Y hepaticojejunostomy may have post-procedure complications such as hepaticojejunostomy anastomotic strictures. These patients may fail or are not a candidate for an intraluminal endoscopic approach. Conventionally, such patients undergo a percutaneous trans-hepatic cholangiography (PTC) with a percutaneous trans-hepatic biliary drain placement (PTBD). Patients are then followed as part of a benign biliary stricture protocol every 2 to 3 weeks for regular PTC, and gradual cholangioplasty upsizing for about 6 months. Patients with refractory or recurrent stenosis not responding to cholangioplasty may need very long-term biliary drains which significantly affects their quality of life.

CLINICAL FINDINGS/PROCEDURE DETAILS: Percutaneous cholangioscopes-assisted laser incision is a feasible novel technique to treat severe benign hepaticojejunostomy stenosis. The biliary stenosis can be localized under combined fluoroscopy and cholangioscopy guidance and the stenosis can be incised using a holmium laser under direct visualization. The initial experiences at our institution (10 cases) showed that patients with postsurgical, severe (more than 50%), short-segment (2–3 cm), benign anastomotic stenosis who are resistant to cholangioplasty alone would benefit the most from percutaneous laser incision. Procedural tips including sedation coverage, optimal percutaneous access, the role of safety wire, laser fiber characterization, and clinical follow-ups are shared in this exhibit. A pictorial review of a stepwise approach and procedural steps is provided.

CONCLUSION AND/OR TEACHING POINTS: Patients with postsurgical, severe, short-segment, benign hepaticojejunostomy stenosis who are not responding to cholangioplasty may benefit from percutaneous cholangioscopes-assisted laser incision.

Abstract No. 727

Malignant Bowel Obstruction: A Pictorial Guide to Advanced Interventional Techniques

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LEARNING OBJECTIVES: (1) Review the pathophysiology and management of malignant bowel obstruction. (2) Demonstrate interventional strategies for enteral access along the alimentary tract. (3) Illustrate advanced techniques for enteral access and palliation using a case-based approach.

BACKGROUND: Malignant bowel obstruction (MBO) is a source of morbidity and mortality in patients with abdominopelvic cancers. These patients can present in acute distress with nausea, vomiting, and pain. MBO also contributes to poor nutrition which can exclude patients from oncologic therapy. This complex problem requires multimodal treatment with attention to the patients' goals of care. Surgery is reserved for patients with good functional status and many cannot receive palliative surgery. Interventional techniques can instead be used to provide patients with meaningful improvements in quality of life.

CLINICAL FINDINGS/PROCEDURE DETAILS: Despite medical management, many patients with MBO have recurrent symptoms and a suboptimal quality of life. Placement of a gastrostomy tube is a safe and effective approach to palliate obstructive symptoms, however, MBO patients may have contraindications to standard gastrostomy placement such as peritoneal carcinomatosis, ascites, or altered anatomy. Additionally, nutrition cannot be effectively administered through a gastrostomy tube in the setting of downstream obstruction. This exhibit provides a pictorial guide of strategies for obtaining access along the alimentary tract including trans-esophageal gastrostomy, gastrostomy, and jejunostomy tube placement. We showcase the use of ultrasound, cone-beam computed tomography (CT), and CT guidance for troubleshooting challenging situations, as well as highlight the use of needle guidance software under fluoroscopy for precise enteral access to facilitate palliation.

CONCLUSION AND/OR TEACHING POINTS: Malignant bowel obstruction is a challenging clinical scenario responsible for significant morbidity and mortality in cancer patients. Interventionalists can provide palliation and nutritional support for these patients, however, standard gastrostomy tube placement is sometimes not possible or sufficient. This exhibit reviews the pathophysiology and management of MBO and uses a case-based approach to illustrate obtaining access along the alimentary tract while using a variety of imaging techniques beyond standard fluoroscopy.

Abstract No. 728

Percutaneous Cholangioscopes-Assisted Electrohydraulic Versus Laser Lithotripsy for Gallbladder and Biliary Tract Stones: Comparison of Technique, Safety and Efficacy

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LEARNING OBJECTIVES: (1) An image-rich case-based review and comparison between two modalities of percutaneous lithotripsy for gallbladder and biliary tract stones. (2) To review the techniques and device settings for each lithotripsy modality. (3) To discuss the efficacy and safety of each modality.

BACKGROUND: Percutaneous transhepatic interventions including stone retrieval and lithotripsy are emerging effective treatment options for gallbladder (GB) and intrahepatic biliary stones, particularly if conventional endoscopic and/or surgical approaches fail or due to non-surgical candidacy. Two percutaneous cholangioscopy-assisted lithotripsy (PCAL) techniques are available: electrohydraulic lithotripsy (EHL) and laser lithotripsy (LL). There is a paucity of standardized data on the safety and efficacy of emerging percutaneous techniques to treat biliary stones. This exhibit provides a comparison between two modalities (EHL versus LL), to help guide interventional radiologists to choose the most suitable option for their patients.

CLINICAL FINDINGS/PROCEDURE DETAILS: PCAL techniques including EHL and LL are becoming widely used by interventional radiologists. Each modality provides certain advantages and disadvantages. EHL uses a charge generator transmitting a charge across the electrodes at the tip of a bipolar probe, generating a spark that expands the surrounding fluid resulting in an oscillating shockwave that fragments the stones. EHL causes displacement of the stone fragments during fragmentation. The Laser system use Holmium laser technology and laser fiber which produces a thermal effect due to its strong absorption by water, which results in stone vaporization, it converts the stones into very tiny fragments or dust, allowing it to pass freely into the bowel via the biliary system, without significantly displacing the stone fragments during fragmentation, providing more control. The dusting technique prolongs the procedure time. EHL can be advantageous in intrahepatic ducts interventions, LL can be favorable in GB interventions in addition to intrahepatic ducts stones. Complications of both EHL and LL include hemobilia, ductal perforation, and bile leak. GB perforation and bile duct injury are more likely to occur with LL due to the thermal effect.

CONCLUSION AND/OR TEACHING POINTS: Both EHL and LL are effective modalities for GB and intrahepatic stones. EHL is advantageous for intrahepatic stones. LL is a favorable option for GB stones in addition to intrahepatic stones. Given the unique characteristics of each modality, in-depth knowledge of both techniques is important to guide interventional radiologists to select the most appropriate modality for their patients.

Abstract No. 729

Retrograde Transvenous Obliteration: Lessons of a Case Series from a Large Academic Center

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LEARNING OBJECTIVES: (1) Provide an image-based review of select cases illustrating nuances in gastric variceal (GV) management. (2) Describe patient selection for variations of retrograde transvenous obliteration (RTO). (3) Provide a pictorial review of RTO variations.

BACKGROUND: A known sequela of portal hypertension (PHTN), gastric varices (GV) often develop collaterals to relieve portal venous pressure, with subsequent draining via gastrosplenic shunts into the left renal vein or less often via a gastrocaval shunt directly into the inferior vena cava. In RTO, the shunt is occluded so that retrograde delivery of sclerosing agent obliterates the GV, thereby preventing or treating bleeding. RTO variations including balloon-assisted retrograde transvenous obliteration (BRTO), coil-assisted retrograde transvenous obliteration (CARTO), and plug-assisted retrograde transvenous obliteration (PARTO) each bears its own technicalities, benefits, and potential complications. Because RTO does not decompress portal venous pressure to control GV hemostasis as seen in transjugular intrahepatic portosystemic shunts (TIPS), success is contingent on patient selection and technique selection. Other factors include the patient's history, portal venous anatomy, and clinician familiarity with RTO variations. This exhibit will provide case-based lessons in matching the right patient with the right procedure to manage GVs.

CLINICAL FINDINGS/PROCEDURE DETAILS: A series of cases will be used to illustrate clinician decision-making regarding proper patient selection and RTO technique. Technical considerations, challenges, and nuanced decision-making by the academic center's clinicians will be highlighted. Visuals of the RTO variations including BRTO, CARTO, and PARTO will be provided either from case images or as original graphics. These visualizations will emphasize the procedural steps both common and unique to these variations. Procedural equipment used will be described as well.

CONCLUSION AND/OR TEACHING POINTS: The clinician with a greater understanding of RTO variations can provide more efficacious management of GV. A deeper understanding of possible anatomic variations, progression of abnormal physiology in PHTN and GV, as well as increased exposure to varying RTO techniques may benefit the clinician in the selection and effective management of a wider variety of patients presenting with PHTN and GV bleeding.

Abstract No. 730

Percutaneous Cholecystoduodenal Stenting: Review of an Effective Option for Long-Term Intraduodenal Drainage for Cholecystitis

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LEARNING OBJECTIVES: To review the clinical indications for cholecystoduodenal stenting, its role in the management of cholecystitis, and detailed procedural technique of this stenting method.

BACKGROUND: Cholecystitis is a common biliary condition that presents a major disease burden. Though first-line treatment for acute cholecystitis includes cholecystectomy, certain patients are poor candidates and rely on other techniques, such as interventional or endoscopic, to treat the condition. Among the interventional techniques, percutaneous drainage of the gallbladder via cholecystostomy tube placement is the first-line for appropriate, non-surgical patients. Although this intervention has been demonstrated to achieve positive clinical outcomes, it can come with disadvantages such as needing

long-term external drainage which may not be tolerated or acceptable to some patients. Cholecystoduodenal stenting can achieve long-term intraduodenal drainage without the need for repeated drainages.

CLINICAL FINDINGS/PROCEDURE DETAILS: This educational exhibit will cover (1) an overview of the structural anatomy of the biliary system, (2) review the pathogenesis and disease burden of cholecystitis, (3) review the current first-time treatments and common alternatives for cholecystitis treatment, (4) analyze the role and indications of cholecystoduodenal stenting, (5) evaluate the potential complications and risks for cholecystoduodenal stenting, (6) describe the technical procedural details of cholecystoduodenal stenting, (7) evaluate current literature in reference to patient outcomes who have undergone cholecystoduodenal stenting, and (8) discuss future considerations and directions of cholecystoduodenal stenting.

CONCLUSION AND/OR TEACHING POINTS: After reviewing the exhibit, the viewer will gain a deeper understanding of the role of cholecystoduodenal stenting in the appropriate candidates, the technical details of the procedure, and important considerations and outcomes of this interventional therapy.

Abstract No. 731

Passing a Camel through the Needle's Eye: Expanding SpyGlass-Assisted Biliary Interventions

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LEARNING OBJECTIVES: (1) Describe and visualize the indications and technicalities of percutaneous endoscopy-assisted biliary interventions in patients with cholelithiasis, biliary strictures, and prior hepaticojejunostomy. (2) Present cases using SpyGlass Direct (SD) in the management of cholecystolithiasis versus choledocholithiasis.

BACKGROUND: Biliary endoscopy is an effective adjunctive tool in managing a variety of biliary pathologies. This is especially true in cases where endoscopic retrograde cholangiopancreatography (ERCP) fails or is unfeasible due to anatomy altered by previous surgery such as hepaticojejunostomy, biliary strictures as seen in primary sclerosing cholangitis, or by extrinsic compression as seen in Mirizzi's syndrome and tumor mass effect. In these circumstances, the use of SD for pathologies of the biliary tree such as choledocholithiasis is well-recorded; we thus include a case of SD utilization in cholecystolithiasis.

CLINICAL FINDINGS/PROCEDURE DETAILS: The SD is advanced through a ≥ 11 -Fr sheath, providing a 3.6-Fr working channel to accommodate objective-dependent wires, catheters, and devices. In general, gallstone management with SD is done 4 weeks after percutaneous biliary drainage to minimize bleeding. The biliary drainage catheter is exchanged over a guide wire for a 25-cm vascular sheath using a 12-Fr peel-away sheath to avoid excessive biliary pressurization. A flexible endoscope is used for choledochoscopy, while a rigid endoscope in cholecystoscopy permits a more direct route through the fundus. Once localized, the stone is fragmented and removed. In cases with

prior hepaticojejunostomy, endoscopic suture removal rids the anastomosis of potential nidi for new stone formation and, as with strictures, stenting may be used to ensure patency. The procedure concludes with placement of external drain catheter if transhepatic, or transcystic internal-external drainage catheter or a cholecystostomy drain in cholecystoscopy.

CONCLUSION AND/OR TEACHING POINTS: While percutaneous endoscopy-assisted biliary interventions for a variety of biliary pathologies gain traction, special considerations and techniques can be considered to optimize outcomes of variant pathologies and patient histories. We highlight cases of SD utilization in cholecystolithiasis versus choledocholithiasis.

Abstract No. 732

Hybrid Angiography-Computed Tomography Angiography for the Localization of Obscure GI Bleeds and Utility in Guiding Treatment

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LEARNING OBJECTIVES: (1) Describe how to use hybrid angiography-computed tomography (CT) for localizing obscure GI bleeds not detected on computed tomography angiography (CTA) or angiography. (2) Describe the technical aspects and contrast infusion protocols of the procedure. (3) Present case-based clinical applications illustrating its utility in guiding treatment.

BACKGROUND: Lower gastrointestinal (GI) bleeding accounts for roughly 20% to 25% of all GI bleeds and occurs at an incidence of 33 to 87 per 100,000 people. The current diagnostic guidelines vary among different societies, but traditionally endoscopy was considered first line for evaluation. In recent years, CTA has gained popularity for the evaluation of suspected acute GI bleeding with a sensitivity of 50% to 86%. For accurate diagnosis, CTA requires an active bleeding rate of at least 0.3 to 0.5 mL/min. CTA is more sensitive than conventional angiography at detecting active extravasation. For this reason, angiography is typically reserved for patients with positive CTA findings with the intention to treat endovascularly. In situations where the bleed is slow and/or intermittent, endoscopic and CTA evaluation can be unrevealing. In these cases, referred to as obscure GI bleeding, next diagnostic steps are variable and could include repeat endoscopy, tagged RBC scan, capsule endoscopy, triple phase enterography, or provocative angiography. With the advent of hybrid angiography-CT (angio-CT), interventional radiologists are now able to perform high-resolution sub-selective mesenteric CTAs, with greater sensitivity than standard CTA, to aid in the diagnosis and treatment of obscure GI bleeds.

CLINICAL FINDINGS/PROCEDURE DETAILS: This educational exhibit will discuss current techniques for the utilization of angio-CT to aid in the identification and localization of obscure GI bleeds and outline our institutional protocols for image acquisition and contrast infusion. We will present multiple cases of slow persistent GI bleeding where hemorrhage was not visualized on CTA and/or angiography and only demonstrated with hybrid angio-CT, allowing effective treatment.

Each case will emphasize specific learning points either pertaining to angio-CT technique or its utility in guiding endovascular treatment or alternative therapies. Some examples include (1) provocative angio-CT with intra-mesenteric tPA administration, (2) bowel “tagging” to guide surgical resection, and (3) considerations for transcatheter arterial embolization of mesenteric arteries.

CONCLUSION AND/OR TEACHING POINTS: Hybrid angiography-CT is an emerging modality that has clinical utility in both the localization and treatment of obscure GI bleeds.

Abstract No. 733

Cryo- and Chemical Ablation of the Gallbladder: Review of Available and Emerging Interventional Therapies for Non-Surgical Cholecystitis

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LEARNING OBJECTIVES: To review available gallbladder ablative interventions, evolving techniques, and indications and outcomes of ablative therapies for cholecystitis.

BACKGROUND: Gallbladder disease affects over 20 million adults, with cholecystitis representing a common and emergent indication for surgery. Though laparoscopic cholecystectomy represents the first-line approach to cholecystitis with excellent outcomes, there is a subset of patients who are poor surgical candidates and require alternative treatments. Percutaneous cholecystostomy drainage of the gallbladder is the preferred route of treatment for non-surgical cholecystitis, though the technique is associated with complications, recurrence of disease, and diminished quality of life. Alternative therapies have been sought to fill the role of a minimally invasive approach with acceptable side-effects. Ablative techniques of the gallbladder using chemical agents have been in development first in animal models beginning in the 1980's. Since then, various chemical and cryo-ablative interventions have emerged as potentially effective treatment options.

CLINICAL FINDINGS/PROCEDURE DETAILS: This educational exhibit will cover a (1) review of the pathogenesis and disease burden of cholecystitis, (2) review current first-line treatments and common alternatives for cholecystitis treatment, (3) analyze the role and indications for ablative treatment of cholecystitis, (4) review early ablative gallbladder interventions with a focus on chemical ablation, (5) describe emerging ablative gallbladder techniques with a focus on cryo- and chemical ablation with adjunct cystic duct embolization, (6) describe the technical procedural details of gallbladder ablative techniques, (7) evaluate current literature and clinical outcomes, and (8) discuss future considerations and directions of gallbladder ablation.

CONCLUSION AND/OR TEACHING POINTS: After reviewing the exhibit, the viewer will gain a deeper understanding of the role of gallbladder ablative interventional techniques in the appropriate candidates, the technical procedural details of the intervention, and important considerations and outcomes of this approach.

Abstract No. 734

Infracolic Gastrostomy: Food for Thought

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LEARNING OBJECTIVES: (1) Review the anatomy relevant to infracolic gastrostomy (ICG). (2) Understand the unique risks associated with ICG. (3) Review the literature relevant to ICG. (4) Reflect on the procedural steps for ICG based on the literature and institutional experience.

BACKGROUND: Debate exists surrounding the safety of infracolic gastrostomy. There is a paucity of literature on this topic and it has not been addressed in several large society guidelines. In contrast to standard gastrostomy insertion, an infracolic approach requires additional consideration due to the unique risks associated with transgression of multiple additional tissue planes, including the greater omentum, transverse mesocolon and gastrocolic ligament. In particular, there is an increased theoretical risk of vascular or colonic injury.

CLINICAL FINDINGS/PROCEDURE DETAILS: MEDLINE, EMBASE, and PubMed searches were performed. Systematic literature review found 12 published cases of ICG in total across three studies (follow-up range 7 days to 54 months). Variable techniques were used; however, there was reportedly no significant morbidity and no mortality across these studies. This may suggest that the perceived risks have been historically overestimated. Significant selection and reporting biases are acknowledged which are difficult to control for in retrospective studies of this type.

Reflecting on our institutional experience of over 8000 gastrostomies during the past 10 years, ICG is rarely required. Some interventional radiologists would choose this approach when no other safe access can be identified whilst others may consider this a contraindication or consider endoscopic assistance to facilitate a traditional supra-colic approach.

To gauge interventional radiology practice patterns of this approach, an online poll of 54 interventionalists highlighted similar contrasting opinions in practise, with 43% who would proceed with ICG when required, 28% against this approach and 24% uncertain when presented with this clinical scenario.

CONCLUSION AND/OR TEACHING POINTS: Following review of the current literature and our own institutional experience, the clinical conundrum persists. Limited available evidence and experience suggest that ICG may be performed safely but operators must be conscious of the risks and unique anatomical considerations involved. Whilst it is difficult to draw any meaningful conclusions, we hope this literature summary and reflection on institutional experience provides a synthesis of what we know so far, to inform operators' decision making.

Abstract No. 735

Exploring the Scope of Interventional Radiology Cholangioscopy with Pictorial Essay

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LEARNING OBJECTIVES: (1) Understand the role of cholangioscopy within the multidisciplinary approach to treating patients with hepatobiliary disease. (2) Understand the indications, peri-procedural management, and procedural techniques for choledochoscopy and cholecystoscopy. (3) For cholecystoscopy, describe the mucosal changes associated with the four stages of cholecystitis. (4) For choledochoscopy, describe the visual characteristics associated with benign versus malignant biliary strictures.

BACKGROUND: Even though interventional radiology (IR) cholangioscopy has been in existence for five decades, the procedure remains largely underused with limited resources detailing how it is performed. This exhibit aims to present the history of IR cholangioscopy, discuss its role in the multidisciplinary approach to treating patients with hepatobiliary disease, and describe the periprocedural management and techniques of choledochoscopy and cholecystoscopy using pictorial correlation.

CLINICAL FINDINGS/PROCEDURE DETAILS:

1. History of cholangioscopy, description of the patient selection, preprocedural preparation, endoscopy equipment set-up including endoscope options, and discussion of how cholangioscopy fits within the multidisciplinary management of patients with hepatobiliary pathology.
2. Basic biliary cholangioscopic findings, including visual characteristics of stones, benign biliary lesions, and malignant biliary lesions, with correlating images.
3. Technical steps of performing choledochoscopy with respect to visually evaluating biliary duct pathology, biopsies, and stone clearance, each with examples cases and images.
4. Technical steps of performing cholecystoscopic gallstone clearance in cases of calculous cholecystitis and symptomatic cholelithiasis. The stages of mucosal changes depending on the degree and chronicity of cholecystitis will be presented, with correlating example cases and images.
5. Summary of technical success, complication, and tube removal rates for Cholangioscopy based on literature and the authors' 7-year experience.

CONCLUSION AND/OR TEACHING POINTS: (1) Choledochoscopy is used for visual inspection, with or without biopsy, of biliary strictures or tumors, or removal of biliary stones in patients with anatomy precluding ERCP. (2) Cholecystoscopy is used to treat calculous cholecystitis or symptomatic cholelithiasis in high surgical risk patients. (3) Choledochoscopy has high rates of complete stone removal (85%) and diagnostic accuracy for biliary strictures and tumors (88%); while

cholecystoscopy has high reported rates of complete stone clearance with subsequent cholecystostomy tube removal (100%).

Abstract No. 736

Gastrostomy and Gastrojejunostomy Tube Exchange—Know What Can Go Wrong!

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LEARNING OBJECTIVES: (1) To discuss common types of gastrostomy (G) and gastrojejunostomy (GJ) tubes that are placed percutaneously, endoscopically, and surgically. (2) Present a case-based review of challenging G and GJ tube exchanges. (3) Provide appropriate management recommendations to overcome or avoid problems encountered with G and GJ exchanges.

BACKGROUND: Enteric tube maintenance is a more frequent procedure encountered in interventional radiology (IR) than initial percutaneous feeding tube placement. Enteric tube evaluation, exchange, and revision are necessary to support an IR practice. Percutaneous exchange of G and GJ tubes is not uniformly simple. We aim to equip IR trainees with knowledge regarding the management of G and GJ tubes, particularly those placed by other specialties.

CLINICAL FINDINGS/PROCEDURE DETAILS: This exhibit provides IR trainees with required information regarding available IR and non-IR enteric tubes and how to troubleshoot challenging enteric tube exchanges. The topics include:

- Management options for newly placed G or GJ tubes in the setting of dislodgement or requested exchange
- Difficult or impossible G to GJ conversions
- Troubleshooting malpositioned or retracted G and GJ tubes
- Techniques to exchange occluded G and GJ tubes
- Conversion to a button-type G tube
- Exchanging pull-type G tubes: Ponsky pulls need not be painful
- Soft tissue infections and granulation tissue presentations and treatment
- Pericatheter leaks and enlarging stoma: short-term and long-term issues
- Colocutaneous fistula is identified during exchange, what should be done now?
- What is the course of action when a G tube traverses the liver?
- Retained G tube fragment, perform retrieval or let it pass with peristalsis?
- Management of bleeding after a G tube exchange

CONCLUSION AND/OR TEACHING POINTS: After reviewing this exhibit, the IR trainees will be better prepared to manage, employ techniques, and avoid pitfalls encountered in enteric tube exchanges.

Abstract No. 737

Comprehensive Review of Anticoagulants, Their Pharmacology and Uses, and Appropriate Reversal Agents

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LEARNING OBJECTIVES: The objective of this educational poster is to give a comprehensive and simple review of the spectrum of current and commonly used anticoagulants, their pharmacology, appropriate uses, and reversal agents. It is essential for all interventional radiologists to be familiar with intra-procedure anticoagulants and understand the appropriate use to optimize management of patients before and after procedures to minimize risk of procedure-related complications.

BACKGROUND: Anticoagulants have been the cornerstone therapy for thrombus prevention and treatment. Advances in venous thromboembolism have resulted in a complex assortment of available anticoagulation. Therefore, interventional radiologists must be familiar with these different anticoagulation regimens, the pathophysiology, pharmacodynamics, and toxicity and have a clear understanding of when and how to use the available anticoagulants.

CLINICAL FINDINGS/PROCEDURE DETAILS: The coagulation cascade is incited by trauma and/or vascular insult. Thrombin is one of the most potent activators of platelet mediated and clotting factor mediated hemostasis. Thrombin can also incite thrombogenesis by fibrin polymerization, platelet receptor activation, and endothelium activation. Anticoagulant agents will inhibit thrombogenesis by altering the clotting cascade. Alternatively, some of the newer agents, indirect inhibitors, will bind to plasma cofactors and catalyze the interaction with clotting enzymes.

CONCLUSION AND/OR TEACHING POINTS: This educational poster aims to summarize salient points on currently available anticoagulants, their mechanism of action as well as the role of reversal agents in management of periprocedural bleeding based on extrapolation of the available data in the medical and pharmacologic literature. While much of this may be common knowledge, there is a large gap of knowledge in the community regarding many of the newer anticoagulants and their appropriate use.

Abstract No. 738

Hepatic Artery Infusion Pumps: The Expected and Unexpected

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LEARNING OBJECTIVES: (1) Review current indications for and most common designs of hepatic artery infusion pumps (HAIPs). (2) Demonstrate expected and unexpected imaging findings following HAIP placement on computed tomography (CT), fluoroscopy, and nuclear medicine studies. (3) Describe techniques of pump assessment which require understanding of pump access and interrogation. (4) Identify complications of HAIPs including catheter tip dislodgment, catheter fracture, pseudoaneurysm formation, and pump leak.

BACKGROUND: HAIPs are used in the treatment of primary and secondary hepatic malignancies, delivering chemotherapy directly to the liver in order to minimize systemic toxicity. HAIPs consist of a subcutaneously implanted reservoir attached to a catheter which is inserted into the gastroduodenal artery. In general, approximately 1 cc of chemotherapeutic drug is delivered through the catheter each day, but a separate access port is available for catheter bolus. HAIPs take advantage of the fact that hepatic tumor blood supply is predominantly arterial.

CT is often the first imaging modality to show a catheter-related complication such as catheter dislodgement, hematoma, or pseudoaneurysm. In cases with high suspicion of catheter malfunction but unclear diagnosis on CT, other modalities can be helpful for troubleshooting.

CLINICAL FINDINGS/PROCEDURE DETAILS: Fluoroscopic assessment should begin with full evaluation of pump positioning and catheter course. Once the interrogation port is accessed with a specialized Huber needle, residual chemotherapy in the catheter should be aspirated. Contrast can be injected to evaluate for catheter fracture or catheter dislodgement. Similarly, a nuclear medicine agent such as ^{99m}Tc-MAA can be injected for an infusion study.

Care should be taken to avoid over-pressurizing the system which can lead to catheter fracture and tip dislodgment. In general, no smaller than a 10-mL syringe is recommended for pump infusion. The ease of access, ability to aspirate, ease of flushing, catheter course, and washout of contrast at the arterial insertion site should be carefully evaluated and documented. If there is catheter dislodgment with associated pseudoaneurysm or bleeding, angiography may be helpful in the diagnosis and treatment which may include embolization or stent graft placement.

CONCLUSION AND/OR TEACHING POINTS: HAIPs are being used increasingly in the treatment of primary and secondary hepatic malignancy. Interventional and diagnostic radiologists should be aware of the expected and unexpected imaging findings following pump placement and understand how to safely access and interrogate these pumps.

Abstract No. 739

The Creation of Ex-Vivo Models for Interventional Radiology Training of Medical Students and Residents

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LEARNING OBJECTIVES: To report our experience with the development of several teaching models to teach basic and advanced interventional radiology (IR) techniques using ex vivo organs.

BACKGROUND: Simulation in IR is very limited due to the high cost of computer base simulators and the lack of realistic experience when using plastic and 3 D models. We have created successfully several teaching models using ex vivo organs to teach and train on several basic and advanced IR techniques.

CLINICAL FINDINGS/PROCEDURE DETAILS: The following models were developed and tested by different operators with different levels of training: (1) PTC model: after the biliary system was opacified using gallbladder injection operators performed a PTC with placement of an internal external drain. The model simulates a PTC in mildly dilated biliary system, US punctures of the bile ducts is also possible. (2) PCN model: Operators developed the skills to perform a PCN using US and fluoroscopic guidance, different levels of hydronephrosis can be simulated injection contrast through a cannulated ureter. (3) Double J ureteral model: Kidneys with long pieces of ureter were used. Operator deployed a DJS using an antegrade access. The model allows to simulate exchange of DJS using a retrograde access. (4) TIPS and TJLB model: the model allows to perform cannulation of the HV and TJLB, puncture of the portal vein under fluoro or intravascular ultrasound and simulate all the steps of a TIPS with placing a Viatorr stent graft. (5) Angiographic and embolization model: Operators can learn basics of DSA, road mapping and selective catheterization of different vessels. A flow model was developed that allows to perform basic embolization techniques using different embolization, the renal artery, the hepatic artery and the portal vein can be used to practice in different vessels sizes and flow situations. (6) Biopsy and drainages models: Organs can be used to learn basics of liver and kidney biopsy. Percutaneous cholecystostomy tube can be practiced.

CONCLUSION AND/OR TEACHING POINTS: Ex vivo models offer a very economical and realistic simulation for different IR procedures that are very useful to teach basic and advanced techniques to medical students, residents, and fellows.

Abstract No. 740

“Breaking One’s Fall”: Risk Stratification, Management Techniques and Patient Safety Initiatives to Prevent Fall-Related Injuries in the Interventional Radiology Setting

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LEARNING OBJECTIVES: (1) To describe factors which may place patients at increased risk of fall-related periprocedural complications. (2) To outline methods for risk stratification and provide practice improvement techniques to mitigate preventable fall-related injuries in the interventional radiology (IR) setting.

BACKGROUND: In-hospital falls are a serious problem, ranking sixth among sentinel events reported to the Joint Commission in 2008. In the hospital setting and in IR, patients are at a greater risk of falls due to acute illnesses, medications, poor mentation, inherent pain, and/or unfamiliarity with the hospital environment. Even though IR procedures are minimally invasive, it may be necessary for patients to move and change positioning for optimal procedural safety and effectiveness. Patients may also be at risk of fall-related injuries as a result of insufficient or excessive periprocedural sedation and/or general anesthesia. Unintended falls pose a considerable risk to patients, their families, and care providers, as well as increase hospital liability exposure.

In light of the substantial morbidity associated with fall-related injuries, interventional radiologists and IR personnel should understand the causes and predisposing risk factors associated with falls, as well as the common injuries sustained after falling in IR departments.

CLINICAL FINDINGS/PROCEDURE DETAILS: (1) Overview of risk factors contributing to in-hospital patient falls. (2) Recommendations for stratifying IR patients based on predisposing risk factors. (3) Best-in-practice performances measures to prevent and mitigate fall related injuries. (4) Suggestions on how to implement fall-related patient safety initiatives in both the academic and private practice IR settings.

CONCLUSION AND/OR TEACHING POINTS: Peri-procedural falls are rare but preventable occurrences in IR departments, but can result in significant morbidity and mortality. Having a comprehensive understanding of patient fall incidence, associated risk factors, and reduction techniques, as well as implementing patient safety initiatives can improve patient care in IR.

Abstract No. 741

Addressing Inequity in Interventional Radiology: Healthcare Disparities in Access, Utilization and Outcomes of Interventional Procedures

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LEARNING OBJECTIVES: To review the current understanding of healthcare disparities in access, utilization, and outcomes of interventional radiology (IR) procedures, as well as provide insights and solutions to further characterize and combat these inequities.

BACKGROUND: Healthcare disparities remain a significant problem in the delivery of healthcare in the United States, and they remain underexplored within IR. Although minimally invasive approaches to treat a wide range of disease processes are associated with less risk when compared with traditional open surgical approaches, existing data has revealed disparities in access and outcomes to these beneficial procedures between race, ethnicity, and socioeconomic status. Certain demographic factors may be associated with objective measures of disparities including, but not limited to delayed times to intervention, procedural complications, follow-up care, disease progression, and mortality rates. While IR is a rapidly evolving field that continues to develop and improve minimally invasive therapies, it is crucial that physicians have the knowledge and tools to combat disparities in utilization, access, and outcomes these IR treatments.

CLINICAL FINDINGS/PROCEDURE DETAILS: This educational exhibit will (1) review the current literature exploring healthcare disparities in IR, (2) discuss key demographic factors and parameters that may allow for better understanding and characterization of existing inequities, (3) describe the barriers preventing equal access and outcomes related to IR procedures, (4) evaluate approaches to combat disparities in other procedural/surgical disciplines (Vascular Surgery, Gastroenterology, etc.), (5) highlight areas within IR where research in disparities would be most pertinent, (6) discuss potential solutions to help combat existing disparities.

CONCLUSION AND/OR TEACHING POINTS: After reviewing this exhibit, the viewer will become more familiar with existing healthcare disparities in IR, gain a better understanding of the key drivers of inequity in specific patient populations, and learn about tools and solutions to both further characterize disparities and mitigate their prevalence in IR care.

Abstract No. 742

Mentorship Expanded Networking and Teaching to Integrate and Enhance Residency (MEN-TIER)

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LEARNING OBJECTIVES: (1) Tiered mentorship with faculty and residents can minimize challenges of trialing various mentors. (2) Regular meetings help provide structure and accountability. (3) Longitudinal relationships help interventional radiology (IR)/diagnostic radiology (DR) residents assimilate earlier and maintain connections to the department during intern year or diagnostic training years.

BACKGROUND: Mentorship is the foundation for training and career development. To this end, a structured mentorship program was created at our institution in 2020 for IR/DR residents to pair one or two faculty advisors with a group of residents, one from each PGY class, based on personal interests and career paths. This is compared with a less formal mentorship program in the diagnostic residency. Funding is provided for both individual mentor/mentee meetings and group outings (both within mentorship “family” and combined events for all participants with team-building exercises), with recommended 1-2 quarterly meetings. Events and meetings are tracked for quality purposes, and there are yearly milestone documents for each mentee to help tailor the mentorship experience.

CLINICAL FINDINGS/PROCEDURE DETAILS: A quality improvement survey with Likert scale format (1-5) was sent to the residency program (diagnostic and IR/DR) and IR faculty mentors. Responses were recorded from 10 diagnostic and 11 IR/DR residents in addition to all 6 IR/DR faculty mentors. There was a higher number of individual and group meetings between IR/DR cohort compared with the diagnostic group (1.6 vs 1.0 and 2.1 vs 1.4, respectively). IR/DR respondents reported 100% satisfaction with feeling more assimilated in the department and all would recommend the current mentorship model to other institutions. In the IR/DR cohort, 91% of respondents agreed the program made them comfortable conducting effective mentorship relationships as an attending, and 82% felt the tiered structured of being mentee and mentor simultaneously was beneficial. Importantly, 91% of residents agreed the program helped prevent burnout, which has been a critical issue during the COVID pandemic. Faculty responses mirrored residents with 100% overall satisfaction and all desiring a similar program when they were in training.

CONCLUSION AND/OR TEACHING POINTS: The tiered mentorship model has had a positive impact on the IR/DR program by providing structured mentoring and longitudinal relationships. The most notable

benefit for IR/DR residents is the early integration into the program, sustained mentorships relationships, and the prevention of burnout. Similar models can help other programs establish structured faculty and peer mentorship for residents early in training.

Abstract No. 743

Role of Interventional Radiology in Sacral Mass Resection

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LEARNING OBJECTIVES: To discuss clinical presentation, risk factors, imaging characteristics and interventional management of sacral masses

BACKGROUND: Tumors of the sacrum are managed typically through surgery and radiotherapy, but due to the variable vascularity found in these masses, there is often a role for interventional radiology through embolization, whether to help with intraoperative bleeding or therapeutically to aid with inoperable metastases. These masses are broken down into benign, neural, or malignant/metastatic lesions, with the most common cause in adults being metastases of distant lesions such as breast, multiple myeloma, prostate, and lung. Sacral tumors are frequently biopsied for tissue diagnosis with computed tomography –guided needle biopsy, and from this, decisions can be made for interventions such as radiotherapy or partial/total resection. In the case of surgical resection, the tenuous vascular structures within the pelvis and the hypervascularity of many sacral masses creates a significant risk for intraoperative hemorrhage. Traditionally, surgery was performed without any pretreatment, and studies such as Hulen et al. reported mean blood losses of 5,000 mL during resection of primary sacral tumors. The current literature today recommends that interventional radiology play a role in the management for these tumors using preoperative angiography and embolization. This has significantly reduced blood loss to < 1,500 mL in most studies, making this a very viable option to manage this potentially lethal complication during resection of sacral tumors.

CLINICAL FINDINGS/PROCEDURE DETAILS: In this educational exhibit, we discuss clinical presentation, risk factors, multimodal imaging findings and management of sacral masses with illustrations from our institution, with special attention given to the role of trans-arterial embolization for management.

CONCLUSION AND/OR TEACHING POINTS: Without pre-treatment, there is a significant risk of large volume bleeding intraoperatively, leading to significant morbidity and mortality. The current literature suggests that there is great benefit in the preoperative angiographic embolization of sacral masses, compared with the alternative of attempting surgery without embolization. This has been shown to be a minimally invasive, safe, and effective addition for these patients, allowing interventional radiologist to play an integral role for the management of sacral masses through trans-arterial embolization.

Abstract No. 744

Pictorial How-To: Balloon Assisted Suprapubic Tubes

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LEARNING OBJECTIVES: (1) Review techniques with which interventional radiologists may use to place suprapubic tubes. (2) Pictorial overview of the balloon-assisted suprapubic tube placement technique.

BACKGROUND: (1) Interventional radiologists work in conjunction with urologists to manage bladder outlet obstruction or to create urinary diversion prior to urethral intervention. (2) Urinary diversion by suprapubic tube can be achieved using various catheters, including pigtail drains, standard and Council Foley catheters, and depending on catheter selected, by using specific techniques. (3) A Council catheter is a type of Foley Catheter with an end-hole, allowing it to track over a guidewire. (4) Primary placement of a standard or Council Foley catheter saves patients additional upsizing procedures, sometimes which occur in the operating room under general anesthesia.

CLINICAL FINDINGS/PROCEDURE DETAILS: (1) Pigtail drains and Foley catheters require serial dilation, but Foley catheters cannot track over a guidewire and thus ultimately require placement through a peel-away sheath. (2) Angioplasty balloons may be used to dilate the suprapubic tract and help "railroad" a Council Foley catheter in a single motion.

Pictorial overview of balloon-assisted suprapubic catheter placement.

CONCLUSION AND/OR TEACHING POINTS: (1) Primary placement of standard or Council Foley catheters as suprapubic tubes obviates the need for secondary procedures to exchange or upsize. (2) Balloon-assisted suprapubic tube placement, which can be done entirely with ultrasound guidance, is a quick and efficient method for primary placement of standard and Council Foley suprapubic tubes.

Abstract No. 745

Interventional Radiology Management of Thyroid Disease: A Review of Thyroid Nodule Ablation and Embolization Therapies

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LEARNING OBJECTIVES: To present advancements in ablation and catheter-directed techniques for treatment of thyroid nodules and discuss evidence-based approaches for proper application.

BACKGROUND: Recent developments in the treatment of thyroid nodules have made the implementation of thyroid ablations a safe and effective alternative to standard surgical procedures. Available modalities include radiofrequency, laser, microwave, ethanol, and high-intensity ultrasound ablation. Recently, arterial thyroid embolization has been introduced as a catheter-directed therapy for thyroid nodules. These procedures can significantly improve the quality of life and outcomes for patients with thyroid disease while avoiding surgical risks and costs, but it is important to understand the advantages of each

procedure to sufficiently treat the patient and prevent repeat procedures and complications.

CLINICAL FINDINGS/PROCEDURE DETAILS: This educational exhibit will (1) present an exhibit relevant thyroid cellular and vascular anatomy, (2) review the characteristics of thyroid nodules and subtypes, and their corresponding treatment paradigms, (3) describe the interventional approach to thyroid nodules and procedural techniques for catheter-directed and ablative therapies, (4) review the relevant indications and patient selection for interventional radiology (IR) therapies for benign and malignant neoplasms, (5) explore risks and contraindications to IR therapies, (6) summarize advancements in tools and techniques to advance therapeutic benefits.

CONCLUSION AND/OR TEACHING POINTS: After reviewing this exhibit, the viewer will gain a deeper understanding of emerging IR therapies for treatment of thyroid nodules and their role in the current medical/surgical treatment paradigm.

Abstract No. 746

A Systematic Review of Hybrid Emergency Interventional Room Systems (HEIRS) and Their Effect on Patient Outcomes

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LEARNING OBJECTIVES: To summarize current data and review cost-benefit analyses of hybrid emergency interventional room systems (HEIRS) and explore the advantages of its implementation in U.S. trauma centers.

BACKGROUND: Conventional trauma care logistics involves patient transport from the field to the trauma bay for evaluation and resuscitation within the emergency room (ER). Most patients undergo computed tomography scanning and subsequently are transferred to surgery or an angiography suite for further treatment. Each transfer requires time, which may delay life-saving procedures. A combined system could mitigate time loss in transfer of critical patients. Proposed and implemented hybrid operating suites have demonstrated decreased patient morbidity and mortality through this concept. Both the Hybrid Emergency Room System (HERS) in Japan and RAPTOR in Canada have demonstrated the benefits of these systems through decreased work-up time and decreased mortality, primarily by reduced deaths from exsanguination. A similar system implemented in tertiary trauma centers across the United States could prove to be financially and medically prudent.

CLINICAL FINDINGS/PROCEDURE DETAILS: Japanese and Canadian cohort studies conducted during the past decade have demonstrated a clear survival benefit in critically injured blunt trauma patients treated using hybrid systems. One study revealed that patients who received care via the hybrid workflow were twice as likely to be alive one month after their hospitalization as compared with those treated with conventional workflows. Subsequent studies have demonstrated that increased survival is directly correlated with time to intervention. The hybrid approach to trauma reduced the time from presentation to

intervention by 30% to 40%, which translated directly into lives saved. A cost analysis of Japanese HEIRS found an incremental cost-effectiveness ratio of \$32,522 when comparing HEIRS to conventional workflows. Repurposing existing suites reportedly cost \$1.2 to \$5 million. Multi-purpose use of hybrid suites among specialties could accelerate cost-saving benefits and improve opportunities for future refinancing.

CONCLUSION AND/OR TEACHING POINTS: In trauma settings where “time is life,” transport delays life-saving procedures. Aggregate review data shows that hybrid systems improve patient morbidity and mortality. Additionally, the cost-benefit analyses of these systems demonstrate long-term financial savings over initial investment. Given its international financial and clinical benefits, the implementation of hybrid systems in level 1 trauma centers across the United States is likely prudent.

Abstract No. 747

Virtual First-Assistant: Integration of a Novel Virtual Reality Curriculum within Interventional Radiology

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LEARNING OBJECTIVES: Educational objectives of the following exhibit include (1) familiarization with a novel virtual reality (VR)-based curriculum for interventional radiology (IR) trainees; (2) understanding of methodology of curricular creation and equipment used for the purposes of emulation; and (3) understanding curricular integration within existing clinical rotations.

BACKGROUND: Medical education, and particularly residency training, has long functioned through a combination of didactics and apprenticeship, which many view as expensive and inefficient. Leveraging VR in procedural training may enhance efficiency of resident learning. We describe a novel curriculum developed at our institution for the purposes of simulating the experience of standing in the first-assistant position for common interventional procedures. This curriculum enhances trainee education via simulation and observation of cases prior to direct hands-on patient care to decrease potential medical errors, improve trainee procedural confidence, and enhance hands-on reinforcement.

CLINICAL FINDINGS/PROCEDURE DETAILS: Using Go-Pro Max 360 (San Mateo, California), we recorded common IR procedures from the perspective of a first assistant. The Go-Pro Max 360 allowed for a 360-degree view of the operating room, and thereby capturing the back table, the operating table, and the imaging screens. VR recording required institutional and patient approval, which was secured with waivers for both HIPAA and media releases for each patient. Furthermore, our team developed a standardized process from patient selection to final recording publishing to purge the media of any protected health information (PHI). After removal of PHI, three layers of review were implemented to ensure that the videos are fully anonymous. The first set of curricular recordings include (1) non-tunneled vascular access, (2) tunneled vascular access, (3) port placement, (4) thoracentesis, and (5) paracentesis.

CONCLUSION AND/OR TEACHING POINTS: VR-based training carries significant potential to meet the demands of 21st century medical education in an innovative and efficient manner. A novel resident training curriculum was developed using 3D recording software that could be viewed and interacted with in a VR setting. Implementation of this curriculum necessitated a standardized protocol that ensures prudent use of recording time, patient safety and anonymity, and institutional approval. This model provides a framework for future research and use of VR simulation to enhance healthcare professional training.

Abstract No. 748

Development of Low-Cost Anatomical Flow Model for Simulation of Embolization of Upper Gastrointestinal Bleeding

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LEARNING OBJECTIVES: Review the development and use of a low-cost, 3D-printed model to simulate embolization of common gastrointestinal bleeding sites.

BACKGROUND: Gastrointestinal bleeding (GIB) is a relatively common condition (150/150,000) with a mortality rate between 2% to 15%. Upper gastrointestinal bleeding (UGIB) is more common than lower gastrointestinal bleeding (LGIB), with incidences of 67/100,000 and 36/100,000 population, respectively. Moreover, gastric and duodenal ulcers are responsible for 50% to 70% of UGIB bleedings (Sudan et al., n.d.). To increase trainee procedural proficiency with angiographic interrogation and embolization, we developed a vascular model allowing for navigation to and deployment of embolization material to target UGIB sites.

CLINICAL FINDINGS/PROCEDURE DETAILS: Computer-assisted drawing on AutodeskFusion360 (San Rafael, CA) was used for the development of the femoral artery, aortic supply, and the celiac trunk with its branches. Individual components were then exported into a stereolithography (.stl) file. Subsequently, the model components were printed on a 3D-printer from Formlabs (Somerville, MA) using their proprietary 50A Resin. Tube connectors of varying sizes were used to assemble the vascular model, which was subsequently filled with fluid. While an on-site printer was used, various printing services offer affordable online options for model assembly.

CONCLUSION AND/OR TEACHING POINTS: Following the above methodology, trainees were able to complete a simulation to practice arterial access, vessel catheterization, and embolization of common upper gastrointestinal sites of bleeding. These same resources, methodologies, and techniques are available for adoption by all trainees.

Abstract No. 749**An Overview of Non-Interventional and Surgical Therapies for Benign Prostatic Hyperplasia**

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LEARNING OBJECTIVES: (1) To review and compare the current medical, surgical, and minimally invasive therapies for BPH, including prostatic artery embolization (PAE), Rezum, aquablation, UroLift, and HoLEP. (2) To review and compare other surgical and minimally invasive approaches suggested by the American Urological Association (AUA) guidelines in the context of interventional radiology. (3) To highlight strengths and limitations of each therapy approach with a focus on PAE, Rezum, aquablation, UroLift, and HoLEP.

BACKGROUND: Benign prostatic hyperplasia (BPH) affects 80% of men by age 80, leading to significant impact on quality of life. Despite a dearth of medical treatments, there is a diverse landscape of surgical treatments and minimally invasive BPH therapies. Thorough knowledge of the strengths and limitations of each approach is critical to determining the best management strategy and honoring patient goals of care. We seek to provide an overview of the medical therapies, surgical interventions, and minimally invasive approaches for the treatment of BPH and associated lower urinary tract symptoms (LUTS).

CLINICAL FINDINGS/PROCEDURE DETAILS: This exhibit will (1) review and compare medical options for BPH treatment, including alpha-adrenergic antagonists (alpha blockers), 5-alpha reductase inhibitors (5ARIs), phosphodiesterase-5 selective inhibitors (PDE5s), anticholinergics, beta-3 agonists, and combination therapies; (2) review the surgical and minimally invasive therapies with a focus on prostatic artery embolization (PAE), Rezum, UroLift, aquablation, and HoLEP; (3) discuss the updated surgical guidelines from the AUA involving transurethral resection of the prostate (TURP), transurethral microwave therapy (TUMT), water vapor thermal therapy (WVTT), transurethral needle ablation (TUNA), laser enucleation, and robotic waterjet treatment (RWT) in the context of interventional radiology; and (4) compare international prostate symptom score (IPSS), maximum urinary flow rate (Qmax), quality of life (QoL), and postvoid residual (PVR) of Rezum, UroLift, aquablation, PAE, HoLEP, and TURP as well as highlight the strengths and limitations of other approaches (TUMT, WVTT, TUNA, RWT, and laser enucleation).

CONCLUSION AND/OR TEACHING POINTS: Knowledge of the various therapy options for LUTS is critical to providing patient-centered care. Each of the therapy options has associated strengths and limitations that should be viewed in the context of a patient's goals, as these interventions directly impact quality of life.

Abstract No. 750**Robotic Assisted Interventional Radiology Procedures: Early Experience and Advice to Ease the Learning Curve**

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LEARNING OBJECTIVES: (1) Patient preparation and robotic case set-up; (2) robotic procedural limitations and patient selection; (3) practical tips and troubleshooting of commonly encountered problems during robotic cases

BACKGROUND: Robotic assisted procedures are commonly performed across specialties and have been shown to improve procedural outcomes, increase technical control, and decrease radiation exposure. Our institution has recently started using robotic assistance for computed tomography (CT)-guided procedures, with initial usage limited to biopsies. We hope to share our early experience as well as lessons learned along the way. We will describe patient selection, setup, limitations, practical tips, and how to troubleshoot commonly encountered problems.

CLINICAL FINDINGS/PROCEDURE DETAILS: Initial patient preparation is similar to non-robotic CT cases. After an initial localization scan, the robotic docking station is then placed over the skin entry site and a registration scan is performed. The robotic workstation is then used to select the skin entry and target sites with resultant trajectory and multiplanar reconstructions displayed on the monitor. The biopsy device assembly is then connected to the robot and the needle is advanced to pre-selected checkpoints. A limited scan is performed at each checkpoint and if trajectory deviation is noted, non-linear steering can be used to redirect the needle between each checkpoint. However, it must be noted that the needle cannot be retracted and if there is excessive deviation from the trajectory, conversion to a non-robotic approach may be required. When the target is reached, the robot can either be left in place or undocked and biopsy samples are obtained in standard fashion. Overall, we find the robotic system beneficial for cases with challenging anatomic locations, target depth, and mobile targets (particularly lung lesions).

CONCLUSION AND/OR TEACHING POINTS: Robotic-assistance is employed for a variety of procedures across specialties. Our early experience demonstrates improved technical control for difficult cases due to anatomy, target mobility, or target depth. We hope that our experience helps others overcome the associated learning curve and add robotic-guidance to the interventional radiologists' armamentarium.

Abstract No. 751**So You Think You Can Code? Basics of Design and Coding in the Development of the Society of Interventional Radiology Guidelines Mobile Application**

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LEARNING OBJECTIVES: (1) Provide an overview of basic mobile application design and coding principles. (2) Present pertinent examples from the development of the Society of Interventional Radiology (SIR) guidelines app.

BACKGROUND: The need for accessible, beneficial, and easy to use clinical resources has been a driving factor for the adoption of mobile devices by healthcare providers to facilitate clinical decision making. SIR published their own sets of guidelines from which a task force was created to develop a mobile guidelines app. Putting guidelines into the hands of healthcare providers via the app interface is imperative, as up to 88% of clinicians use their mobile devices frequently in their practices.

CLINICAL FINDINGS/PROCEDURE DETAILS: Two independent prototypes, one web-based design and one mobile application, were taken into consideration during the design phase to combine successful ventures. Brainstorming and clinician insight among the task force were taken into account to create a user-friendly and adaptable user interface for a mobile application. Iterative designs were created and subsequently coded in Xcode. GitHub served as the codebase host platform, allowing for a central repository and collaborative coding. Use of third-party application programming interfaces and structured query language allowed for greater function, cross-platform integration, and analytics. Beta tests were completed initially with TestFlight for members in the task force and subsequently a limited release of the app on the Apple Store. Feedback was integrated into the app platform, and the app was made publicly available.

CONCLUSION AND/OR TEACHING POINTS: The use of mobile apps has the potential to improve guideline uptake and clinical workflow. A degree of coding literacy is beneficial to all members of the interventional radiology community.

Abstract No. 752

Peripheral MR Lymphangiography: Integration into Clinical Workflow in a Hybrid Interventional US/MR Suite

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LEARNING OBJECTIVES: (1) To review lower extremity lymphatic anatomy and variations. (2) To review procedural and imaging techniques of transpedal interstitial gadolinium-enhanced MR lymphangiography. (3) To provide a case-based review of peripheral MR lymphangiography utility.

BACKGROUND: MR Lymphangiography (MRL) is a useful diagnostic imaging adjunct to conventional lymphangiography (CL). Abdominopelvic and thoracic MRL can be performed via ultrasound-guided nodal access, transhepatic, trans-mesenteric, retrograde thoracic duct or via transdermal injection via the feet. When suitable inguinal lymph nodes are not present or in patients with prior CL via nodal access, peripheral MRL is a favored diagnostic approach. Peripheral MRL also enables assessment of thigh and calf lymphatics in suspected lower extremity lymphedema. This educational exhibit will detail the

experience to date integrating peripheral MRL into the hybrid procedural suite with a 1.5T magnet.

CLINICAL FINDINGS/PROCEDURE DETAILS: (1) Review the anatomy of the lower extremity lymphatic channels. (2) Review the method for injection of dilute gadolinium contrast into different regions of the feet to achieve opacification of unique calf and thigh lymphatic channels: a) webspaces: anteromedial; b) medial foot to medial malleolus: posteromedial; c) lateral forefoot: anterolateral; d) posterior (heel) and posterior lateral foot: posterolateral. (3) Review imaging techniques to optimize visualization of lymphatic channels in the lower extremities: a) High-resolution Dixon imaging; b) time-resolved MR angiography; c) T2-weighted non-contrast peripheral MRL; d) dual-agent relaxation contrast MRL using Ferumoxytol (intravenous) for venous suppression. (4) Case-based review of peripheral MRL utility: a) unilateral limb lymphedema in a patient with a lymphatic malformation; b) unilateral limb lymphedema in a patient with a lymphatic malformation of the thigh and pelvic soft tissues; c) localizing source of post-operative lymphatic leak in patients with limited nodal access: i) post-EVAR explant with graft placement for infection, continued peritoneal leak; post CL without visualization of thoracic duct; ii) post soft tissue mass resection with ongoing lymphatic leak. Challenges in peripheral MRL: a) distinguishing normal lymph channels from enhancing veins with "intravasation" of intradermal contrast and b) diffuse venous shunting with long-standing lymphedema.

CONCLUSION AND/OR TEACHING POINTS: Integrating contrast-enhanced peripheral MR lymphangiography (MRL) into a hybrid interventional suite with a 1.5T magnet is feasible but requires dedicated resources and team.

Abstract No. 753

Radiogenomics: Bridging Artificial Intelligence and Interventional Radiology to Inform Clinical Decision-Making Strategies

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LEARNING OBJECTIVES: To review technical details and methodology of radiogenomics and its potential for enhancing interventional radiology (IR) therapy outcomes.

BACKGROUND: Radiogenomics refers to the application of combining distinct image characteristics with individual genotypic data to construct models that predict tumor behavior. Over recent years, radiogenomics has rapidly garnered interest in IR, especially within the interventional oncology domain, to predict tumor response or non-invasively determine molecular features to drive therapy strategies. As methods combining artificial intelligence (AI) and machine learning algorithms with tumor gene characteristics, there is potential to further improve the precision and efficacy of current IR approaches.

CLINICAL FINDINGS/PROCEDURE DETAILS: This education exhibit will: (1) provide an overview of radiogenomics and describe current methods for building data models and IR-tailored algorithms, (2) review recent data using radiogenomics in IR with a special emphasis on

interventional oncology, (3) present an evidence-based review of radiogenomic applications and their emerging role in IR therapies for hepatocellular carcinoma, renal cell carcinoma, and non-small cell lung cancer, among other tumors, (4) discuss challenges and limitations of radiogenomic techniques, and (5) review future directions of this data-driven tool for enhancing patient outcomes in interventional oncology.

CONCLUSION AND/OR TEACHING POINTS: After reviewing this exhibit, viewers will become familiar with the diagnostic and clinical applications of radiogenomics, understand a general framework of how AI-based models are constructed using imaging and genetic data, and advantages and barriers of radiogenomics use in interventional treatments particularly in the oncology domain.

Abstract No. 754

The Use of Ultrasonography in the Creation and Maintenance of Hemodialysis Arteriovenous Fistulas and Grafts: Pictorial Review

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LEARNING OBJECTIVES: This pictorial review aims to explore the utility of ultrasonography (US) in the evaluation of vascular access (VA: AVF/AVG/percutaneous AVF) and demonstrate its ability to accurately screen for primary or delayed complications. After this review, participants should be able to appropriately identify patients who could benefit from invasive angiographies.

BACKGROUND: Obtaining a viable VA is a crucial step in the process of Hemodialysis (HD). US of the VA offers a fast and noninvasive means for evaluating patients with issues detected either by physical examination or dysfunction during HD sessions. US should include real time imaging of the inflow artery, outflow vein, needle access site, vein wall depth from the skin and the identification of possible complications mentioned.

CLINICAL FINDINGS/PROCEDURE DETAILS: Stenosis: grayscale, color, and spectral doppler US are used for diagnosis of vessel stenosis. Grayscale imaging is performed to detect any measurable decrease in luminal diameter. Peak systolic velocity (PSV) ratio (anastomosis/artery 2 cm upstream) greater than 3:1 suggests a stenosis, if associated with diameter reduction greater than 50%. Elevated PSV at the anastomosis alone (>375 cm/s) was shown to have a significant correlation with 50% stenosis in a study.

Maturation failure: Draining vein US evaluation for large venous branches and for outflow stenosis, as described above, is performed to evaluate for causes of immaturity.

Thrombosis: A history of recent onset of access difficulty, a significant drop in blood flow (>25% from baseline), or a new onset of lowered blood flow (<500 mL/min in AVG or <300ml/min in AVF) may be clues to an impending VA thrombosis. Measurement of dynamic venous pressure, measurement of access flow are noninvasive methods of measuring the blood flow in the VA.

Hemodialysis steal: Duplex Doppler US is performed in symptomatic patients to detect flow reversal distal to VA and either low or high flow velocities, that is useful in planning treatment.

Aneurysm or pseudoaneurysm: Grey scale US imaging can detect out-pouching arising from the main draining vein or graft, and turbulent flow within the outpouching producing a “yin-yang” or “to-and-fro” appearance will be seen on Doppler imaging.

CONCLUSION AND/OR TEACHING POINTS: Ultrasonography plays an important role in the evaluation of VA and their associated complications. The widespread use of screening ultrasound can aid in the recognition of common complications and decrease the time required to receive appropriate therapeutic treatment.

Abstract No. 755

Withdrawn

Abstract No. 756

Detection of Right Heart Strain in Pulmonary Embolism Using Artificial Intelligence

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LEARNING OBJECTIVES: To facilitate detection of right heart strain with pulmonary embolism (PE) using machine learning to expedite intervention.

BACKGROUND: PE is a medical emergency representing the third most common cause of death worldwide, responsible for 100,000 deaths annually within the United States alone. PE has high mortality rates within the first few hours of presentation; thus, accurate and timely diagnosis is essential for initiating potentially lifesaving interventions. Management of PE has dramatically improved with recent advances in device technology, allowing improved percutaneous thrombectomy early on in management of select submassive and massive pulmonary emboli.

Artificial Intelligence (AI) powered algorithms are becoming more integrated within diagnostic radiology. The use of AI across multiple modalities and specialties within radiology is gradually changing clinical practice by enhancing accuracy and efficiency, interrater reliability, and overall workflow for more timely recommendations. AI algorithms have been shown to have a high sensitivity in detection of PE on computed tomography angiography pulmonary angiography (CTPA). Algorithms have also been developed to estimate right heart strain associated with PE. The purpose of our study was to determine accuracy of AI in detecting right heart strain in patients with PE.

CLINICAL FINDINGS/PROCEDURE DETAILS: CTPA of patients presenting to a tertiary center emergency department between July 25, 2021, and October 16, 2021, were reviewed. A total of 74 patients with acute PE shown in CTPA were included. An AI algorithm was used to calculate right to left ventricular ratio. The calculated results of right ventricular strain by AI algorithm, the radiology reports, and echocardiogram results were collected. A right ventricle to left ventricle ratio of 1.2 was set as a trigger for the AI algorithm to detect right heart strain.

The result of right ventricular strain calculated by AI algorithm and radiology reports was concordant in 64 cases (20 positive, 44 negative cases) and discordant in 10 cases (6 positive and 4 negative cases by AI). More than half of the patients (38/74 patients) had subsequent echocardiograms. Compared with the results of echocardiogram, the AI algorithm had a higher sensitivity (80% vs 73%) than the radiology reports with equivalent specificity (74%).

CONCLUSION AND/OR TEACHING POINTS: Artificial Intelligence algorithms are not inferior to radiology reports in detecting right heart strain in patients with PE and should play a role in clinical management of PE to expedite thrombectomy in treatment of patients with submassive or massive PE.

Abstract No. 757

Use of Virtual Anatomic 3D-Models in Education and Medical Device Testing: What We can Learn from @ VisibleHeartLab

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LEARNING OBJECTIVES: Educational objectives of the following exhibit include (1) understanding the applications and impact of 3D-models in patient education; (2) understanding the applications and impact of 3D-models in trainee education; and (3) understanding how 3D-models can improve and accelerate medical device development.

BACKGROUND: The potential impact of growing virtual reality (VR) technologies in interventional radiology (IR) remains untapped. However, the Visual Heart Lab has explored VR uses in medical device development and patient and trainee education. Based in the University of Minnesota, the lab was founded in 1977 by Dr. Izzo et al and Medtronic for research on translational physiology with expansion to include 3D modeling to help inform patients and their families of anatomic defects and associated therapeutic medical device placements. Eventually, their 3D anatomic data set was also used to inform medical device development in catheter technologies.

CLINICAL FINDINGS/PROCEDURE DETAILS: Given the importance of patient and family education in pre-surgical consultation, VR-based 3D models can educate patients on their specific anatomic abnormalities. Patients can interact with the model through a virtual interface developed using Unity (California, USA) and C++ coding, where tools can be imported to demonstrate an intervention, such as a transcatheter replacement of a defective valve. Similar approaches to patient education for complex IR procedures may significantly enhance patient and family understanding and satisfaction. The Visual Heart lab has also been used to virtually introduce new medical technologies in pathologic anatomy to educate physicians on the benefits, limitations, and nuances of novel medical devices in an interactive display. Last, the Visual Heart Lab's platform has been leveraged to educate patients and physicians to accelerate medical device development. With a large volume of organ-specific pathology from the hospital, the lab has been

able to simulate device placement within many pathologic, anatomic variants to unveil device design constraints for further iteration.

CONCLUSION AND/OR TEACHING POINTS: The Visual Heart Lab has developed a successful VR-based program for patient, family, and physician education. Its further use of the VR-based platform has accelerated medical device development. This pipeline to improved patient care and acceleration of medical device development is one that can be emulated in IR.

Abstract No. 758

A Primer on the Lost Art of Hand Angiography: Anatomy, Technique and Clinically Relevant Images

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LEARNING OBJECTIVES: After reviewing this poster, the reader will be able to (1) describe the arterial anatomy from the aortic arch to the fingertips, (2) recognize common variants of the upper extremity arterial anatomy, (3) describe how to carry out an angiogram of the upper extremity, and (4) recognize common pathology of the upper extremity and hand.

BACKGROUND: Upper extremity angiography was historically used as the primary method of diagnosing arterial pathology of the upper extremity and hand. Angiography continues to be the gold standard due to superior spatial and temporal resolution as well as ability to therapeutically intervene. However, PubMed publication data regarding angiography demonstrates conventional angiography has been largely replaced by magnetic resonance imaging (MRI) and computed tomography angiography (CTA).

Due to local practice variation and dominance of MRI/CTA, an experienced, competent interventional radiologist may be faced with the daunting task of assisting a hand surgeon in making a diagnosis or informing a treatment choice with little relevant experience in upper extremity angiography. This poster is meant for both the above noted attending, and with sequential review as a learning tool for the neophyte.

CLINICAL FINDINGS/PROCEDURE DETAILS: (1) Arterial anatomy to be presented in pictorial form. (2) Variant anatomy to be presented in pictorial form. (3) Technique described sequentially from access to closure. (Length too long for character limit). Includes tips, troubleshooting techniques, and alternative methods for the vasodilated angiogram. (3) Common pathology: annotated high-resolution images demonstrating findings of hypothenar hammer, thenar hammer, acute thrombus, scleroderma, and lupus.

CONCLUSION AND/OR TEACHING POINTS: After conscientious review of this poster, it is the hope of the authors that the prospect of a hand angiogram, and rendering a clinically meaningful report will be less daunting. The goal is to produce a work that would be posted in reading rooms, as a reference, learning aid, and repository of techniques for this interesting, though infrequently carried out procedure. The take-aways from this poster will be the relevant anatomy, the most common anatomical variants, a stepwise procedure guide, and high resolution images of common pathology.

Abstract No. 759**Immunotherapies for Hepatocellular Carcinoma: Quick Reference for the Interventional Radiologist**

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LEARNING OBJECTIVES: (1) Summarize updated guidelines regarding the role of immunotherapy in hepatocellular carcinoma (HCC) treatment. (2) Review the clinical use of immunotherapy agents in HCC treatment, including evidence from landmark clinical trials, treatment regimens, and known adverse effects. (3) Discuss existing literature and ongoing studies for immunotherapy regimens combined with interventional locoregional therapies for HCC.

BACKGROUND: The Barcelona Clinic Liver Cancer (BCLC) staging criteria is one of the most widely used guidelines for evaluating disease severity and management of HCC. In 2018, the BCLC guidelines recommended sorafenib as the first-line systemic immunotherapy for advanced stage HCC, and this represented the standard of care for years. Now, the updated 2022 BCLC guidelines recommend Atezolizumab-Bevacizumab and Tremelimumab-Durvalumab as first-line therapies, due to improved overall survival as published by trials such as IMbrave150 and HIMALAYA. However, these new therapies may bring different risks and side effect profiles. For example, bevacizumab carries a known increased risk for bleeding and vascular injury, which may increase the risk of complications in patients who have received bevacizumab and seek subsequent transarterial therapies for HCC management. Thus, it is crucial for interventional radiologists to stay informed about this continuously evolving landscape, as interventionalists involved in HCC management will inevitably encounter increasing numbers of patients undergoing these treatments. Aside from current treatment strategies, there is also expanding interest in the combination of systemic immunotherapy with locoregional therapies (e.g., ablation, transarterial embolization), as these are hypothesized to create changes in the local tumor microenvironment that potentiate the activity of immunotherapies.

CLINICAL FINDINGS/PROCEDURE DETAILS: This exhibit summarizes the currently available evidence on immunotherapy agents used for HCC treatment, as well as current evidence and efforts in developing treatment strategies combining immunotherapy with interventional locoregional therapies.

CONCLUSION AND/OR TEACHING POINTS: It is vital that interventional radiologists stay abreast of the evidence and potential adverse effects of immunotherapies in the treatment of HCC. Increasing numbers of patients receiving these therapies will be under the care of interventionalists, and new combined treatment strategies incorporating both locoregional therapies and immunotherapies are on the horizon.

Abstract No. 760**Desmoid Cryoablation: A Step-by-Step Poster for Complex Extraabdominal Desmoid Tumors**

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LEARNING OBJECTIVES: Selection of patients for desmoid tumor ablation and planning for minimal collateral tissue damage.

BACKGROUND: Desmoid tumors (DT) are often intractable to chemotherapy with only a 33% to 37% success rate on chemo monotherapy. Furthermore, side effects of medical therapy alone may limit treatment course and success. Reports of ongoing severe pain are common for these patients. In the early 2000s, ablations were piloted by IR for better therapeutic outcomes. In the last 10 years, cryoablation for DT has been found the most beneficial method of percutaneous treatment with a 97% partial or complete symptom relief. Many of these tumors are adjacent to sensitive tissues, such as bowel, skin, nerves, and vasculature. In this discussion, we explore a single-center approach for protecting these sensitive tissues.

CLINICAL FINDINGS/PROCEDURE DETAILS: Ablation procedures are performed primarily with computed tomography guidance, with ultrasound available to assist with probe placement. Cryoablation probes are positioned under imaging guidance, and measurements are performed to ensure adequate lesion coverage. After probes are positioned, multiple different techniques are used to protect nearby structures including hydrodissection, pneumodissection, and placing heated saline in sterile gloves on the skin surface. For abdominal wall desmoid tumors, the peritoneal cavity is insufflated with CO₂ prior to freezing to protect the adjacent bowel and omentum. Cryoablation was performed with multiple freeze/thaw cycles and tract ablation where available. From January 2014 through September 2022, a total of 26 patients have successfully undergone desmoid ablation. The most common indication was pain. Complications encountered in 4 patients (skin discoloration which resolved, lower extremity motor weakness in 2 patients with desmoids involving lower extremity motor nerves, and infection requiring antibiotics). There were no instances of bowel injury or bleed requiring transfusion or intervention.

CONCLUSION AND/OR TEACHING POINTS: For DT candidates, evaluation of surrounding tissues for relative contraindications is extremely important. However, tumors abutting sensitive tissues can undergo ablation if proper safety techniques are used, including hydrodissection, pneumodissection, and peritoneal cavity insufflation. These methods can protect sensitive tissues from incurring damage during the freeze-thaw cycles. Further protection of the skin from the penetrating probes can be offered by a variety of sterile innovations. Cryoablation of DT is a safe and effective minimally invasive treatment option for desmoid tumors.

Abstract No. 761

Primary and Metastatic Pulmonary Tumors: A Primer on Lung Cryoablation

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LEARNING OBJECTIVES: To review indications, technical approaches, and outcomes of cryoablation of primary and metastatic pulmonary malignancies and to discuss current literature.

BACKGROUND: Cryoablation is a technique that uses cold-induced injury to cause cellular damage and necrosis. Cryoablation has been well tolerated with great outcomes with other solid organ lesions in the past. This procedure continues to demonstrate similar outcomes when compared with surgical or radiation therapy.

CLINICAL FINDINGS/PROCEDURE DETAILS: The exhibit will include (1) the mechanisms and indication of cryoablation in metastatic and primary lung lesions; (2) pictorial overview of the technical steps for successful computed tomography angiography-guided lung ablation; (3) potential complications and their appropriate management; (4) a review of technically challenging cases with notable teaching pearls; (5) a discussion of expected imaging findings on follow-up; and (6) a review of current literature demonstrating the efficacy of lung ablation.

CONCLUSION AND/OR TEACHING POINTS: Cryoablation of lung lesions is gaining momentum as a viable treatment option in poor surgical candidates with demonstrable decreased morbidity. Patient selection is key, and ablation has delivered similar outcomes to surgical management in a subset of primary and metastatic pulmonary lesions.

Abstract No. 762

Extrahepatic Radioembolization: New Frontiers Beyond the Liver

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LEARNING OBJECTIVES: To review current concepts regarding the application of extrahepatic yttrium-90 radioembolization.

BACKGROUND: Yttrium-90 transarterial radioembolization (TARE) has been established as a locoregional therapy for intermediate and advanced hepatocellular carcinoma. TARE is typically reserved for primary and secondary liver neoplasms, but recent studies have reported use of radioembolization applied to extrahepatic sites (e.g., colorectal, prostate, brain). Although many investigations have been limited to primarily animal models, growing interests in expanding the role of TARE marks potential for new indications using this treatment strategy.

CLINICAL FINDINGS/PROCEDURE DETAILS: This educational exhibit will: (1) present an overview of current indications and procedure approaches for TARE, (2) review studies using extrahepatic radioembolization beyond conventional use, (3) present a case-based review of extrahepatic applications of TARE including treatments of the prostate, colon, spleen, and brain, (4) highlight treatment outcomes, along

with limitations and pertinent contraindications, and (5) discuss future directions and current gaps in the literature.

CONCLUSION AND/OR TEACHING POINTS: After reviewing this exhibit, the viewer will develop a deeper understanding of the technical components and advantages of using TARE with a focus on its potential utility among extrahepatic disease-states.

Abstract No. 763

Review of Current Literature on Intra-Arterial Chemotherapy in Nonoperative Cancers and Downstaging to Resection

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LEARNING OBJECTIVES: (1) Review challenges in the treatment of alimentary tract neoplasms. (2) Highlight the most recent literature on intra-arterial chemotherapy for nonoperative cancers and downstaging to resection.

BACKGROUND: The role of intraarterial chemotherapy (IAC) is well established in certain types of malignancy, such as retinoblastoma. However, its role in other types of tumors is less clear and often overlooked. The concept of IAC is based on local infusion of chemotherapy medications directly into the tumor blood supply to help increase concentration of the medication and decrease systemic side effects. Intravenous chemotherapy is thought to be less effective than IAC because a considerable amount of drug binds to plasma proteins in the blood along its course and decreases the amount of biologically active free drug. In IAC, the drug-protein binding rate is much lower than with intravenous administration. The drug titer can be increased by 2 to 20 times and the curative effect increased by 4 to 10 times.

CLINICAL FINDINGS/PROCEDURE DETAILS: Google Scholar and Cochrane Library were used to identify all papers pertaining to intraarterial chemotherapy and the alimentary tract. Studies were limited to those published from 2012 to 2022. A total of 9 studies were identified, which included 720 patients. Of these, 8 were single-center retrospective reviews and one was a case report. Objective response (OR) was defined as complete response (CR) + partial response (PR) on follow-up. The overall OR rate across the available studies was 76.6%. However, 3 studies did not include imaging follow-up as part of their study design. Unique benefits that were also evaluated included decreased dosage of analgesic medications (66.7%), improved weight gain (52.2%), improved dysphagia (67.7%), and closure of perianal fistulas (83.3%). Two studies looked at post-operative pathology following neoadjuvant IAC for gastric cancer. One showed a statistically significant decrease in pro-proliferation gene expression, tumor suppressor gene expression, and invasion-related gene expression following IAC. Another saw a neo-adjuvant postoperative pathological response rate of 46.1% and complete pathological remission in 2.2%.

CONCLUSION AND/OR TEACHING POINTS: IAC for advanced stage alimentary tract cancers is an underused and potentially beneficial

component of the interventional radiologists armamentarium. Further studies are needed to determine the optimum treatment regimen and patient population.

Abstract No. 764

Demystifying ⁹⁰Y Dosimetry for Early Career Interventional Radiologists

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LEARNING OBJECTIVES: (1) What is dosimetry? (2) Common terminology. (3) Determining goal of ⁹⁰Y therapy. (4) Pre-treatment planning. (5) Dose models and their benefits/pitfalls. (6) Dosimetry optimization by treatment strategy. (7) Step-by-step example of dosimetry planning. (8) Limitations and future directions.

BACKGROUND: Microsphere radiation therapy (MRT) with yttrium-90 (⁹⁰Y) is a treatment for hepatocellular carcinoma (HCC) and liver metastasis. It involves administration of radiation to the liver tumor using ⁹⁰Y, which is a radioactive isotope embedded onto glass or resin microspheres. Often considered to be a palliative therapy, MRT has been shown to have improved outcomes or curative potential when dosimetry is optimized. With a proven dose-effect relationship, the goal of treatment is to deliver a tumoricidal radiation dose to the liver lesion(s) while keeping dose to normal liver at a minimum. There are several dosimetry models, which can create confusion among inexperienced users, primarily trainees. Therefore, the aim of this abstract is to educate users on the essentials of ⁹⁰Y dosimetry to optimize outcomes of MRT.

CLINICAL FINDINGS/PROCEDURE DETAILS: MRT can be performed with curative intent or local disease control when lesions are confined to ≤ 2 segments. Palliative intent is reserved for multifocal or bi-lobar disease and/or portal vein invasion. Dosimetry is performed based on clinical indication for treatment, estimated lung shunt fraction (using Tc-99m MAA planar or SPECT imaging) and several other factors that separate the existing dosimetry models. Currently three dosimetry models are routinely used: body surface area model (BSA), medical internal radiation dose model (MIRD), and the partition model. This exhibit will provide case-based examples illustrating step-by-step dosimetry calculation using each model (including comparison of contrast-enhanced intra-procedural and diagnostic preoperative computed tomography [CT] imaging), including advantages and disadvantages of each model. Intra-procedural CT enables accurate measurement of perfused liver and tumor volume, thereby allowing maximal dosimetry optimization. It also helps in accurate assessment of tumor perfusion and any variant anatomy.

CONCLUSION AND/OR TEACHING POINTS: Sound understanding and application of dosimetry and a clear treatment intent are essential for good treatment response with MRT. Intra-procedural CT imaging improves accuracy in volume calculations, assessment of tumor perfusion, and evaluation of variant anatomy when compared with diagnostic preoperative CT imaging.

Abstract No. 765

Techniques in Cryoablation of T1b and T2a Renal Cell Carcinoma

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LEARNING OBJECTIVES: To discuss approaches to percutaneous cryoablation (CA) in the treatment of patients with T1b and T2a renal cell carcinoma (RCC).

BACKGROUND: The incidence of RCC has been increasing in the US since the 1990s. Accordingly, there has been a greater demand for treatment, and various treatment modalities have been developed. Percutaneous ablation is a curative option with similar outcomes to surgery. It is a preferred treatment modality in select patients, particularly those who are poor candidates for partial or radical nephrectomy. Current guidelines recognize CA as a curative treatment of RCC tumors staged T1a (<4 cm). However, several reports have demonstrated that CA may be a safe and effective option for larger tumors, staged T1b (4.1-7 cm) and T2a (7.1-10 cm). These larger tumors pose a higher risk of complication and potentially less favorable oncologic outcomes, thus warranting a review of CA treatment strategies and techniques.

CLINICAL FINDINGS/PROCEDURE DETAILS: In this educational exhibit, we will provide a review of clinical guidelines and literature comparing patient outcomes following CA and surgical treatment of RCC. We will also provide a pictorial review of CA strategies for ablating larger tumors, including approaches to probe placement, displacement techniques, and staged CA. Additionally, we will review evidence and considerations for transarterial embolization prior to CA. We will conclude with the strategies to manage and avoid the most common post-procedural complications.

CONCLUSION AND/OR TEACHING POINTS: CA of T1b and T2a RCC can be a safe and effective treatment option. Operator considerations, such as planned probe placement, displacement techniques, pre-ablation transarterial embolization, and staged CA can optimize results. After viewing this exhibit, the viewer will better understand the literature on CA of RCC beyond T1a stage, approaches to CA of larger tumors, as well as management of post-procedural complications.

Abstract No. 766

Ethanol Ablation of Cervical Node Metastases from Differentiated Thyroid Carcinoma

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LEARNING OBJECTIVES: 1) Review clinical indications of percutaneous ethanol ablation (EA) of cervical lymph nodes metastases from thyroid carcinoma. 2) Describe the technical approach of EA. 3) Discuss current literature evidence of EA clinical outcomes.

BACKGROUND: Differentiated thyroid cancer often metastasizes to cervical lymph nodes. Resection is the treatment of choice, but recurrent surgeries can be challenging due to adhesions, fibrosis, or scar tissue. Ultrasound-guided ethanol injection has been used to ablate cervical node metastases for patients with < 4 metastatic lymph nodes, unresponsive to radioiodine therapy, or considered unsuitable candidates for surgery or general anesthesia. EA has been shown to be efficacious and safe, with minimal procedural morbidity. A long-term efficacy study recently demonstrated that approximately 80% ($n = 35/44$) of patients that underwent EA achieved permanent local control at a median follow-up of 11.3 years.

CLINICAL FINDINGS/PROCEDURE DETAILS: According to the largest published patient group treated with EA, 13 recurrent lesions (in 10 of 44 patients) were detected at the site of previous ablation, resulting in 19% recurrence rate. The most common location was the lateral neck (10 lesions), followed by central neck (3 lesions). A total of 6 of 10 lesions had a diameter of >10 mm (median, 13.5 mm; range, 10-18).

Preliminary sonography is used to plan the approach. After preparation of the skin, local anesthetic is administered only along the expected needle path. A 25-gauge needle is mounted on a 1-mL syringe loaded with absolute ethanol. Using real-time sonographic visualization, the needle is advanced into the target lesion and the ethanol is slowly injected. Diffusion of ethanol produces hyperechogenicity. Ethanol leak identification is based on the sonographic observation of extravasation from the target lesion or the patient reporting a sudden change in pain sensation. Ethanol leak must be identified to minimize the risk of nerve injury. The volume of ethanol injected generally is proportional to node size. No recovery time is required after the intervention and patients can be discharged immediately.

CONCLUSION AND/OR TEACHING POINTS: In patients with cervical node metastases from differentiated thyroid cancer who are unresponsive to radioiodine and poor surgical candidates, sonographically guided EA is safe, low cost and effective and can be implemented with widely available equipment.

Abstract No. 767

Radiation Lobectomy Versus Portal Vein Embolization Versus Liver Venous Deprivation: Which Is Best for Maximizing Future Liver Remnant?

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LEARNING OBJECTIVES: Compare and contrast the current interventional radiology (IR) options for future liver remnant (FLR) hypertrophy.

BACKGROUND: Surgical resection is the gold standard treatment for patients with liver malignancies who are not transplant candidates. Surgery may require the assistance of IR for FLR hypertrophy before a large-volume resection. Current IR options include radiation lobectomy (RL), portal vein embolization (PVE), and liver venous deprivation (LVD).

CLINICAL FINDINGS/PROCEDURE DETAILS: PVE is currently the standard of care for maximizing FLR. PVE involves the injection of embolic material into the portal vein with the goal of redirecting flow to the FLR,

resulting in hypertrophy. One disadvantage of PVE is that FLR hypertrophy can occur four or more weeks after PVE, which can lead to tumor progression and cancellation of surgery. PVE can lead to increased tumor growth secondary to increased arterial flow to the tumor, termed hepatic artery buffer response. LVD can potentially reduce the time to surgical resection. LVD involves concomitant embolization of the portal vein and the hepatic vein. There is evidence that LVD can lead to accelerated FLR hypertrophy and function compared with PVE. This is theoretically due to decreased portal collateralization, antegrade portal venous flow, and hepatic arterial flow. RL involves the injection of radiation-coated microparticles into the hepatic artery. RL offers hypertrophy of the FLR, with an animal study showing similar FLR hypertrophy to PVE at 3-6 months. Unlike PVE and LVD, RL provides the benefit of tumor necrosis, which allows for better tumor control or downstaging. RL allows for a “test of time” approach, which creates better patient selection prior to surgery. For example, a patient undergoing PVE or LVD may lose their surgical candidacy despite adequate FLR hypertrophy. This may be secondary to tumor progression or the development of major systemic illness. Non-surgical candidates who underwent RL would have local tumor control. In contrast, a similar patient who underwent PVE or LVD would have limited future treatment options.

CONCLUSION AND/OR TEACHING POINTS: PVE is currently the standard of care when attempting to maximize FLR hypertrophy. Drawbacks to PVE include tumor progression leading to surgery cancellation. The evidence suggests that LVD stimulates accelerated FLR hypertrophy compared with PVE, which may lead to faster surgical resection. RL provides FLR hypertrophy, albeit at a slower rate than PVE and LVD. Benefits of RL over PVE and LVD include tumor necrosis allowing for tumor control or downstaging, and the test of time benefit.

Abstract No. 768

Role of Histotripsy in Interventional Oncology: Current Applications and Future Directions

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LEARNING OBJECTIVES: To review the current applications, recent evidence, and future directions for histotripsy in interventional oncology.

BACKGROUND: Histotripsy is an emerging non-invasive, non-thermal ablation technique which uses ultrasound waves to generate mechanical forces that cause cell lysis. This technique is currently under investigation for use in a variety of clinical settings including the treatment of cardiovascular, neurologic, genitourinary, and oncologic disease. Recent data supports histotripsy as an excellent modality for liver tumors in particular, demonstrating excellent technical success and the presence of an abscopal effect. As a result, it is essential that interventional radiologists become familiar with the unique mechanism, applications, current data, and future directions for histotripsy.

CLINICAL FINDINGS/PROCEDURE DETAILS: This educational exhibit will: (1) describe the mechanism of histotripsy, (2) review the current applications under investigation, (3) describe the abscopal effect in the treatment of tumors, (4) present the clinical management of liver tumors using histotripsy, (5) review the procedural indications,

contraindications, and potential risks, and (6) review the current literature, treatment outcomes, and future therapies.

CONCLUSION AND/OR TEACHING POINTS: After reviewing this exhibit, the viewer will understand the mechanism of histotripsy, the variety of clinical applications currently under investigation for this technique, treatment outcomes, and current literature and future directions for histotripsy.

Abstract No. 769

Second Line Therapy for Neuroendocrine Tumor Liver Metastases: Where Do Transarterial Therapies Belong?

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LEARNING OBJECTIVES: (1) Explore the role of locoregional therapy (LRT) for neuroendocrine tumor liver metastases (NELMs) in the setting of emerging systemic therapies. (2) Discuss selection criteria and treatment intent for LRT to maximize outcomes and minimize adverse events. (3) Summarize reported outcomes of radioembolization for NELM. (4) Should peptide receptor radionuclide therapy (PRRT) even be considered when a liver-predominant pattern of disease is present?

BACKGROUND: Neuroendocrine tumors (NETs) are rare neoplasms typically of gastroenteropancreatic or pulmonary origin. Aside from the primary site, tumors are classified by functional status, presence or absence of metastasis, degree of differentiation, and proliferative activity. Patients commonly present with stage IV disease, with the liver as the most frequent site of metastasis.

Surgery for NELM is often reserved for low-grade, well-differentiated tumors with favorable size and distribution characteristics. Somatostatin analogues (SSA) are typically employed as first-line therapy for non-surgical candidates. For second-line therapy, guidelines support systemic therapy with mTOR/protein-tyrosine kinase inhibition, cytotoxic chemotherapy with capecitabine-temozolomide, PRRT, or LRT such as percutaneous ablation or transarterial therapy. Further LRT indications include bulk-related symptoms, symptomatic on first-line SSA, or progression on a second-line systemic agent.

CLINICAL FINDINGS/PROCEDURE DETAILS: This exhibit explores the role of LRT for NELM, with a focus on radioembolization and bland embolization, and discusses optimal patient selection. We summarize key LRT outcomes, including imaging response and patient survival. Optimal treatment parameters and expected imaging response characteristics are discussed and illustrated with case examples. Lastly, we discuss whether LRT or PRRT should be used as second-line therapy for NELM, particularly when there is a liver-predominant metastatic pattern.

CONCLUSION AND/OR TEACHING POINTS: Unresectable NELMs can benefit from multiple therapies; the decision requires local expertise and multidisciplinary discussion. Bland embolization and radioembolization are useful therapies for NELMs with unique capabilities for both symptom and tumor control.

Abstract No. 770

The Role of Image-Guided Percutaneous and Transarterial Therapies in the Management of Lung Cancer

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LEARNING OBJECTIVES: (1) To discuss and compare the various image-guided percutaneous thermal ablation therapies used in lung cancer management. (2) To review the pulmonary vasculature anatomy and the bronchial circulatory system in the context of transarterial therapies. (3) To discuss the several transarterial therapies, targeting the bronchial or pulmonary artery, used in lung cancer management.

BACKGROUND: Lung cancer remains the leading cause of cancer mortality worldwide, with approximately 1.8 million deaths annually, despite advances in prevention and therapies. While surgery is the ideal treatment option for resectable lung cancer, not all patients are suitable for resection and a significant proportion develop recurrence. With the advent of lung cancer screening, more early-stage, locoregional tumors are being discovered, leading to the increased utility of various minimally invasive treatment options. Various national guidelines and societies have recommended and affirmed the use of thermal ablative modalities as a viable treatment option for lung cancer. Several transarterial therapies that have adapted from liver cancer management are also starting to be effectively used as well.

CLINICAL FINDINGS/PROCEDURE DETAILS: Image-guided locoregional therapies play a crucial role in the management of patients with lung tumors. Percutaneous therapies include radiofrequency ablation, microwave ablation, and cryoablation, and are proven to be effective for early-stage or oligometastatic lung cancer. We describe the various percutaneous therapies and compare their efficacy and safety using best available evidence. In addition to percutaneous therapies, transarterial therapies include a set of catheter-based treatments to deliver embolic and/or chemotherapeutic agents directly to the arteries supplying tumors. Given the dual supply to the lung, arteries can be targeted while sparing adjacent lung parenchyma. We describe several transarterial methods used to target the pulmonary or bronchial artery with chemotherapy, embolization, or chemoembolization (with or without drug-eluting beads). Our exhibit also includes several unique cases illustrating these modalities.

CONCLUSION AND/OR TEACHING POINTS: After viewing this exhibit, attendees will appreciate the various image-guided percutaneous and transarterial therapies that have proven to be highly promising for primary and metastatic lung cancer. Future clinical trials and multicenter large cohort studies will further optimize and validate these modalities' role in lung cancer management.

Abstract No. 771**Tip of the Iceberg: Emerging Applications and Technical Considerations for Cryoablation Therapy**

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LEARNING OBJECTIVES: (1) Review mechanism of cryoablation therapy and common indications. (2) Discuss newer applications of cryoablation and clinical significance. (3) Review current available cryoablation systems, methods and indications for use, and periprocedural care.

BACKGROUND: Cryoablation therapy has proven to be a useful alternative in the treatment of certain solid organ malignancies such as those involving the liver, lung, or kidney. Among its many advantages, cryoablation has shown to be less painful for patients and can also act as a form of local anesthesia, compared with the effects of thermal ablation. Within the last decade, interest in expanding cryoablation techniques and indications have continued to grow.

CLINICAL FINDINGS/PROCEDURE DETAILS: We aim to provide a case-based review of newer applications of cryoablation. Cryoneurolysis for primary pain palliation as well as perioperative pain management have been performed with technical and clinical success, including cryoneurolysis of the celiac axis and pudendal nerve. In cases of cholecystitis, cryoablation of the gallbladder has demonstrated feasibility as an alternative to not only cholecystectomy, but to percutaneous cholecystostomy altogether. Cryoablation is also efficacious as a definitive treatment of vascular malformations and tumors, which are often treated endovascularly. This has been expanded to include more superficial tumors such as breast and desmoid tumors. Special care is needed in selection of cryoablation devices and close attention must be paid to anatomic approach and surrounding anatomy. Cases that were not feasible historically such as large renal tumors are now also possible due to several novel techniques that we will discuss in detail.

CONCLUSION AND/OR TEACHING POINTS: Cryoablation has great potential for application in a wide range of clinical scenarios and should not be limited to oncologic indications. It provides a safe, minimally invasive alternative to surgery in otherwise high-risk candidates and can also be performed for pain management. Further study of potential uses of cryoablation are needed to maximize its utility and promote interventional radiology services to patients and providers.

Abstract No. 772**Cryoablation of Subcutaneous Desmoid Neoplasms**

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LEARNING OBJECTIVES: To review cryoablation techniques for treatment of extra-abdominal desmoid tumors.

BACKGROUND: Desmoid tumors are uncommon neoplasms originating from mesenchymal stem cell progenitors with a low potential for distal metastasis. They typically present as a palpable firm mass in the soft tissues when extraperitoneal. They are locally aggressive and often well embedded in muscle and fascia. Symptoms and complications typically arise from local compression and invasion of adjacent structures. They are insensitive to chemotherapy and have a high incidence of recurrence after surgical resection. In addition, local invasion of vital structures often makes wide surgical resection infeasible. More recently, less invasive therapies such as percutaneous cryoablation have been employed with promising results.

CLINICAL FINDINGS/PROCEDURE DETAILS: We present a small series of patients with symptomatic extra-peritoneal soft tissue desmoid tumors who were treated with cryoablation at our center. Under computed tomography (CT) guidance and general anesthesia, subdermal nerve block followed by hydro or pneumo-dissection was used to separate the tumor from the overlying dermis. Next, multiple cryoprobes were inserted percutaneously into the tumor under CT guidance. Cryoablation was performed with two 10-minute freeze cycles separated by 5-minute active thaw cycles in each ablation zone. Intermittent monitoring of the hypoattenuating cryoablation zone was performed under CT. Warm compresses were employed intra-procedurally to protect the overlying dermis. Patients were discharged the day of the ablation. Follow-up MR imaging was employed at one month for response assessment, followed by 6 month surveillance imaging. All patients demonstrated significant regression in tumor bulk and permanent relief of reported symptoms by 6-month follow-up. No major adverse events occurred. Minor complications included temporary treatment area skin sloughing, blistering, skin discoloration and numbness or paresthesia. All minor complications had resolved by 6-month follow-up.

CONCLUSION AND/OR TEACHING POINTS: Desmoid tumors are an uncommon clinical entity with limited therapeutic options and high rates of local recurrence after surgical resection. Cryoablation is a promising treatment for symptomatic extraperitoneal desmoid tumors that can offer substantial volume reduction and symptomatic relief.

Abstract No. 773**Radiation Lobectomy to Facilitate Liver Resection: Volumetric and Dosimetric Considerations**

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LEARNING OBJECTIVES: (1) Update on the role of radiation lobectomy (RL) as a tool to induce future liver remnant (FLR) hypertrophy to facilitate surgical resection. (2) Provide specific details regarding best patient selection, radioembolization techniques, imaging considerations, and volumetric calculations. (3) Use case examples to illustrate the concepts of radiation lobectomy.

BACKGROUND: Surgical resection is considered a first line curative treatment for early-stage hepatocellular carcinoma (HCC). However, some patients do not qualify for surgical resection due to insufficient FLR, increasing the risk of hepatic decompensation following surgery. RL has become a tool to facilitate future surgical resection through the creation of an atrophy-hypertrophy complex. The techniques of RL to ensure appropriate tumor control while optimizing FLR hypertrophy (kinetic growth and overall hypertrophy) are evolving. FLR imaging strategies and volumetric considerations are also expanding. The intent of this educational exhibit is to provide a comprehensive review of current best practice of RL, illustrated by case examples.

CLINICAL FINDINGS/PROCEDURE DETAILS: Evidence-based patient selection criteria will be presented to identify patients that are optimal candidates for RL. This will include a discussion on necessary FLR for surgical resection, with a critical review of available volumetric algorithms. Technical aspects of RL, planning and treatment, will be reviewed, with technical tips to provide tumor control and initiate the atrophy-hypertrophy complex. The optimal embolic load and radiation absorbed dose to the targeted tumor and hepatic parenchyma will be discussed, in the context of pre-treatment macro-aggregated albumin scan and post-treatment imaging. Finally, evolving imaging techniques to assess size and function of the FLR will be reported.

CONCLUSION AND/OR TEACHING POINTS: The application of RL to facilitate surgical resection in those patients initially presenting with inadequate FLR is evolving. Best outcomes will come from optimization of this therapy and patient selection, to dosimetry and post-treatment imaging and evaluation.

Abstract No. 774

Post ⁹⁰Y Induced Radiation Pneumonitis

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LEARNING OBJECTIVES: (1) Review dose considerations to minimize risk. (2) Outline prevention strategies in patients with borderline lung shunt fraction. (3) Demonstrate clinical and imaging findings. (4) Review course of disease and treatment. (5) compare and contrast computed tomography (CT) findings (specifically, CT images of 2 patients presenting with pneumonitis post-⁹⁰Y; one consistent with radiation pneumonitis and one likely reflecting antineoplastic drug induced pneumonitis).

BACKGROUND: Radiation induced pneumonitis is a very rare but potentially fatal complication of ⁹⁰Y radioembolization. Pre-procedure MAA shunt study is used to calculate estimated dose to the lungs, with dose limit to the lungs of 30 Gy in a single session and 50 Gy over a lifetime to minimize risk. When estimated dose approaches these thresholds, dose reduction strategies include pretreating with bland or chemoembolization, treatment with systemic chemotherapy with interval re-evaluation of shunt, or low dose treatment with interval retreatment.

CLINICAL FINDINGS/PROCEDURE DETAILS: Case reports demonstrate rare instances where patients developed radiation pneumonitis

despite adhering to these thresholds, suggesting that other factors affecting pulmonary reserve, such as underlying COPD or prior lung resection, may require stricter dose thresholds. Symptoms typically arise 1 to 6 months following ⁹⁰Y treatment, with dry cough, low-grade fever, and dyspnea on exertion. CT of the chest shows a “bat-wing” appearance of patchy consolidation with peripheral sparing, that can progress to fibrosis. In patients on concurrent systemic antineoplastic therapy, careful attention to CT findings can help differentiate the cause of injury to ensure proper treatment. Management relies on supplemental oxygen, and steroids and bronchodilators.

CONCLUSION AND/OR TEACHING POINTS: ⁹⁰Y operators must be knowledgeable about the risks and findings of pneumonitis during treatment course. While hepatopulmonary shunts can complicate treatment planning for hypervascular liver tumors, mitigation strategies can reduce the risk of radiation pneumonitis.

Abstract No. 775

The Role of Artificial Intelligence in the Diagnosis and Management of Hepatocellular Carcinoma in Interventional Radiology

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LEARNING OBJECTIVES: (1) To review the various interventional radiology (IR)-based treatment modalities for hepatocellular carcinoma (HCC). (2) To describe the role of AI in the diagnosis of HCC. (3) To discuss the role of AI in the treatment of HCC as well as its follow-up.

BACKGROUND: HCC is the most common type of liver cancer, representing approximately 73% of cases. Image-guided locoregional therapies such as ablation, embolization, and radioembolization have been increasingly used for the management of HCC and are now being considered primary treatments. Artificial intelligence is a branch of computer science that is based on the notion of computers mimicking the human behavior that uses intelligence, such as thinking and making decisions. Through the development of AI came various subfields like machine learning and deep learning that have revolutionized various disciplines like medicine and now IR, more specifically. Because the management of patients with HCC is multifaceted with new minimally invasive modalities, AI is starting to play a crucial role in the way we detect, treat, and follow-up patients with HCC.

CLINICAL FINDINGS/PROCEDURE DETAILS: Several AI-based algorithms, including convolutional neural networks, have started to aid in not only the diagnosis of HCC, using several imaging modalities (abdominal ultrasound, computed tomography [CT] with contrast, magnetic resonance imaging, ¹⁸F-FDG positron emission tomography/CT, histopathological classifications) but also the selection of patients for the IR-based treatment options, including transarterial chemoembolization (TACE), transarterial radioembolization (TARE) and tumor ablation. Several studies have also shown promising findings of AI in predicting the response to treatment with TACE/ablation as well as in local tumor progression and recurrence. This exhibit reviews and discusses some of the major findings to date.

CONCLUSION AND/OR TEACHING POINTS: AI is starting to play a pivotal role in the way we manage patients with HCC, particularly in the context of interventional radiology. After viewing this exhibit, attendees will learn the various image-guided percutaneous and transarterial therapies that have proven to be highly promising for HCC as well as the role of AI in selecting suitable candidates for IR-based modalities, predicting response to treatment, and in follow-up care.

Abstract No. 776

Bowel Protection Achieved by Percutaneous Fine Needle Deflation during Percutaneous Renal Tumor Cryoablation: A Case Report

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PURPOSE: To report a case of colon protection during computed tomography (CT)-guided percutaneous renal tumor cryoablation achieved by percutaneous fine-needle deflation.

MATERIALS AND METHODS: A 56-year-old male patient presented with microhematuria and a 2.8 cm right kidney upper pole mass abutting the right hepatic lobe and ascending colon for CT-guided biopsy and cryoablation. Under general anesthesia, three cryoablation probes were successfully placed into the mass percutaneously followed by a core needle biopsy. Four 21-gauge Chiba needles were advanced into the spaces between the right hepatic lobe / ascending colon and the renal mass to perform hydrodissection and pneumodissection. Successful displacement of the right hepatic lobe away from the renal mass was obtained with initial dissection. However, the displacement of the ascending colon was inadequate due to the severely dilated colon. A 22-gauge spinal needle was then advanced into the adjacent ascending colon percutaneously to deflate the colon by aspirating approximately 40 mL of bowel gas. Cryoablation was then performed with intermittent hydro- and pneumodissection. A total of 800 mL of diluted contrast and 800 mL of CO₂ were used for dissection.

RESULTS: Adequate displacement of the ascending colon from the renal mass was obtained after the fine-needle deflation and the following hydro- as well as pneumodissection. Post-procedure immediate CT scan demonstrated the ice ball covering the whole renal mass with a small hematoma, and no evidence of colon perforation. The patient was discharged home within 24 hours. The post-ablation course was uneventful except for low-grade fever and moderate right flank pain for 5 days. Follow-up CT with IV contrast 2 days post-procedure revealed no enhancement of the renal mass without evidence of active bleeding or abscess, nor other acute complications.

CONCLUSION: Percutaneous fine-needle deflation of the dilated bowel may be a safe and effective technique for bowel protection during renal tumor thermal ablation when failed initial hydro- or pneumodissection.

Abstract No. 777

Modulating the Tumor Immune Microenvironment with Locoregional Image-Guided Interventions

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LEARNING OBJECTIVES: This presentation will explain the biological rationale for locoregional image-guided immunotherapy administration, summarize the existing interventional oncology approaches to immunotherapy, and discuss emerging technological advances in biomaterials and drug delivery that could further advance the field of interventional oncology.

BACKGROUND: Cancer immunotherapy has gained significant attention in recent years and has revolutionized the modern approach to cancer therapy. However, cancer immunotherapy is still limited in its full potential due to various tumor immune-avoidance behaviors and delivery barriers, and this is seen in the low objective response rates of most cancers to immunotherapy. A novel approach to immunotherapy uses image-guided administration of immunotherapeutic agents directly into a tumor site; this technique offers several advantages, including avoidance of potent toxicity, bypassing the tumor immunosuppressive microenvironment, and higher therapeutic bioavailability relative to systemic drug administration.

CLINICAL FINDINGS/PROCEDURE DETAILS: Locoregional immunotherapy has fewer systemic side effects than conventional chemotherapeutics with similar tumor reduction potential due to their targeted delivery to tumor cells. Recent preclinical studies have established the therapeutic viability of locoregional immunotherapy delivery, demonstrating significant potential to revolutionize the modern approach to cancer treatment. Existing strategies for locoregional immunotherapy include oncolytic viruses, intratumoral delivery of checkpoint inhibitors, and innate immune system activation. Engineered methods such as nanoparticle encapsulation of therapeutics, magnetic resonance targeting, and clustered regularly interspaced short palindromic repeats (CRISPR) – CRISPR-associated protein 9 (Cas9) multiplex editing systems can be combined with image-guided injections for robust and highly precise administration of cancer therapeutics.

CONCLUSION AND/OR TEACHING POINTS: Intratumoral administration of cancer immunotherapy in particular has significant potential to alter the landscape of cancer treatment in the coming years, both independently and in conjunction with conventional treatment strategies. Many treatment-resistant or difficult-to-reach malignancies could become accessible with further advances in locoregional therapeutic administration. Moreover, the exciting developments in biomaterials and biotechnology will further enhance the precision and efficacy of locoregional immunotherapy.

Abstract No. 778**The Rise of Medical Therapies for the Treatment of Hepatocellular Carcinoma (HCC)**C. Chao¹; ¹ Harbor UCLA Medical Center

LEARNING OBJECTIVES: Learn the current state of the expanding number of medical therapies for hepatocellular carcinoma (HCC), including combination therapies. Review the medical trial results and understand the differences between the medications.

BACKGROUND: Interventional radiologists have dominated the treatment of HCC since less than 20% of patients qualify for surgery and medical therapies have not been particularly effective. However, recently an increasing number of medical therapies been developed and proven effective in clinical trials including multi-receptor tyrosine kinase inhibitors, immunotherapies, monoclonal antibodies and combinations thereof. The medications are significantly different, even in the same class and may affect interventional radiology (IR) procedures.

CLINICAL FINDINGS/PROCEDURE DETAILS: Current medical therapies available to treat HCC including multi-receptor tyrosine kinase inhibitors (sorafenib, regorafenib, lenvatinib, cabozantinib); monoclonal antibodies (ramucirumab and bevacizumab) which target vascular endothelial growth factor (VEGF); and immunotherapies (nivolumab, atezolizumab, pembrolizumab, durvalumab, tremelimumab). The updated trial data of these medical therapies will compare overall survival and time to progression of disease as well as adverse effects. Important combination medical therapies will be reviewed including (1) atezolizumab and bevacizumab, the first combination to have improved overall survival over sorafenib and is now first line therapy; (2) tremelimumab and durvalumab, a combination of 2 immunotherapies also finding improved survival over sorafenib; and (3) lenvatinib and pembrolizumab which did not find a benefit over lenvatinib alone. Other medical therapies with phase 3 trial results such as tislelizumab and camrelizumab plus rivoiceranib will be reviewed. The two successful trials combining medical therapy and chemoembolization, TACTICS and LAUNCH, will be reviewed and compared. Finally, we will review a single arm trial of combined neoadjuvant cabozantinib and nivolumab which converted 80% of non-resectable HCCs to successful resection.

CONCLUSION AND/OR TEACHING POINTS: Interventional radiologists treating patients with HCC need to stay abreast of the medical therapies available to HCC since the therapies are continuously expanding in number and combinations and may interplay with IR treatments. Moreover, some oncologists are now espousing medical therapy as neoadjuvant, adjuvant or even as alternative therapies.

Abstract No. 779**What's New with TACE and TARE: Enhancing Tumor Response by Overcoming Biophysical and Immunological Barriers**S. Pavuluri,¹ X. Zhao,¹ H. Athwal,¹ L. Marrone,¹ P. Shukla,¹ A. Kumar;¹ Rutgers New Jersey Medical School

LEARNING OBJECTIVES: To discuss recent enhancements to the use of transarterial chemoembolization (TACE) and transarterial radioembolization (TARE) in overcoming biophysical and immunosuppressive barriers within the tumor microenvironment through combination with techniques such as pressure-enabled drug delivery, immunotherapy, and molecular targeting.

BACKGROUND: TACE and TARE are commonly used in the treatment of hepatocellular carcinoma (HCC) and hepatic metastases. These procedures use selective chemotherapeutic and radiation delivery, respectively, offering advantages in increasing delivery of therapeutics to the site of the tumor while minimizing adverse offsite effects compared with their systemic alternatives. Still, there are barriers to optimizing delivery due to the hurdles the tumor microenvironment (TME) innately presents, including increased intratumoral pressure, immunosuppressive effects, and risk of local adverse effects. Recent studies have found that supplementing TARE and TACE with additional techniques such as pressure-enabled drug delivery (PEDD), immunotherapy via immune checkpoint inhibitors (ICIs), and molecular targeting may be beneficial.

CLINICAL FINDINGS/PROCEDURE DETAILS: (1) PEDD makes use of an incorporated intermittently occlusive valve system in the delivery catheter to prevent backflow and thereby increase pressure of delivery at the site of the tumor. This allows it to better overcome the enhanced pressure of the TME. PEDD has thereby been demonstrated to increase both tumor penetration and pathological response. (2) TACE and TARE both have innate immunostimulatory mechanisms in the TME. Combinatorial therapy with ICIs serves to supplement this effect by further increasing immune cell proliferation and infiltration within tumors, effectively increasing tumor response duration. (3) Although TACE and TARE are already selective through delivery via the desired blood vessel, this is not tumor-specific. Molecular targeting makes use of agents that specifically bind to the tumor itself to increase tumor penetration and prevent off-target delivery.

CONCLUSION AND/OR TEACHING POINTS: This exhibit will: (1) discuss the mechanisms, indications, and benefits of using TACE/TARE in combination with therapies such as PEDD, immunotherapy, or molecular targeting and (2) highlight the most recent literature evaluating the effectiveness and utility of these combinations, including relevant clinical trials and example cases with clinical and diagrammatic images.

Abstract No. 780**Let that CSF Flow! A Review of the Use of Venous Sinus Stenting in the Treatment of Idiopathic Intracranial Hypertension**J. Moirano,¹ B. Ryu,¹ S. Dalal,² T. White,² J. Khoury,² A. Patsalides²; ¹Donald and Barbara Zucker School of Medicine At Hofstra/Northwell; ²Northwell Health

LEARNING OBJECTIVES: (1) To review the clinical signs and symptoms suggestive of idiopathic intracranial hypertension (IIH). (2) To discuss the use of and procedural details that are involved in venous sinus stenting (VSS). (3) To compare VSS to alternative management in the treatment of IIH.

BACKGROUND: Idiopathic intracranial hypertension (IIH) is a disorder that is characterized by increased intracranial pressure. This condition most commonly occurs in middle-aged, overweight women and presents with symptoms including chronic headaches, papilledema, tinnitus and vision loss. Although the pathogenesis of IIH is not entirely known, venous sinus stenosis is thought to be a primary cause or a secondary manifestation. Treatment of IIH includes medical management (lifestyle and pharmacology), surgical interventions, and VSS.

CLINICAL FINDINGS/PROCEDURE DETAILS: This exhibit will provide an overview of the clinical indications and procedural details involved in VSS for IIH. We will focus on what makes an ideal candidate for VSS and certain indications for treatment. MRV and cerebral angiographic images will be provided to show areas of stenosis in select patients. Procedural details will be outlined, including pre-stenting medical optimization, catheter venography and manometry, and the stenting process itself. Angiographic images will be displayed to highlight pre-stenting stenosis and post-stenting relief of flow obstruction. VSS will then be compared with other management techniques for the treatment of IIH.

CONCLUSION AND/OR TEACHING POINTS: IIH is a complex disorder that can be difficult to diagnose and treat. The use of VSS can provide significant symptomatic relief for patients. VSS is a safe, minimally invasive and effective alternative treatment that should be offered to patients with IIH who fail medical management. Further studies can be done to better compare VSS to other forms of surgical intervention.

Abstract No. 781

Pneumocephalus and Cranial Nerve Palsies in Spinal Interventions: A Review of Literature

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LEARNING OBJECTIVES: Pneumocephalus causing a cranial nerve palsy is rare with only a few cases reported in the literature. Its complications may be as trivial as headaches, to more complex presentations such as a cranial nerve palsy, to exceedingly dangerous complications such as tension pneumocephalus. Signs and symptoms resolve spontaneously with conservative management.

BACKGROUND: Minimally invasive and surgical spine procedures are commonplace with various risks and complications. Cranial nerve palsies, however, are infrequently encountered, particularly after procedures such as lumbar punctures, epidural anesthesia, or intrathecal injections and are understandably worrisome for clinicians and patients as they may be interpreted as secondary to a sinister etiology. However, a less commonly considered source is a pneumocephalus which may, in rare cases abut cranial nerves and cause a palsy as a benign and often self-resolving complication. Here, we highlight the utility of various imaging modalities, treatment options, and review current literature on spinal procedures resulting in cranial nerve palsies attributable to pneumocephalus presenting as malignant etiologies.

CLINICAL FINDINGS/PROCEDURE DETAILS: We present one rare case of abducent nerve palsy due to pneumocephalus after intrathecal chemotherapy injection. We will discuss the most up-to-date literature on this complication as it pertains to pneumocephalus causing extraocular visual motor dysfunction after spinal procedures, including the following: epidural anesthesia, intrathecal chemotherapy, steroid injections, lumbar punctures, and lumbar laminectomies. We will also analyze different presentations of pneumocephalus clinically, highlight their location on various imaging modalities, including computed tomography (CT) and magnetic resonance imaging, and discuss treatment options used among cases reported.

CONCLUSION AND/OR TEACHING POINTS: Pneumocephalus causing a cranial nerve palsy due to a spinal procedure is a rare condition with only a few cases reported in the literature to date. Pneumocephalus is most often secondary to various surgical and minimally invasive techniques, such as intrathecal injections. Its complications may be as trivial as headaches, to more complex presentations such as a cranial nerve palsy, to exceedingly dangerous complications such as tension pneumocephalus. A non-contrast CT scan of the head can be an effective and rapid diagnostic tool with treatment using high oxygen air-flow supplementation and conservative management of constitutional symptoms.

Abstract No. 782

Ultrasound Guided Injection of Potassium Chloride or Methotrexate into Ectopic Pregnancies: Experience from a Single Institution

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LEARNING OBJECTIVES: (1) Explore potential indications for potassium chloride (KCl) or methotrexate injection of the gestational sac in ectopic pregnancies with ultrasound guidance. (2) Review techniques and tips based on experience for ultrasound-guided injection of the gestational sac. (3) Review cases performed at our institution including clinical follow up.

BACKGROUND: Ectopic pregnancy, a pregnancy in which the embryo implants in a location other than the normal uterine cavity, accounts for approximately 1% to 2% of all pregnancies. The most common location for ectopic pregnancy is within the fallopian tube (greater than 90%), with other locations including interstitial, cesarean scar, peritoneum. Current treatment options of non-ruptured ectopic pregnancy include intramuscular methotrexate administration or laparoscopic surgery. A less commonly described treatment option includes intrasac injection of methotrexate or potassium chloride (KCl). Management of live interstitial and cesarean scar ectopic pregnancies can be especially challenging given the increased risk of hemorrhage, morbidity and potential loss of reproductive capacity with surgical management. Direct intrasac injection is an especially viable treatment option for patients with poor follow up, who may not be dependable to follow up for routine beta HCG levels after intramuscular methotrexate injection, failed treatment with intramuscular methotrexate, treatment of heterotopic pregnancy, in which the intrauterine pregnancy is desired,

or in interstitial or cervical scar ectopic pregnancies, in which risk for hemorrhage is increased.

CLINICAL FINDINGS/PROCEDURE DETAILS: The cases over the past 10 years at our institution will be reviewed, including technique and clinical outcome. This exhibit will also review technical pearls and options to consider, including percutaneous versus transvaginal approach.

CONCLUSION AND/OR TEACHING POINTS: Ultrasound-guided intrasac injection for ectopic pregnancy is a potentially underdiscussed treatment option for ectopic pregnancy, which in the correct patient population offers advantages over systemic methotrexate treatment and surgery.

Abstract No. 783

Percutaneous Endoscopy-Assisted Genitourinary Interventions

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LEARNING OBJECTIVES: (1) To discuss clinical indications and contraindications of percutaneous endoscopy-assisted genitourinary (GU) interventions. (2) To discuss the technical details and device settings of endoscopy-assisted procedures in native and transplant kidneys. (3) To summarize postprocedural follow-ups after percutaneous endoscopy of the GU system.

BACKGROUND: There is an up-trending clinical indication for percutaneous endoscopy procedures operated by interventional radiologists in different organs. The utility of percutaneous endoscopy in the biliary system is relatively well studied, but there is a paucity of data on percutaneous endoscopy-assisted procedures in GU diseases. Patients with multiple comorbid conditions, or difficult anatomy who are not an optimal candidate for conventional urologic surgeries or cystoscopy can benefit from percutaneous endoscopic procedures.

CLINICAL FINDINGS/PROCEDURE DETAILS: Emerging percutaneous endoscopy-assisted techniques provides direct visualization of the collecting system which can be combined with fluoroscopic guidance in anatomically challenging cases. The percutaneous access to the collecting system can be used to accept a small caliber percutaneous endoscope over a wire and through a sheath. The percutaneous endoscopy-assisted procedures in the GU system include lithotripsy of ureteral stones not amenable to cystoscopy, ureteral lesion biopsy, recanalization of severe ureteral stenosis, and laser incision of short-segment ureteral strictures after renal transplant. Mid to upper pole access is preferable and lowers the chance of luminal injury at the ureteropelvic junction while advancing the endoscope. The potential post-procedural complications are rare and include bleeding and ureteral perforation. A safety nephrostomy or nephroureterectomy catheter is placed after percutaneous interventions which can be removed on the follow-up visits.

CONCLUSION AND/OR TEACHING POINTS: Percutaneous endoscopy equips interventional radiologists with direct visualization and can be beneficial to treating ureteral stones and strictures and performing

intraluminal biopsies. These novel percutaneous techniques offers new possibilities particularly to patients with altered anatomy or multiple comorbidities precluding surgical interventions.

Abstract No. 784

Use of Radiofrequency Tip Wire to Cross Ureteral Anastomotic Obstruction for Placement of Retrograde Nephroureteral Stent

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LEARNING OBJECTIVES: (1) Present a novel technique of using the PowerWire radiofrequency wire to transverse ureteroenteric strictures in patients who have undergone creation of an ileal conduit status post cystectomy with prior failed placement of a retrograde nephroureteral stent. (2) Describe the technical aspects of this procedure. (3) Outline advantages and disadvantages of this technique.

BACKGROUND: Radiofrequency (RF) tip wires can be used in recanalization of central venous stenosis where standard practices to transverse occlusions have failed. In the literature, this wire has also been used in urologic and non-urologic interventions such as creating a neoureterocystostomy for chronic ureteral stricture or crossing post-surgical bile duct stenosis. Endoscopic procedures have been used to transverse these strictures with a 46% success rate. Open surgical revision has been used as a last resort for symptomatic strictures when recanalization is not feasible. We propose a novel technique using the PowerWire radiofrequency device to transverse distal ureteroenteric strictures in these patients when standard procedures have failed in order to avoid open surgical revision.

CLINICAL FINDINGS/PROCEDURE DETAILS: In the first case, the patient developed a left ureteroenteric anastomotic stricture, and an RF wire was used to cross this stricture and a retrograde nephroureteral stent was placed. There was a minor complication of abscess formation which resolved with percutaneous drainage. In the second case, the patient developed a left ureteroenteric stricture requiring placement of a left nephrostomy tube. During a future visit, internal stent placement with sharp recanalization was unsuccessful. An RF wire successfully crossed the stricture and a left retrograde nephroureteral stent was placed. The third case is a patient who developed bilateral ureteroenteric strictures. An internal stent was successfully placed through the left stricture. An RF wire was used to cross the right ureteral stricture and balloon dilation of the stricture was performed resulting in contrast extravasation. A 7-mm × 2.5-cm Viabahn stent graft (Gore, Flagstaff, AZ) was placed across the stricture with a retrograde nephroureteral stent. The fourth case involves an ileal conduit who developed a left ureteroenteric stricture. An RF wire was used to cross the distal stricture and a retrograde nephroureteral stent was placed after balloon dilatation.

CONCLUSION AND/OR TEACHING POINTS: The use of a radiofrequency wire is a feasible alternative for recanalization of ureteroenteric strictures after ileal conduit creation.

Abstract No. 785**Percutaneous Ablative Techniques for Definitive Treatment of Disconnected Duct Syndrome in Necrotizing Pancreatitis: Review and Institutional Experience**

J. Roebker,¹ K. Gjeluci,¹ J. Moulton,¹ D. Vu;¹ University of Cincinnati Medical Center

LEARNING OBJECTIVES: (1) Review the evolving therapeutic approach for disconnected pancreatic duct syndrome (DPDS) and the role of percutaneous alcohol and cryoablation as definitive management. (2) Provide a pictorial review of cases performed at our institution and briefly outline techniques. (3) Identify patients who are candidates for intervention and anatomic considerations.

BACKGROUND: DPDS is a morbid complication of severe necrotizing pancreatitis caused by necrosis, resulting in a segment of pancreas and main pancreatic duct disconnected from the gastrointestinal tract. The current standard of care for DPDS is distal pancreatectomy, with endoscopic transmural stenting or surgical transgastric drainage often attempted first given the morbidity and mortality associated with resection. Limited studies have reported efficacy of ablative techniques in the management of pancreatic cancer. We describe pancreatic ablation successfully performed at our institution as definitive treatment of DPDS.

CLINICAL FINDINGS/PROCEDURE DETAILS: We present our institutional case series of patients with necrotizing pancreatitis complicated by DPDS treated with percutaneous ablation of an isolated pancreatic remnant ($n = 8$; 2 cryoablation, 6 chemical). All patients were deemed poor surgical candidates or failed prior distal pancreatectomy with recurrent peripancreatic fluid collections. Cryoablation or chemical ablation (alcohol) was determined based on the available percutaneous approach and the proximity of the remnant pancreas to the adjacent critical structures. Computed tomography was used to localize the isolated pancreatic tissue in either the supine or prone position, based on the patient's anatomy. A direct percutaneous approach was used in most cases, with percutaneous trans-splenic chemical ablation performed when a direct approach was unsafe. For the remnants larger than 3 cm, cryoablation was preferred unless deemed unsafe due to risk of injury to the surrounding colon and small bowel, as larger remnants required repeat sessions with ethanol ablation. 17-gauge Acuvance catheters and 2-3 Galil Ice Rod Plus cryoablation probes with 2-3 total freeze/thaw cycles were used for cryoablation cases. Chemical ablation was performed using 2-5 mL absolute ethanol and tantalum powder. All cases were technically successful and clinical success—defined as resolution of peripancreatic fluid collections—was achieved in all patients.

CONCLUSION AND/OR TEACHING POINTS: Percutaneous ablation of the isolated pancreatic remnant is an effective definitive treatment for necrotizing pancreatitis complicated by DPDS.

Abstract No. 786**Sharp Recanalization and Radiofrequency Wires for Biliary Occlusion and Neo-Anastomosis Creation: How-to and Brief Review of Reported Outcomes**

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LEARNING OBJECTIVES: Illustrate normal bile duct anatomy and post-surgical bile duct anatomy. Highlight biliary injury classification systems. Review patient presentation and imaging diagnosis of bile duct injury. Illustrate tools and techniques used for biliary access in preparation for biliary neo-anastomosis creation, including radiofrequency wires in addition to sharp recanalization. Discuss post-neo-anastomosis management using either internal/external biliary drain or internal metallic biliary stent.

BACKGROUND: Bile duct injury is an important consideration for patients undergoing invasive liver interventions, such as liver transplantation or hepatic resection. Partial hepatectomy, especially, can rarely result in biliary occlusion where a portion of the biliary tree can no longer drain into the enteric system. Interventional radiologists play a key role in the management of this complex biliary complication, including short-term biliary drain placement, but also creation of biliary neo-anastomoses as a long-term, durable solution.

CLINICAL FINDINGS/PROCEDURE DETAILS: Using simple instruments, fluoroscopy, and sometimes collaboration with other specialties, interventional radiologists can safely create new connections from occluded bile ducts to allow enteric drainage of bile, thereby helping patients avoid additional invasive surgery. The process of neo-anastomosis creation begins with biliary access, with placement of one or more external biliary drains. After decompression of the biliary tree, recanalization attempts can begin with either simple long 21-gauge needles, or radiofrequency wires. Based off of pre-procedural imaging, needles or wires can be directed toward the region of the enteric system and, after advancement, contrast injected to confirm position. Additionally, a rendezvous approach can be taken, where a balloon in the enteric system is used as a target for puncture.

CONCLUSION AND/OR TEACHING POINTS: Biliary duct injuries, such as total biliary occlusion, are a rare complication of hepatic surgical procedures. Interventional radiologists have a unique skillset to temporize and treat bile duct occlusion, including the creation of biliary neo-anastomoses.

Abstract No. 787**Applications of U-type Tube Drainage Catheters: A Through-and-Through Drainage Solution**

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LEARNING OBJECTIVES: (1) To review clinical settings associated with failure or complication of percutaneous catheter drainage (PCD). (2)

To describe concept of U-type tube drainage catheters (UTDCs) and advantages over traditional PCDs. (3) To discuss indications for UTDCs and fundamentals of post-procedure management.

BACKGROUND: PCD has a wide range of clinical indications, high success rate, and has replaced surgery as the primary treatment for many conditions. However, catheter-related complications remain an issue for complex collections associated with specific pathologies (including necrotizing pancreatitis or collections associated with fistulae).

UTDC is a large-bore, percutaneous drainage catheter with both catheter ends exiting at the skin surface and the mid-catheter portion with side holes that drain a fluid collection or a visceral cavity. At our institution, UTDC is often used instead of surgical necrosectomy. The two percutaneous openings allow for bidirectional drainage, percutaneous lavage, and extended dwell times with a very low risk of catheter-related dysfunction (internal migration, erosion into adjacent structures, or obstruction).

CLINICAL FINDINGS/PROCEDURE DETAILS: The clinical indications, procedural details, and considerations of UTDCs are provided in this exhibit. The UTDC is particularly useful when long-term drainage is needed in a large complex fluid collection. The application of UTDCs is pictorially illustrated in the following categories:

- Necrotizing pancreatitis: provide long-term drainage and avoid surgical necrosectomy
- Gallbladder: function as a chronic cholecystostomy tube in patients with recurrent tube dislodgement
- Biliary obstruction: alternative to internal/external biliary catheter that cannot be placed into small bowel or with recurrent tube dislodgement
- Kidney: provide urinary tract drainage in the setting of chronic obstruction
- Miscellaneous: drainage of complex pleural effusions, soft tissue hematomas, infected collections

CONCLUSION AND/OR TEACHING POINTS: (1) Certain collections, including those that are multiloculated, phlegmonous, or associated with downstream fistula, are notoriously difficult to treat with traditional PCD. (2) UTDC is an innovative technique with bidirectional drainage technique that extends the therapeutic reach of traditional PCDs. (3) Understanding the advantages, disadvantages, and proper technique of UTDC placement is critical to optimizing its use in patient care.

Abstract No. 788

The Role of Interventional Radiology in the Management of Non-Vascular Post-Liver Transplant Complications

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LEARNING OBJECTIVES: Review biliary complications that can occur post-liver transplantation (LT) and the procedures performed by interventional radiology (IR) to relieve biliary strictures and bile leaks.

BACKGROUND: LT is the definitive treatment for end-stage liver disease. Improvements in surgical technique, immunosuppressive therapy, complication management and careful patient selection are credited for gradual increases in 1- and 3-year LT survival rates; 91% and 83%, respectively. Despite these advances, non-vascular post-LT complications remain a major cause of morbidity and mortality. Non-vascular complications include biliary stricture, bile leak, bile duct stones/sludge, biloma, and cholangitis. Biliary strictures can be anastomotic or non-anastomotic. Underlying risk factors for anastomotic biliary strictures include living donor transplants (owing to the relatively smaller caliber and increased number of biliary ducts), presence of a T-tube, concurrent ischemia, and biliary-enteric anastomosis. These strictures often present within 1-year-post liver transplant with jaundice, abdominal pain, and abnormal liver function tests.

CLINICAL FINDINGS/PROCEDURE DETAILS: While endoscopic retrograde cholangiopancreatography (ERCP) is the first-line treatment for biliary complications, complex post-surgical anatomy, and patient clinical factors may render the biliary system inaccessible to an endoscopic approach. In these instances, percutaneous biliary access (transhepatic or transjejunal) performed by IR is crucial. Percutaneous treatments performed by IR to decompress the biliary system include percutaneous transhepatic biliary drainage (PTBD), cholangioplasty and stenting. PTBD has technical success rates of 78% to 83% in the post-LT patient cohort and experiences primary patency rates of 55%, comparable to that achieved by ERCP. There has been a recent focus on the use of cholangioscopy by IR and the use of cholangioplasty, laser stricturotomy, and endobiliary ablation to improve technical success and improve patency. Percutaneous biliary hygiene for ischemic cholangiopathy or recurrent primary sclerosing cholangitis will also be discussed.

CONCLUSION AND/OR TEACHING POINTS: IR is a crucial part of the multi-disciplinary team and offers minimally invasive therapies that are effective and safe in patients resistant to or unable to undergo ERCP or surgical revision. Here, we review cases of percutaneous management of post-LT biliary complications and highlight lessons to be gleaned from our institutional experience.

Abstract No. 789

Nerve Monitoring Augmented Computed Tomography-Guided Cryoablation for Neuropathic Pain in the Anterior Femoral Cutaneous Nerve

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LEARNING OBJECTIVES: (1) Understand the anatomy of the anterior femoral cutaneous nerve. (2) Determine optimal cryoablation probe positioning. (3) Explore the utility of nerve monitoring during cryoablation.

BACKGROUND: We describe a novel technique for computed tomography (CT)-guided cryoablation of the anterior femoral cutaneous nerve. This is a 36-year-old male patient with myxopapillary ependymoma status post thoracic and sacral laminectomies. He developed disease recurrence requiring radiation therapy with persistent dysesthesia and

neuropathic pain, particularly along the anterior left thigh, refractory to medical therapy. His pain intermittently reached 7 to 8 of 10 in severity with burning sensations, worse in the evening, and prohibitive to activities of daily living.

CLINICAL FINDINGS/PROCEDURE DETAILS: The patient underwent diagnostic nerve block 1.5 months prior, in which 3 cc of 0.5% bupivacaine was infiltrated along the anterior femoral cutaneous nerve. He endorsed complete pain relief for the remainder of the day. Given this response, he presented for ablation under general anesthesia. Due to proximity of the left femoral nerve, intraoperative nerve monitoring was used to increase procedural safety.

The area of interest was scouted and nerve monitoring probes were applied to muscle groups above and below the femoral nerve. Under CT guidance, nerve monitoring probes were applied to the left femoral nerve fascicle above and below the area of cryoablation. Lidocaine was infiltrated and an IceSeed 1.5 90-degree probe (Boston Scientific) was advanced to the left anterior femoral cutaneous nerve. Two cycles of freeze/thaw (3 and 2 minutes, respectively) were performed with continuous nerve monitoring demonstrating no functional compromise of the femoral nerve. Periodic CT images visualized the extent of the ice ball. Upon completion of the freeze/thaw cycles, the probe was removed and hemostasis was achieved with manual compression. Post-procedural nerve stimulation confirmed no injury to the femoral nerve. The patient was extubated and admitted overnight for observation.

CONCLUSION AND/OR TEACHING POINTS: The patient returned to clinic one week post-procedure and noted significant symptomatic improvement. His pain is dulled, now 3 to 4 of 10 with decreased frequency of onset (less than once an hour; previously three to four times per hour) and no nighttime episodes, which had disrupted his sleep. He has no neurological deficits in the rest of his lower extremity. This case demonstrates the efficacy of CT-guided neurolysis via cryoablation of the anterior femoral cutaneous nerve with enhanced safety through the use of intraprocedural nerve monitoring.

Abstract No. 790

Basivertebral Nerve Ablation: How I Do It

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LEARNING OBJECTIVES: Basivertebral nerve ablation (BVNA) is procedure in which thermal ablation is used to destroy the basivertebral nerve to alleviate low back pain. Herein the authors will describe the process by which they perform BVNA starting with patient selection and ending with post operative management and followup.

BACKGROUND: Low back pain (LBP) is the most ubiquitous cause for musculoskeletal ailment in the USA. Basivertebral nerve ablation is a recently approved procedure for patients with LBP. The basivertebral nerve lays within the posterior-central region of the vertebral body and receives signals from the superior and inferior endplate prior to carrying these nociceptive signals to the spinal cord. Ablation of the

BVNA stops this pathway and results in pain relief with recent studies demonstrating almost 90% of patients improving by >50%. The procedure itself can be performed under image guidance whether it be fluoroscopic or via computed tomography (CT). Targeted ablation of the BVN is relatively straightforward when using proper landmarks and technique.

CLINICAL FINDINGS/PROCEDURE DETAILS: (1) Patient selection: evaluation in clinic, indications, contraindications, pre-operative imaging. (2) Procedural considerations: anticoagulation hold, antibiotic choice, anesthesia type (moderate sedation vs general), Patient positioning (prone), image guidance (CT vs fluoroscopy). (3) Anatomic landmarks: vertebral body anatomy, transpedicular access, location of BVN on AP/LAT fluoro and on CT. (4) Postoperative care and follow-up: Toradol 30 mg IV, Ice packs, lidocaine patches. Clinic visits post op.

CONCLUSION AND/OR TEACHING POINTS: Basivertebral nerve ablation is a relatively new procedure that has been hugely impactful for helping patients who have low back pain. It is a safe and effective procedure when properly performed but there are key nuances such as the precise location of the BVN that one must know before performing this procedure.

Abstract No. 791

Peripheral Nerve Injury and Regeneration: Overview of the Sunderland Classification and What it Means for Pain Intervention

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LEARNING OBJECTIVES: (1) To provide an overview of peripheral nerve injury in interventional radiology. (2) Review the Sunderland Classification. (3) Provide an overview of how interventional radiology procedures cause nerve injury: blockade, thermal neurolysis, chemical neurolysis.

BACKGROUND: Interventional pain procedures frequently involve disruption of nociceptive pathways. This disruption can be achieved by causing temporary blockade of the nerve or through intentional damage to the nerve. The Sunderland classification is a system that categorizes the degree of nerve damage and correlates it with the expected regeneration time of the nerve. This is very important for pain interventionists to understand as this has implications for nerve recovery and possible return of symptoms.

CLINICAL FINDINGS/PROCEDURE DETAILS: Exhibit will provide a review of mechanism of action, Sunderland Classification of injury, and expected regrowth time frame using the following techniques: local anesthetic and steroids, phenol, ethanol, cryoablation, and radiofrequency ablation.

CONCLUSION AND/OR TEACHING POINTS: Intentional peripheral axonal injury is the basis for pain intervention and it is important to recognize the underlying mechanism of injury in the context of expected outcomes and eventual regeneration.

Abstract No. 792**Use of Cone-Beam Computed Tomography During Vertebral Augmentation**

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LEARNING OBJECTIVES: Illustrate the utility of cone-beam computed tomography (CT) in altering intraprocedural management in percutaneous vertebral augmentation through a series of challenging cases.

BACKGROUND: Spinal compression fractures can result in debilitating pain for many people, whether due to osteoporosis, trauma, or osseous metastatic disease. Percutaneous vertebral augmentation (PVA), including vertebroplasty, kyphoplasty, and now other novel implantable devices, has been an effective and minimally invasive treatment modality resulting in pain reduction, improved quality of life, and biomechanical restoration. Traditionally, PVA is achieved under fluoroscopic guidance, however, the advent of intraprocedural cone-beam CT (CBCT) with or without needle guidance may further reduce complications and lead to improved technical proficiency with potentially better outcomes.

CLINICAL FINDINGS/PROCEDURE DETAILS: A series of cases will be presented demonstrating how CBCT altered intraprocedural management resulting in a more optimal and durable procedural outcome. We will highlight cases of cement deposition variation with unipedicular approach, assessment of appropriate Kirschner wire placement in vertebra plana cases, and guidance for vertebral lesion biopsy.

For cases of unipedicular access, a curved balloon system is used to reach the contralateral hemivertebra. While unipedicular approach can reduce procedure time and radiation dose, this technique may result in a paucity of cement deposition in the contralateral posterior quadrant. CBCT can easily illustrate this pitfall, ultimately necessitating contralateral pedicle access to attain uniform vertebral body cement deposition. Conversely, excessive cement deposition leading to extra-vertebral leak or intravasation can readily be identified and quantified. Severe vertebra plana cases are challenging as interposition of Kirshner wires between the end plates may be unclear under fluoroscopy alone. CBCT provides three-dimensional characterization to ensure proper wire placement prior to implementation of an implantable device, such as SpineJack.

Lastly, CBCT can aid in suspected vertebral body lesion biopsy prior to augmentation. While needle trajectory in relation to a vertebral body targeted lesion may be opaque under fluoroscopy, CBCT provides greater detail allowing for a higher likelihood of adequate specimen yield.

CONCLUSION AND/OR TEACHING POINTS: The utilization of CBCT can be an effective tool for improved technical proficiency in PVA, altering and enhancing intraprocedural management to achieve durable and optimal results in select cases.

Abstract No. 793**Esoteric Nerve Blocks**

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LEARNING OBJECTIVES: (1) Review the indications and contraindications for stellate ganglion, interscalene, and phrenic nerve blocks. (2) Describe the procedure for stellate ganglion, interscalene, and phrenic nerve blocks.

BACKGROUND: Stellate ganglion, interscalene and phrenic nerve blocks are useful procedures for the modern interventional radiologist and provide significant clinical benefit when performed correctly. Stellate ganglion blocks can be used for patients with complex regional pain syndrome, post-operative shoulder pain, and upper extremity pain. Interscalene blocks can be used for neurogenic thoracic outlet syndrome (nTOS), both diagnostically and therapeutically. Phrenic nerve blocks can be used for intractable, medically resistant hiccups. Herein we present a technical overview on how to perform these procedures.

CLINICAL FINDINGS/PROCEDURE DETAILS: *Stellate ganglion block:* Using an ipsilateral oblique view, a 25-gauge needle is inserted and carefully advanced in a lateral-to-medial fashion under fluoroscopy toward the C6 uncovertebral junction (joint of Luschka). After trialing a small dose of contrast to confirm extravascular position, 10 cc of local anesthetic is injected with or without steroids. Ipsilateral Horner's is expected in a successful block.

Interscalene triangle block: Using an ultrasound, the brachial plexus cords are identified between the anterior scalene and middle scalene. A 25-gauge needle is advanced under US guidance in posterior to anterior fashion until the tip is within the perineural echogenic fat. A total of 5-10 cc of local anesthetic with steroid is injected into the region under US guidance.

Phrenic nerve block: Phrenic nerve can be identified as a small, hypoechoic structure on ultrasound crossing the anterior scalene posterior to the sternocleidomastoid. Blockade using 5-10 cc of local anesthetic can result in cessation of hiccups. A sniff test under fluoroscopy can also be used to determine success of phrenic block.

CONCLUSION AND/OR TEACHING POINTS: Fluoroscopic stellate ganglion blocks should be employed by interventional radiologists in the treatment of complex regional pain syndrome I, as well as many other conditions. Ipsilateral Horner's syndrome and upper extremity warming are indications of a successful stellate ganglion block. Interscalene triangle block can be useful for diagnosis and potential symptomatic treatment of nTOS. Phrenic nerve blockade can be reasonably achieved under image guidance and provides significant benefit to patients with shoulder pain and intractable hiccups.

Abstract No. 794**Applications and Advancements of Regional Anesthesia in Interventional Radiology**

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LEARNING OBJECTIVES: To describe the clinical and experimental uses of regional anesthesia in interventional radiology (IR).

BACKGROUND: As the complexity of IR procedures increases, there is a demand for periprocedural pain management. Regional anesthesia or “nerve blocks” involve injection of local anesthetics near sensory nerves to temporarily interrupt nociceptive impulses. Nerve blocks are an increasingly popular option for periprocedural analgesia in IR because they decrease post procedural hospitalization, the side effects and risks of opioids, and the need for general anesthesia.

CLINICAL FINDINGS/PROCEDURE DETAILS: Regional anesthesia can be performed as a single-injection or continuous infusion via perineural catheter. Commonly used agents are lidocaine, bupivacaine, ropivacaine, and mepivacaine. Nerve blocks are usually performed under image guidance to reduce complications and the volume of local anesthetics needed for success. We will discuss the common techniques and applications of nerve blocks in IR as detailed in Table 1.

Regional anesthesia techniques in IR are still developing. For example, while several IR procedures target the liver, there have traditionally been few peri-procedural pain control options beyond systemic medications. A new technique has been developed to deliver a hepatic hilar nerve block with 0.25% bupivacaine by image guidance near the main portal vein. Hepatic hilar nerve blocks are shown to effectively lower pain during chemoembolization and liver ablation, while decreasing opioid use and complications.

CONCLUSION AND/OR TEACHING POINTS: Regional anesthesia reduces risks of perioperative complications and adverse events, so they should be incorporated into an interventional radiologist’s clinical repertoire.

Abstract No. 795**Vertebral Augmentation Saves Lives**

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LEARNING OBJECTIVES: (1) Present a chronological, visual, and literature-based appraisal of minimally invasive vertebral augmentation (VA) techniques. (2) Discuss benefits and drawbacks of each vertebral augmentation method and the biomechanical support they provide. (3) Demonstrate the safety and efficacy of various vertebral augmentation techniques and discuss how they improve patient outcomes.

BACKGROUND: Vertebral body compression fractures are a common and morbid pathology. Etiologies include trauma, osteoporosis and neoplasm, though a single fracture may be multifactorial in origin. It is estimated that over 1.5 million occur annually, costing the healthcare system \$17.5 billion and increasing the mortality risk of these patients by a factor of nine.

CLINICAL FINDINGS/PROCEDURE DETAILS: Vertebroplasty was first attempted in 1984, and has since been supplemented by the advent of balloon kyphoplasty (BKP). Decades later, implantable devices were introduced, including the Kiva implant and SpineJack, the safety and efficacy of which were evaluated in the KAST and SAKOS trials. The KAST study showed that the Kiva implant is non-inferior to BKP in several primary and secondary endpoints, including a positive trend in adjacent level fracture. The SAKOS trial showed the superiority of the SpineJack to BKP, with better pain relief, height restoration, and rate of adjacent level fracture. Both studies demonstrated enhanced biomechanical effects. Overall, these therapies have demonstrated significant improvement in vertebral height, stability, pain and mortality rates. Work has also been done to compare the outcomes for nonsurgical management, kyphoplasty, and vertebroplasty, showing that 12 patients need to be treated with kyphoplasty to save one life and 24 with vertebroplasty. Several studies have shown a mortality benefit to VA. One showed patients who underwent VA were 22% less likely to die up to 10 years after treatment. Another showed that compared with kyphoplasty, patients managed non-surgically have a 55%

Table 794.1 Commonly Used Nerve Blocks in Interventional Radiology

Nerve Block	Applications
Paravertebral	Biliary drainage, thermal and radiofrequency tumor ablation
Periprostatic	Transrectal prostate biopsy
Phrenic nerve	Percutaneous aspiration biopsy of pulmonary nodules
Stellate ganglion	Refractory cerebral vasospasm after aneurysmal subarachnoid hemorrhage or coil embolization of basilar tip aneurysms
Superior hypogastric plexus	Uterine artery embolization
Supraclavicular brachial plexus	Arteriovenous (AV) hemodialysis access creation, treatment of dysfunctional AV fistulas
Femoral, saphenous, and sciatic nerves	Endovenous laser ablation and sclerotherapy for lower extremity venous insufficiency
Subgluteal sciatic	Stent or angioplasty treatment of below-the-knee occlusions
Transverse abdominus	Peritoneal dialysis catheter placement

higher adjusted risk of mortality, as well as higher risk of developing pneumonia, cardiac complications, deep vein thrombosis, and urinary tract infection.

CONCLUSION AND/OR TEACHING POINTS: In this educational exhibit we present a multifaceted appraisal of these minimally invasive VA techniques, offering the reader both context of the past and new directions on the horizon. We will also discuss the outcomes in patients receiving VA to those receiving nonsurgical management and show that VA resulted in a low number needed to treat to save one life and lower morbidity and mortality.

Abstract No. 796

Geniculate Artery Embolization: Vascular Anatomy and Technical Considerations

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LEARNING OBJECTIVES: (1) Review most common etiology of recurrent hemarthrosis. (2) Explore the role of geniculate artery embolization (GAE) in recurrent hemarthrosis as well as potential complications. (3) Describe the anatomy and technical approach of the procedure. (4) Discuss the current literature evaluating the role of GAE in treatment of osteoarthritis.

BACKGROUND: Geniculate artery embolization is an effective treatment for recurrent hemarthrosis following total knee arthroplasty (TKA), which occurs in up to 1.6% of cases, and typically results from trauma to hypertrophic vascular synovium. Treatment options range from conservative therapies (aspiration, rest, ice packs) to surgical intervention (open vs arthroscopic synovectomy). GAE is a minimally invasive treatment option, both curative and considerably less morbid than surgery, with resolution of symptoms within 2-3 weeks.

The safety and efficacy of GAE for hemarthrosis has laid groundwork for application as osteoarthritis (OA) therapy. Early clinical evidence with ovine models has demonstrated improvement in knee pain and function with particle embolization of neovascularization by disrupting angiogenesis as well as nociceptive nerve fiber growth. It is therefore important for trainees to understand the vascular anatomy and technical steps of GAE.

CLINICAL FINDINGS/PROCEDURE DETAILS: Preoperative imaging includes contrast-enhanced MR to evaluate for synovial thickening and enhancement within GA vascular territory. Selective catheterization of the descending genicular, superior medial genicular, inferior medial genicular, superior lateral, inferior lateral genicular and recurrent genicular artery should be performed based on location of pain and pre-procedural imaging. Angiography should demonstrate blush in the area of hemarthrosis and may reproduce pain due to increased pressure within the synovium. Cutaneous branches should be excluded if possible. An ice pack over the area can be used for vasoconstriction to

prevent non-target embolization. Embolization is performed with 100- to 300- μ m particles in 0.2 mL aliquots while avoiding reflux. Alternative embolics should be considered with AV fistulae, aneurysms, and pseudoaneurysms. End goal of embolization is the reduction of hyperemic blush, while retaining patency of parent arteries

CONCLUSION AND/OR TEACHING POINTS: GAE is a safe and effective treatment option for hemarthrosis following TKA and has demonstrated early success for treatment of OA, a novel interventional radiology application. Our presentation will provide an essential primer on the vascular anatomy and technical considerations for catheter interventions in this region.

Abstract No. 797

Adhesive Capsulitis: Clinical Management and Endovascular Therapies

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LEARNING OBJECTIVES: To review diagnostic imaging evaluation, clinical management, and interventional techniques for adhesive capsulitis, as well as examine the current literature, treatment outcomes, and future therapies.

BACKGROUND: Adhesive capsulitis is a common and debilitating condition, especially among diabetics and women. Adhesive capsulitis embolization is an emerging procedure within musculoskeletal interventional radiology which has recently demonstrated the ability to significantly decrease shoulder pain and increase range of motion. Furthermore, angiography has demonstrated characteristic imaging findings in a disease previously considered a clinical diagnosis. The success of embolization and findings of neoangiogenesis and contrast blush on angiography shed light on the underlying mechanisms of a disease whose etiology was previously unknown. Understanding of the clinical management, technical aspects, and current evidence is essential for the practicing interventional radiologist.

CLINICAL FINDINGS/PROCEDURE DETAILS: This educational exhibit will (1) present an overview of adhesive capsulitis reviewing relevant anatomy and physiology; (2) diagnostic criteria; (3) clinical management of adhesive capsulitis including medical, interventional, and surgical techniques; (4) present current endovascular techniques and technical pearls; (5) review the procedural indications, contraindications, and potential risks; and (6) review the present literature, treatment outcomes and prognosis, and future therapies.

CONCLUSION AND/OR TEACHING POINTS: After reviewing this exhibit, the viewer will gain a better understanding of the management of adhesive capsulitis including the proper utility of endovascular techniques, technical pearls and treatment outcomes, as well as current data and future therapies.

Abstract No. 798**Intercostal Nerve Block and Neurolysis, Tips and Tricks**

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LEARNING OBJECTIVES: (1) Review the anatomy of the intercostal nerves, including relation to vascular structures, branching pattern, and dermatomes. (2) Describe the indications for an intercostal nerve block or neurolysis. (3) Summarize the steps of performing an intercostal nerve block or neurolysis, highlighting tips and tricks for optimal technique through clinical cases.

BACKGROUND: An intercostal nerve block is a useful primary or adjunct intervention that can treat a variety of acute and chronic pain conditions, including rib fractures, incisional pain from breast or thoracic surgery, or cancer-related pain due to rib or pleural metastases. Intercostal nerve blocks have also been used as a perioperative analgesic for several procedures commonly performed by interventional radiology, such as chest tube placement or percutaneous cryoablation of lung tumors. For definitive or long-term pain control, intercostal neurolysis can be performed using a similar technique.

CLINICAL FINDINGS/PROCEDURE DETAILS: Our nerve block cocktail consists of a mixture of Bupivacaine 0.5% solution and Kenalog (triamcinolone 40 mg/mL) in a 6:1 ratio with a small volume (< 1 mL) of iodinated contrast for visibility if being done under computed tomography (CT) or fluoroscopic guidance. We perform the majority of our procedures under CT guidance; however, fluoroscopic and ultrasound guidance are used when concurrent procedures dictate their use. The patient is positioned in a prone or treatment side decubitus position. Under imaging guidance, a 25-gauge needle is inserted in a caudo-cranial orientation to the underside of the rib at the level of interest, approximately 2 to 4 inches lateral to the spinous process. After confirmation of needle tip position, 2 to 3 mL of the nerve block agent are injected at each level. CT guidance allows visualization of agent diffusion along the neurovascular bundle. At a minimum, block of the intercostal nerves above and below the level of interest should be performed due to radiating innervation from adjacent levels. For permanent intercostal neurolysis, 15 minute is allowed for the block to take effect, and then 1.5 to 2 mL of dehydrated ethanol is injected at each level.

CONCLUSION AND/OR TEACHING POINTS: Intercostal nerve block and neurolysis are valuable tools available to the interventional radiologist that are easy to learn, cost-efficient, safe, and quick to perform. Incorporating these techniques when performing a procedure requiring percutaneous access through an intercostal dermatome can help to achieve optimal analgesia for the patient in the perioperative setting, and potentially in the long-term if neurolysis is performed.

Abstract No. 799**Percutaneous Thermal Ablation for Treatment of Benign Bone Tumors: Principles, Technologies and Clinical Outcomes**

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LEARNING OBJECTIVES: (1) To describe the clinical and imaging features of benign bone neoplasms. (2) To review percutaneous ablative technologies, indications, and clinical outcomes in the treatment of bone tumors. (3) Describe representative case examples of ablation treatment of benign bone tumors.

BACKGROUND: Benign bone tumors are the most common variety of primary bone neoplasms and primarily affect children and young adults younger than 25 years of age. Although they have low or no metastatic potential, benign bone tumors may cause significant pain during activity or at rest and exhibit increased fracture risk due to aberration of healthy bone architecture. Furthermore, many types are locally aggressive and exhibit a high rate of recurrence after initial surgical treatment, including osteoblastoma, giant cell tumors, and chondromyxoid fibromas. Traditionally, multiple surgeries are required, which poses an increased risk of complications including growth abnormalities and functional deficit, given the predominantly pediatric population. Thermal ablation has emerged in the last two decades as both an adjuvant and primary treatment alternative to surgery due to comparable efficacy combined with a reduced risk profile, with shorter post-operative stays, reduced procedural complications, and lower cost.

CLINICAL FINDINGS/PROCEDURE DETAILS: Ablation technologies used in the treatment of benign bone tumors include radiofrequency, microwave, laser, and cryoablation. These technologies differ in utility and must be selected on a case-to-case basis depending on the tumor size, lesion pathology, and adjacent structures. In this exhibit, we will review the differences in ablation technologies and procedural techniques. We will also review literature-reported outcomes of different ablation technologies on the treatment of benign bone tumors, stratifying by common tumor types, and we will describe use cases of each modality through multiple case reports.

CONCLUSION AND/OR TEACHING POINTS: Ablation is an established treatment for benign bone tumors and includes multiple modalities. Consideration of each type's characteristics in combination with the clinical context allows for a safe and effective surgical treatment alternative.

Abstract No. 800

Techniques for Percutaneous Image-Guided Radiofrequency Ablation for Chronic Hip Pain

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LEARNING OBJECTIVES: To review the anatomical targets, diagnostic imaging, patient selection, procedural approach, potential complications, and reported outcomes in percutaneous radiofrequency ablation (RFA) of articular branches of the femoral (FN) and obturator nerve (ON) to treat chronic hip pain.

BACKGROUND: Hip pain, presenting as groin or posterolateral pain, is prevalent in 7% to 10% of patients older than the age of 45 years, most commonly due to osteoarthritis, which can impact ambulation and quality of life. RFA is commonly used to treat chronic knee and back pain. With the emergence of new techniques and a better understanding of the intricate anatomy of the hip, adaptation of RFA for refractory hip pain can provide relief for patients without the extended recovery period.

CLINICAL FINDINGS/PROCEDURE DETAILS: Patients considering RFA first undergo diagnostic nerve blocks. Under fluoroscopy, a 25- or 22-gauge spinal needle is advanced to the cortex at the anatomic landmarks for the articular branches of the FN (12 o'clock superior acetabular position) and the ON (just inferior to the "teardrop" silhouette at the junction of the pubic and ischial bones). 1-2 mL of 0.5% bupivacaine is then injected at each site. A patient is deemed a good candidate for RFA if they report at least a 50% reduction in their pain.

For the RFA, a 17-gauge Coolief RF introducer cannula is advanced under fluoroscopy to the anatomic locations of the articular branches of the FN and ON. The ablation probes are then advanced through the cannulas and motor function testing using 2Hz/2V stimulation is performed to ensure no gross muscle fasciculations are observed. Ablation at each nerve site is performed for 2 minutes to reach a target temperature of 80 degrees. Evidence from cadaveric studies have suggested that repositioning the ON probe 1 cm inferior to the first target for a second ablation has superior results. A small volume of 0.75% bupivacaine and triamcinolone is then administered at each ablation site.

This procedure takes about 15 minutes with total fluoroscopy time under 0.8 minutes. The patients can go home after a 30-minute observation. Available studies demonstrate 100% technical success with immediate post-operative relief which has been replicated in our clinical practice. Patients are scheduled to follow-up at 1 and 6 months post procedure, and the ablation can be repeated if needed.

CONCLUSION AND/OR TEACHING POINTS: Percutaneous RFA of the hip joint is a minimally invasive, outpatient intervention that can bring immediate long-term functional improvement to patients with recalcitrant hip pain who are poor surgical candidates.

Abstract No. 801

Techniques for Percutaneous Image-Guided Cooled Radiofrequency Ablation for the Management of Refractory Greater Trochanteric Pain Syndrome

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LEARNING OBJECTIVES: To describe the pathophysiology of greater trochanteric pain syndrome (GTPS) as well as indications and procedural techniques for image-guided cooled radiofrequency ablation (CRFA) of the trochanteric nerves.

BACKGROUND: GTPS is one of the most common causes of lateral hip pain in adults and is caused by repetitive hip abduction and stabilization motions resulting in gluteus medius and minimus tendinopathy. After failed conservative therapy, glucocorticoid injections may offer short-term pain relief, however, repeated injections pose a risk of steroid-induced tendon rupture and many patients will continue to experience chronic pain despite intervention. CRFA of the trochanteric branches of the femoral nerve is a minimally invasive approach to treat refractory GTPS in select patients.

CLINICAL FINDINGS/PROCEDURE DETAILS: Patients with chronic GTPS considering CRFA first undergo diagnostic nerve blocks. The patient is placed in a prone position. Under fluoroscopy, the anatomical landmarks for the trochanteric branches of the femoral nerves at the femoral head and greater trochanter are identified. The posterior aspect of the greater trochanter is targeted to avoid the insertions of the gluteus medius and quadratus femoris. Two 25- or 22-gauge spinal needles are advanced under fluoroscopic guidance to the periosteum. A small volume of 0.5% bupivacaine is injected at each site. A patient is deemed a good candidate for CRFA if they report at least a 50% reduction in their pain.

For the ablation, two 17-gauge CRFA introducer cannulas are advanced under fluoroscopy to the anatomic locations of the trochanteric nerves. The ablation probes are then advanced through the cannulas and motor function testing using 2Hz/2V stimulation is performed to ensure no gross muscle fasciculations. Ablation at each nerve site is performed for 2 minutes to reach a target temperature of 80 degrees. A small volume of 0.75% bupivacaine and triamcinolone are administered at each ablation site to control pain and inflammation.

This outpatient procedure takes approximately 15 minutes with a total fluoroscopy time under 0.8 minutes and minimal blood loss. After observation for 30 minutes in the post-operative area, patients can go home the same day. Patients are scheduled to follow-up after 1-month and 6-month post procedure, and the ablation can be repeated if needed.

CONCLUSION AND/OR TEACHING POINTS: Percutaneous CRFA of the greater trochanter is a minimally invasive, outpatient intervention that can bring immediate long-term functional improvement to patients with greater trochanteric pain syndrome who are poor surgical candidates.

Abstract No. 802

Vertebral Compression Fractures: Optimal Augmentation Material Selection

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LEARNING OBJECTIVES: (1) To review current augmentation material options for treatment of vertebral compression fractures including injectable polymethyl methacrylate (PMMA), composite cement, biodegradable cement, calcium phosphate cement (CPC), and newer cementless biologic materials. (2) To present the optimal role of each agent based on the clinical and anatomic scenario. (3) To highlight the varying biomechanical and biochemical effects each augmentation material has on the spine. (4) To recognize the unique benefits, risks, and complications associated with each augmentation material.

BACKGROUND: Vertebral compression fractures remain a leading cause of morbidity and mortality affecting nearly 1.5 million individuals in the United States annually. Augmentation remains an effective intervention for vertebral compression fractures that are refractory to nonoperative management and results in pain improvement, decreased opioid requirements, and enhancement of quality of life. Multiple augmentation materials are available for interventional therapy including unique cement formulations and biologics. Each material has distinctive characteristics, and operator optimal selection of agent can improve technical and clinical outcomes in spinal augmentation procedures.

CLINICAL FINDINGS/PROCEDURE DETAILS: This exhibit will describe the biomechanical and biochemical effects of injectable PMMA, composite cement, biodegradable cement, CPC, and biologic material on the spine. Pictorial models will be used to demonstrate the relevant anatomic and procedural details that accompany augmentation with each material. Evidence-based review of the literature will be provided to assess the clinical and technical outcomes of each agent. Lastly, there will be a discussion on future improvements in care through the exploration of available augmentation agents and materials under development.

CONCLUSION AND/OR TEACHING POINTS: After reviewing this exhibit, the viewer will gain a deeper understanding of spinal augmentation materials, proper agent selection for optimal clinical and technical outcomes, and current and future developments in spinal augmentation techniques and agents.

Abstract No. 803

Interventional Pain Management: Now and Future

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LEARNING OBJECTIVES: Provide information about the current approach to pain management in acute and elective settings. Compare and illustrate the routine applications of interventional radiology

to relief of pain. Discuss the results of commonly practiced pain management procedures, the role of advanced image-guided modalities and role of interventional radiologists.

BACKGROUND: Pain management in cancer patients, elderly, and children are challenging that often requires minimally invasive procedures and an interdisciplinary approach. Commonly used methods such as intercostal nerve block, spinal injection, and other peripheral nerve injections that preferred for non-cancer-induced pain, while nerve ablation is generally preferred for severe medication-resistant cancer-related pains. Recently, more advanced techniques such as deep brain stimulation become a novel approach to pain management. Moreover, there are interventional therapies to relieve pain through tumor ablation, embolization, and vertebral augmentation. Interventional pain management offers an efficient, minimally invasive approach with fewer side effects and risks than traditional methods.

CLINICAL FINDINGS/PROCEDURE DETAILS: This educational exhibit will provide various currently available interventional pain management approaches. We will illustrate techniques used in pain management with indications, contraindications, possible alternatives, and potential risks. We will also discuss and review the role of interventional radiologists and emerging image guidance systems in interventional pain management.

CONCLUSION AND/OR TEACHING POINTS: There are multiple pain management options available for the patient. However, treatment-resistant patients often require a multidisciplinary approach and novel technique. Minimally invasive procedures offer a relatively safe option for pain management. Advancements in image-guided technologies can provide a more efficient and safer procedure option for pain management.

Abstract No. 804

An Interventionalist's Guide to Performing Abdominopelvic Nerve Blocks

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LEARNING OBJECTIVES: (1) Describe the indications for performing nerve blocks within the abdomen and pelvis. (2) Review the clinically relevant anatomy and intervention technique. (3) Highlight the technical challenges and troubleshooting methods. (4) Discuss various complications and post-procedure management.

BACKGROUND: Abdominal and pelvic nerve blocks are minimally invasive procedures that aim to prevent the perception of pain from an offending location. These therapies are often employed in the setting of post-operative pain, refractory chronic pain, or severe acute pain. Their use limits the need for opioid pain management and its inherent risks while providing effective pain management when alternatives are inadequate. Interventional radiologists are often called on to perform these procedures when imaging expertise is required to locate and block the nerve.

CLINICAL FINDINGS/PROCEDURE DETAILS: A case-based approach illustrating a variety of abdominal and pelvic nerve blocks will be

presented including celiac plexus block, hepatic hilar nerve block, renal hilar block, hypogastric nerve block, pudendal nerve block, ilioinguinal/iliohypogastric nerve blocks, and obturator nerve block.

CONCLUSION AND/OR TEACHING POINTS: Abdominal and pelvic nerve blocks are useful tools in the interventional armamentarium to provide adequate pain relief and help improve patients' experiences in interventional radiology.

Abstract No. 805

Percutaneous Image-Guided Basivertebral Nerve Radiofrequency Ablation for Chronic Low Back Pain

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LEARNING OBJECTIVES: (1) To review etiology, clinical presentation, diagnostic imaging, and treatment options for chronic low back pain. (2) To describe indications, procedural techniques, outcomes, adverse effects, and clinical efficacy for percutaneous radiofrequency ablation of basivertebral nerves.

BACKGROUND: Low back pain is a ubiquitous concern in healthcare, posing many challenges because of its variation in etiology and presentation. Vertebral body degenerative changes can be visualized on magnetic resonance imaging and classified as Modic type changes of the endplate marrow, with a high specificity for correlating with chronic vertebrogenic axial low back pain. Basivertebral nerve (BVN) ablation is an emerging procedure that provides relief to patients with chronic low back pain that is unresponsive to treatment.

CLINICAL FINDINGS/PROCEDURE DETAILS: Patient selection for radiofrequency ablation (RFA) for chronic vertebrogenic low back pain involves physical exam, documentation of impaired function, and evaluation of imaging to identify Modic type changes of the lumbar vertebral bodies. The BVN, which is the main nociceptive carrier from damaged vertebral endplates, is targeted. RFA of the BVN is performed with the patient in the prone position. Local anesthesia with 1% lidocaine is administered and a small dermatotomy is made with a scalpel. Under fluoroscopic guidance, a cannula assembly is advanced through the target vertebral pedicle starting with a superolateral access point. The introducer needle is removed and a curved cannula assembly is advanced to create a channel to the trunk of the BVN in the posterior 1/3 of the vertebral body at the midline of the bone. A radiofrequency probe is inserted into the curved path and placed at the trunk of the BVN. The nerve is then ablated for 15 minutes at 85°C. This procedure can be repeated in a single session if there are multiple vertebral targets. The trocars are then withdrawn and hemostasis is achieved with manual compression or pressure dressings. Patients should be monitored for vital signs and neurological function after the procedure. Available studies demonstrate no reports of spinal cord injury, avascular necrosis, or post-procedure infection. BVN RFA has become increasingly recommended in patients with pain greater than five years in duration that is unresponsive to prior treatment.

CONCLUSION AND/OR TEACHING POINTS: Basivertebral nerve ablation is a novel, minimally invasive treatment option that has been shown to

provide relief to patients whose chronic vertebrogenic low back pain has not improved with alternative treatment.

Abstract No. 806

An Interventional Radiologist's Primer for Congenital Cardiac Repair

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LEARNING OBJECTIVES: Provide a pictorial review of congenital cardiac repairs with relevance to procedures performed by vascular and interventional radiologists).

BACKGROUND: About 25% of patients with congenital heart defects (CHDs) require surgery which entails alteration or creation of new vascular anatomy. As vascular and interventional radiologists' role in assessing and treating pediatric surgical patients increases, understanding these surgically corrected anatomy, imaging findings and interventional implications associated with common CHDs is imperative.

CLINICAL FINDINGS/PROCEDURE DETAILS: Blalock-Taussig shunts are temporary shunts used to increase pulmonary blood flow while pulmonary artery (PA) pressures normalize; on imaging, a synthetic graft connects the subclavian artery to the PA. A bidirectional Glenn (BDG) shunt is an end-to-side anastomosis between a ligated superior vena cava (SVC) to the right PA. For vascular and interventional radiologists, the placement of central lines will demonstrate tip termination in the PA. There is possibility of SVC syndrome, shunt thrombosis, pulmonary arteriovenous malformations, or aortopulmonary collaterals. The Norwood procedure treats hypoplastic left heart syndrome. On imaging, the SVC empties into the PA through a BDG shunt; the inferior vena cava (IVC) blood empties to the PA through a Fontan conduit. There are two Fontan approaches. In the lateral tunnel approach, an atriotomy is created for a baffle for caval blood to reach the right PA. In the extracardiac conduit approach, the IVC is divided at the cavoatrial junction. A synthetic conduit connects the IVC to the right PA. Thrombosis is common; many require life-long anticoagulation. In the Damus-Kaye-Stensel procedure for transposition of the great arteries, the main PA is divided and the proximal PA is anastomosed to the ascending aorta; a conduit connects the RV to the distal PA. In the Waldhausen procedure for aortic coarctation, the left subclavian artery is ligated and used as a flap. In total anomalous venous pulmonary return, the extracardiac repair approach involves anastomosing the venous confluence to the left atrium (LA). In the cardiac approach, the wall between the coronary sinus and the LA is cut. In partial anomalous pulmonary venous return, the anomalous pulmonary vein drains into a systemic vein instead of the RA; for interventional radiologists, this may present as a malpositioned line on imaging.

CONCLUSION AND/OR TEACHING POINTS: For vascular and interventional radiologists, CHD and their surgical repairs encompass a wide-range of anatomic considerations to perform safe interventional procedures. This pictorial review will include imaging and illustrative diagrams highlighting the key findings for the major types of congenital cardiac repairs.

Abstract No. 807

Percutaneous Cholecystocholangiogram in the Evaluation of Biliary Atresia

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LEARNING OBJECTIVES: Review the clinical utility, technical considerations, and normal and abnormal findings of percutaneous transhepatic cholecystocholangiogram in the evaluation for biliary atresia (BA).

BACKGROUND: Morbidity and mortality in infants with BA are greatly impacted by timely diagnosis and treatment. Diagnostic evaluation of neonatal cholestasis includes laboratory tests, non-invasive imaging with nuclear medicine and ultrasound, and percutaneous liver biopsy, although diagnostic errors may occur particularly early in the course of the disease. The gold standard has been intra-operative cholangiogram for the diagnosis of biliary atresia. Percutaneous transhepatic cholecystocholangiogram (PCC) may be performed by pediatric interventional radiology if the gallbladder is visualized at the time of percutaneous liver biopsy in the evaluation of biliary atresia. PCC has been shown to decrease the negative laparotomy rate by up to 47%.

CLINICAL FINDINGS/PROCEDURE DETAILS: Using ultrasound guidance, a small 21- to 25-gauge needle is advanced into the gallbladder via a transhepatic approach. Contrast is injected under fluoroscopic guidance to opacify the biliary tree. Examples of normal and abnormal PCC studies are presented. A normal PCC fully opacifies the gallbladder, cystic duct, intra- and extra-hepatic biliary tree, and duodenum. An abnormal PCC is compatible with biliary atresia if the biliary tree is diminutive, tortuous, and incompletely opacified.

CONCLUSION AND/OR TEACHING POINTS: Percutaneous cholecystocholangiogram is a minimally invasive diagnostic procedure that can be performed by pediatric IR at the time of percutaneous liver biopsy in the evaluation of biliary atresia.

Abstract No. 808

Transcholecystic Cholangiogram for Neonatal Hyperbilirubinemia: Techniques and Spectrum of Imaging Findings

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LEARNING OBJECTIVES: (1) Describe technical considerations for sonographic gallbladder identification and percutaneous access in

neonates with hyperbilirubinemia. (2) Identify potential complications with and alternatives to transcholecystic cholangiography (TCC). (3) Review the differential diagnosis of neonatal hyperbilirubinemia and the spectrum of imaging findings on cholangiography.

BACKGROUND: Infants with persistent cholestasis and conjugated hyperbilirubinemia require expedited evaluation to exclude biliary atresia. Although the historical gold standard for diagnosis of biliary atresia has been intraoperative cholangiography, this requires laparotomy, which can be problematic for critically ill neonates who are not ideal surgical candidates. Percutaneous approaches such as TCC can offer a safe, minimally invasive alternative for these high-risk neonates.

CLINICAL FINDINGS/PROCEDURE DETAILS: Here we present our institutional experience of patients that highlight the utility and efficacy of TCC. We discuss clinical manifestations as well as the interventional radiologist's role in the diagnostic stratification of neonatal hyperbilirubinemia. A comprehensive pictorial review of proper pre-procedural work-up, indications, contraindications, imaging findings and technical considerations for TCC are presented. Using a case-based format, procedural steps are outlined, and potential pitfalls and complications are emphasized.

CONCLUSION AND/OR TEACHING POINTS: Interventional radiologists can play a pivotal role in the diagnosis and management of neonatal hyperbilirubinemia. In the case where surgery is not a reasonable option for the patient, TCC is a safe, effective, minimally invasive alternative. With knowledge of basic principles of TCC and a firm understanding of potential pitfalls, interventional radiologist can be equipped to manage even the smallest of patients.

Abstract No. 809

Percutaneous Distal Deep Venous Arterialization (dDVA): A Case-Based Review of Clinical Indications and Interventional Techniques

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LEARNING OBJECTIVES: (1) To describe percutaneous distal deep venous arterialization (dDVA) via a case-based discussion, including patient selection, technical tips, post-procedural management, and clinical follow-up. (2) To highlight advantages and technical differences of distal deep venous arterialization compared with the more conventional proximal deep venous arterialization (pDVA).

BACKGROUND: Chronic limb-threatening ischemia (CLTI) is the most severe complication of peripheral artery disease (PAD), which affects about 8.5 million Americans. Patients with "no-option" CLTI, including those without patent arteries in the foot ("desert foot" or "small vessel disease"), do not benefit from surgical bypasses and may fail even the most complex endovascular arterial procedures. pDVA, in which an arteriovenous fistula is created percutaneously between the proximal tibial artery and vein, usually with stent grafts placed along the

length of the vein to the ankle, has increasingly been used to offer an additional limb salvage option to these patients. pDVA can be associated with severe side effects, known as DVA storm. A newer variation of the DVA technique, dDVA, has potential advantages to reduce venous hypertension, obviate the need for stent grafts to lower cost, and diminish deleterious side effects.

CLINICAL FINDINGS/PROCEDURE DETAILS: Percutaneous dDVA involves percutaneous creation of a fistula between a distal tibial artery and distal tibial vein, usually just above the ankle joint, in conjunction with disruption of venous valves in the foot. Stent scaffolding is used only at the fistula site or avoided altogether. This exhibit will highlight real-world clinical scenarios, including discussion of indications, complications, intraprocedural tips, and post-procedural management of the dDVA procedure. Various procedural techniques including catheter selection, techniques of fistula creation with commercial devices or gunsight technique will be described with follow-up clinical images.

CONCLUSION AND/OR TEACHING POINTS: Percutaneous dDVA provides patients with “no-option” CLTI an opportunity for wound healing and limb salvage with potential advantages compared with pDVA. As interventional radiologists are increasingly caring for patients with CLTI, they must be familiar with patient selection and procedure planning for dDVA to be successful and effective.

Abstract No. 810

An Overview of Noninvasive Evaluation of Peripheral Artery Disease

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LEARNING OBJECTIVES: To review noninvasive modalities commonly used to assess peripheral arterial disease including arterial duplex, ankle-brachial index, pulse volume recordings, segmental pressures, toe photoplethysmography (toe PPG), transcutaneous oximetry (TcPO₂), and skin perfusion pressure (SPP) measurement.

BACKGROUND: Physiologic testing in patients with lower extremity peripheral arterial disease is an essential component in the work-up and management of these patients. Non-invasive physiologic testing helps determine if anatomic findings on cross-sectional imaging (computed tomography angiography, magnetic resonance angiography) are physiologically significant. The available testing methods can also serve as stand-alone tests to diagnose peripheral arterial disease, stratify the severity of disease, help prognosticate the likelihood of wound healing post-intervention, identify failure of previous intervention, and highlight the need for reintervention. We present here a review of various non-invasive testing modalities available.

CLINICAL FINDINGS/PROCEDURE DETAILS: This exhibit will (1) provide a review of common non-invasive physiologic testing modalities for evaluating patients with PAD. This review will include the arterial duplex, ankle-brachial index, pulse volume recordings, segmental limb pressures, toe photoplethysmography (toe PPG), transcutaneous oximetry (TcPO₂), and skin perfusion pressure (SPP) measurement; (2) describe

how to perform bedside ABI; (3) illustrate how segmental pressures, pulse volume recordings, toe PPGs, TcPO₂, and SPP are obtained and interpreted; (4) describe how to use arterial duplex, ABIs, PVRs, and segmental pressures to determine the distribution of disease using a case-based review; and (5) highlight specific advantages and limitations of each non-invasive testing modality.

CONCLUSION AND/OR TEACHING POINTS: Knowledge of updated non-invasive evaluative methods for peripheral arterial disease is critical to identifying hemodynamically significant lesions, assessing the next steps of care, and determining the success of prior interventions. Proficiency in these techniques along with an understanding of their advantages and limitations is significant in determining patient outcomes.

Abstract No. 811

Basics of Lower Extremity Wound Evaluation and Management

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LEARNING OBJECTIVES: (1) Detail the Wound, Ischemia, and Foot Infection (WiFi) Classification system. (2) Demonstrate a systemic method of lower extremity wound evaluation. (3) Highlight physical exam and laboratory findings that help differentiate chronic ischemic changes from acute infectious changes. (4) Differentiate debridement and dressing options for wound management.

BACKGROUND: Outcomes of patients with chronic limb-threatening ischemia depends on wound management. Because poor wound management following revascularization can lead to limb loss, wounds must be systematically evaluated, debrided, and dressed to promote maximum change of wound healing and limb salvage.

CLINICAL FINDINGS/PROCEDURE DETAILS: This exhibit will (1) review the WiFi Classification system and its significance to determine potential for wound healing and amputation risk; (2) discuss physical exam findings, erythrocyte sedimentation rate and C-reactive protein blood tests, and radiographs to guide evaluation of wounds; (3) compare and contrast wound debridement strategies including irrigation, surgical intervention, enzymatic method, and biologic method; (4) compare and contrast wound dressing options for various stages of wound healing including polymers, foams, alginates, hydrocolloids, hydrogels, and Hydroactive.

CONCLUSION AND/OR TEACHING POINTS: Evaluation and management of lower extremity wounds is essential, especially in patients with peripheral artery disease, chronic limb-threatening ischemia, or other risk factors for limb loss. Proper wound care, with appropriate debridement and dressing especially, is an essential component to healing following revascularization. Furthermore, routine evaluation of wounds ensures the outcome of revascularization is satisfactory and establishes whether additional intervention is required.

Abstract No. 812

An Update on Devices Used in Vascular Disease

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LEARNING OBJECTIVES: (1) Explore cutting-edge vascular devices recently approved by the FDA within the past year. (2) Highlight the advantages of these devices and how they are used to target specific vascular diseases. (3) Identify the limitations of current vascular devices and areas of future improvement.

BACKGROUND: Vascular disease (VD) comprises various pathologies of the circulatory system affecting nearly 200 million people globally leading to billions of dollars in healthcare spending. The insidious nature of this disease explains why most patients remain asymptomatic until complications such as claudication, myocardial infarction, or stroke ensues. We have seen a trend toward increasingly less invasive modalities that leverage structural and pharmacological innovation to manage these complex pathologies. In this educational exhibit, we will be reviewing the most recent FDA-approved devices used to treat VD.

CLINICAL FINDINGS/PROCEDURE DETAILS: In 2022, we saw advancements in coronary and cerebral stenting using new balloon and stent technology, novel delivery of pharmacologic adjuncts, structural innovations for aortic valve repair, and improved catheter ablation devices to treat abnormal heart rhythms. The FDA has approved nine devices used in endovascular repair (GORE TAG), cerebrovascular stenting (NeVA VS), coronary stenting (BIOFREEDOM/SLENDER), carotid artery stenting (ENROUTE), balloon angioplasty (Stellarex), aneurysm repair (Thoraflex Hybrid), catheter ablation (TactiCath), and aortic valve repair (Portico). This exhibit will highlight the indications, advantages, disadvantages, and future direction for using these devices in the sphere of vascular and interventional radiology.

CONCLUSION AND/OR TEACHING POINTS: As the incidence of VD increases, devices used in vascular interventional radiology are continually improving. In this exhibit, the learner will gain an overview of the current techniques and procedures used in treating vascular disease. The limitations discovered from the implementation of these modalities are uncovering new avenues of investigation. Overall, understanding these cutting-edge devices will improve the management of VD, and therefore is important for all vascular and interventional radiologists.

Abstract No. 813

A Review of Techniques to Cross Lower Extremity Chronic Thrombotic Occlusions

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LEARNING OBJECTIVES: (1) Understand various chronic thrombotic occlusion (CTO) morphology and its relevance to intervention. (2) Elaborate on a few CTO crossing algorithms, and how or whether they

are relevant for intervention. (3) Explain various antegrade and retrograde CTO crossing techniques and available hardware.

BACKGROUND: Peripheral arterial disease (PAD) is currently an epidemic in the US particularly with the older age, and comorbidities such as diabetes mellitus. Currently, surgeons and cardiologists are the leading providers of vascular intervention for PAD. Given the origin of PAD intervention within the field of interventional radiology, it is vital to keep up to date with new techniques and hardware for peripheral arterial intervention. Chronic thrombotic occlusions (CTO) are highly prevalent in the PAD, and the techniques below can assist with crossing the lesion, allowing increased blood supply and saving limbs.

CLINICAL FINDINGS/PROCEDURE DETAILS: Endovascular crossing of CTOs is vitally important in PAD, particularly in patients with severe disease when they have critical limb ischemia. Intervention can prevent surgical amputations, and improve wound healing in patients with wounds related to arterial ulcers or diabetes. Strategies for lesion crossing can possibly be made more algorithmic based on plaque morphology. The importance of CTO plaque morphology, and how it allows for easier retrograde vs antegrade intervention, and intimal vs subintimal recanalization will be discussed. There are currently a few available CTO intervention algorithms such as those by Roy, and Banerjee that will be discussed. However, their use has not been extensively validated and criticisms and controversies will be addressed. Most importantly, the varying techniques for CTO crossing will be discussed using cases including sliding, drilling, drilling via specialized hardware, parallel wire, subintimal recanalization, ablation of plaque, CART, reverse CART, SAFARI, and various flossing-based techniques will be discussed.

CONCLUSION AND/OR TEACHING POINTS: After the presentation, learners will be able to describe the common algorithms for approaching CTOs, and describe the numerous available techniques and common hardware. This should help to serve as an introduction to further practicing such techniques under supervision.

Abstract No. 814

Needleless Technique for Trans-splenic Portosystemic Shunt Creation: A Case Series

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LEARNING OBJECTIVES: The purpose of this case series is to present two cases of trans-splenic portosystemic shunt creation via a novel needleless technique in patients unable to receive conventional trans-jugular intrahepatic portosystemic shunt (TIPS).

BACKGROUND: TIPS is a less invasive alternative to conventional surgical portosystemic shunts. TIPS has become a well-established treatment of portal hypertension due to its minimally invasive nature and low rates of major complications. Trans-splenic TIPS has generally been avoided due to the hypervascularity of spleen increasing the risk of massive hemorrhage. However, a trans-splenic approach has shown to be beneficial in situations when conventional TIPS is unfavorable.

CLINICAL FINDINGS/PROCEDURE DETAILS: Two patients in their 60s with extensive portal vein thrombosis (PVT) necessitating TIPS were included. In both cases, portosystemic shunt was created via a trans-splenic approach, due to unfavorable anatomy and portal thrombus. Using catheter and guidewire, trans-parenchymal subintimal access was obtained from the portal vein to the hepatic venous system. The wire and catheter were advanced to the inferior vena cava and snared from a trans-jugular approach flossing the patient. Thus allowing stent graft deployment via a traditional transjugular approach.

Both patients demonstrated improved PV patency on post-procedure imaging. No immediate complications were observed. In one case, ascites was significantly improved, and patient was subsequently discharged to hospice. In the second case, subsequent imaging demonstrated improved mesenteric edema and resolving bowel ischemia. This patient was successfully discharged, and is undergoing routine surveillance for shunt patency.

CONCLUSION AND/OR TEACHING POINTS: TIPS has been proven effective for patients with refractory ascites, variceal bleeding, or portal vein thrombus. Classically, portosystemic shunt is created from the right or middle HV to an intrahepatic PV. In cases with difficult anatomy, or portal vein thrombus, trans-splenic access may be obtained to provide a portal vein target for needle passes from a trans-jugular approach. In both cases presented in this review, transsplenic access was used for direct portosystemic shunt creation via a needle-less trans-parenchymal subintimal approach. This novel technique has not been previously described in the literature, and should be considered in cases where traditional TIPS is not possible.

Abstract No. 815

Tips for Dealing with Unsuccessful TIPS (Transjugular Intrahepatic Portosystemic Shunt): An Image-Rich Primer of Procedural Alternatives in the Setting of Unsuccessful TIPS

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LEARNING OBJECTIVES: To discuss procedural alternatives to standard TIPS technique, which may become necessary with unfavorable anatomy and/or portal vein thrombosis.

BACKGROUND: With increasing indications and a greater volume of patients meeting the criteria for TIPS procedure, request for TIPS in patients with complex anatomy and pathophysiology has become more common. Indications for TIPS includes the treatment for portal hypertension, refractory ascites, Budd-Chiari syndrome, variceal bleeds and more. Portal vein thrombosis and unfavorable vascular anatomy between the hepatic and portal systems can lead to unsuccessful TIPS through the traditional method. Some alternatives to the standard TIPS procedure include DIPS (direct intrahepatic portosystemic shunt), transsplenic access, transvariceal access, and mini-laparotomy with a transmesenteric approach. By obtaining dedicated contrast-enhanced preprocedural imaging, interventional radiologists

can execute preprocedural planning, and stratify patients to conventional TIPS versus alternative procedures.

CLINICAL FINDINGS/PROCEDURE DETAILS: Diagrams, procedural technique, and intraprocedural images will be provided for each of the following procedures: (1) direct intrahepatic portocaval shunt (DIPS), (2) transsplenic TIPS, (3) transvariceal TIPS, and (4) transmesenteric TIPS.

CONCLUSION AND/OR TEACHING POINTS: The use of TIPS has become more common place with an increasing number of indications, making it vital for medical students, trainees, and early career interventional radiologists to be familiar with alternative/salvage techniques. With the aid of an image rich review, the audience will be able to better understand how these procedures can be performed and what the major steps are under ultrasound and fluoroscopic guidance.

Abstract No. 816

Beyond the TIPS: An Approach to Direct Intrahepatic Portocaval Shunt Creation

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LEARNING OBJECTIVES: The focus of this educational exhibit is to present a case of direct intrahepatic portocaval shunt (DIPS) creation in a patient with hepatocellular carcinoma and portal hypertension following a failed transjugular intrahepatic portosystemic shunt (TIPS) creation secondary to extensive portal vein thrombosis.

BACKGROUND: TIPS has been widely established as an effective minimally invasive procedure to treat the complications associated with portal hypertension in patients with decompensated cirrhosis. However, in a subset of patients with portal vein thrombosis or unfavorable anatomy secondary to prior surgical intervention or anatomic variants, conventional TIPS may not be feasible. In this setting, a DIPS can be performed using real-time image guidance to access the portal vein via the inferior vena cava and create a side-to-side portocaval shunt.

CLINICAL FINDINGS/PROCEDURE DETAILS: We will detail an approach to DIPS placement which used a combination of fluoroscopic guidance and intraprocedural cone-beam computed tomography to delineate the relevant anatomy. In contrast to many of the cases described in the current literature, our method illustrates the technique employed to perform the procedure in a safe manner without the aid of intravascular ultrasound (IVUS). The use of mechanical thrombectomy and adjunctive variceal embolization will also be discussed. The preprocedural imaging, procedural steps/angiographic findings, outcomes and potential complications will be reviewed while also highlighting the evidence provided in the most recent retrospective studies. Given the relative infrequency with which DIPS is performed compared with TIPS at most institutions, an emphasis will be placed on important factors that need to be considered to safely perform the procedure without the use of IVUS.

CONCLUSION AND/OR TEACHING POINTS: After reviewing this educational exhibit, the viewer will gain a better understanding of the techniques and pearls involved in performing a DIPS to decompress the

portal system in patients for which TIPS creation may be technically difficult due to a variety of anatomical reasons.

Abstract No. 817

Alternative/Adjunctive Approaches for Transvenous Obliteration of Gastric Varices

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LEARNING OBJECTIVES: To discuss various approaches, techniques, efficacy, and complications associated with transvenous obliteration of gastric varices.

BACKGROUND: Hemorrhage from gastric varices remains a major cause of morbidity and mortality in patients with portal hypertension. Traditionally, retrograde transrenal vein approach for obliteration of gastric varices is an effective method in controlling variceal bleeding; however, in cases with difficult cannulation or absence of gastrosplenic shunt, its management becomes challenging. Alternative routes and adjunctive approaches used for management in such cases is discussed here.

CLINICAL FINDINGS/PROCEDURE DETAILS: Alternative routes are divided into portal venous access routes and systemic venous access routes. Procedural technique, efficacy, and complications of each of these approaches is discussed.

Portal venous access routes discussed include direct percutaneous puncture of portal vein and trans-TIPSS access. Antegrade obliteration of the gastric varices is then done with balloon/plugs/coils/glue followed by distal embolization using sclerosant (BATO/PATO).

Systemic venous access routes: When GRS is absent and in cases with portal vein thrombosis/ cavernoma formation, portal venous access is difficult. Here direct access into the systemic veins draining into the GV can be done. We will describe access into the following systemic veins: left inferior phrenic vein, the pericardial vein, paraesophageal vein.

We will also discuss combination of various access routes (retrograde-antegrade, antegrade-transcollateral) for complete obliteration of GV, in complex cases or in cases with incomplete obliteration.

CONCLUSION AND/OR TEACHING POINTS: Knowledge of the various afferent-efferent pathways of the gastric varices and its depiction on pre-procedural computed tomography is essential for planning and choosing appropriate route for treatment. When traditional treatment methods for transvenous obliteration of the gastric varices fail, alternative and adjunctive approaches can be a valuable option to improve clinical outcomes.

Abstract No. 818

Achieving Competence in Evaluation & Management Billing in the Outpatient Setting

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LEARNING OBJECTIVES: (1) Highlight the importance of evaluation and management (E&M) billing to the growth of interventional radiology (IR). (2) Understand the different work relative value units (RVUs) associated with each code. (3) Demonstrate how interventional radiologists can use different levels of code to capture time spent or provide detailed documentation for each clinical encounter. (4) Maximize work RVUs for work already being done by accurately reflecting the service provided.

BACKGROUND: As health care evolves, medical specialties providing patient-facing services are increasingly more valued, with policymakers using E&M billing to determine our value. Over the past decade, IR has become a more clinical service with pre- and post-procedural care in both inpatient and outpatient settings. Outstanding patient care demands clinical excellence, and due to the complexity of medical decision-making in IR, E&M services and documentation are critical and medically necessary. Interventional radiologists must understand how to accurately bill for the services provided to maximize revenue, promote our specialty's growth, and optimize patient care.

CLINICAL FINDINGS/PROCEDURE DETAILS: The IR department at our institution generated 4,213 RVUs for E&M in the 2022 fiscal year. We will focus on E&M billing for outpatient/televisit RVUs for this exhibit. An outpatient clinical encounter may be categorized as one of two options: consultation or office visit, and either as a new patient or established patient. A consultation, a service requested by another physician for an opinion on the E&M of a specific problem, requires documentation in the electronic medical record and written communication to the requesting physician, and thus, generally carries higher reimbursement than office visit codes. However, only office visit codes are eligible for Medicare billing. Encounter codes are billed based on the time spent or on the aggregate of points associated with specific components of documentation, which we will summarize in this exhibit. Additionally, we will provide data from our institution to demonstrate the RVUs associated with each code and the total RVUs generated in 2022.

CONCLUSION AND/OR TEACHING POINTS: As IR becomes a more clinical service, outpatient clinical encounters have become a necessary component of pre- and post-procedural care. E&M billing is an important skill for interventional radiologists to maximize departmental revenue, increase the value of our specialty, and optimize patient care. This exhibit will provide examples of outpatient/televisit clinical encounters and walk the learner on how to appropriately bill for each encounter.

Abstract No. 819

Interventional Radiology as a Clinical Specialty: Trends in Use of Outpatient E&M Services by Interventional Radiologists Over a 10-Year Period

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LEARNING OBJECTIVES: To evaluate the trends in utilization of Evaluation and Management (E&M) codes by interventional radiologists over a 10-year period by reviewing Medicare Part B utilization data provided by the Centers for Medicare & Medicaid Services (CMS) between 2010 and 2019.

BACKGROUND: In recent years, many interventional radiology (IR) practices have spotlighted the importance of maintaining or creating robust outpatient clinics. To better understand financial reimbursement in the outpatient setting, it is essential to have a basic understanding of the overall utilization trends of Current Procedural Terminology (CPT) codes used by interventional radiologists.

CLINICAL FINDINGS/PROCEDURE DETAILS: In 2010, a total of 37,090 outpatient visits were billed to CMS from interventional radiologists. In 2015, this number increased to 73,220 and data from 2019 demonstrates a total of 111,010 E&M services billed. This accounts of an over 199% increase over a 10-year period from 2010 to 2019. Data from 2020 was not used because of the effects of the COVID-19 pandemic.

CONCLUSION AND/OR TEACHING POINTS: As IR continues to grow as a specialty, so does its clinical presence. The data presented demonstrates a strong upward trend in the number of outpatient services reimbursed to interventional radiologists with an over 199% increase of services from 2010 to 2019. It is important to recognize and monitor the utilization of CPT codes among interventional radiologists as this is reflective of reimbursement for these outpatient visits.

Table 819.1

Year	CMS-Allowed Services via Billed E&M Services from Interventional Radiologists
2010	37,090
2011	37,961
2012	42,322
2013	52,466
2014	60,952
2015	73,220
2016	94,877
2017	104,901
2018	109,109
2019	111,010

Abstract No. 820

Bariatric Arterial Embolization: How to Build a Clinical Program?

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LEARNING OBJECTIVES: The goal of this exhibit is to educate the reader on our experience with building a clinical, insurance-supported bariatric arterial embolization (BAE) program that integrates BAE as a part of the standard care path for treating obesity.

BACKGROUND: Obesity is a major public health issue that contributes to significant disability, cardiovascular risk, mortality, and healthcare costs. Over the last 50 years, there has been a dramatic increase in the prevalence of obesity in the United States. Obesity is associated with an increased risk of all-cause mortality and a significant reduction in life expectancy. For these reasons, obesity has been labeled a major

healthcare epidemic in the United States. Thus, there is an urgent need to develop new therapies for obesity.

BAE is an emerging, minimally invasive therapy for patients with obesity. This image-guided transcatheter procedure involves occlusion of the arteries supplying the gastric fundus, which contains the majority of ghrelin-producing cells. BAE has an excellent safety profile with more than 100 patients with obesity having undergone the procedure worldwide, without any significant adverse sequelae. These early findings suggest that BAE may represent an additional tool in the treatment of patients with obesity that could be used alone or in conjunction with a dedicated lifestyle management program.

CLINICAL FINDINGS/PROCEDURE DETAILS: Between July 2021 and April 2022, our interventional radiology (IR) team received 25 consultations for BAE. Of the 25 referrals, 18 patients showed up to their appointments at our clinic, with 7 directly excluded by IR due to technical or medical contraindications and 11 patients considered for interdisciplinary review. In 2 patients, the decision was to give more time with conservative weight management before being re-considered for BAE in the future. One patient declined to pay the out-of-pocket portion after insurance approval. Ultimately, 8 patients were cleared to proceed with BAE. Of whom, 4 patients had already undergone BAE, completed their follow-up with IR, and are currently cared for by their obesity physicians. While the other 4 patients are waiting for computed tomography angiography assessment and/or appointment for the procedure. All patients with disordered eating behaviors were consulted with a psychiatrist before the procedure to ensure stable condition.

CONCLUSION AND/OR TEACHING POINTS: The exhibit provides a step-by-step guide on how to build a successful clinical BAE program, including program structure, patient acquisition and workflow, multidisciplinary discussion process, peri-procedural care, BAE technique, cost analysis, and pearls and lessons learned.

Abstract No. 821

The Effects of COVID-19 on Nonprocedural Billing in Interventional Radiology

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LEARNING OBJECTIVES: The establishment of non-procedural billing practices is imperative for the growth of interventional radiology (IR) as an independent clinical specialty. The upward trend of evaluation and management (E&M) coding in IR is well established. However, the COVID-19 global pandemic threatened to uproot the progress made over recent years. We set out to evaluate the impact of the 2020 pandemic on the trend of IR E&M billing in the United States.

BACKGROUND: Archived fee for service data, Medicare utilization statistics for Part B were accessed from CMS.gov. Specifically the files for "CY Evaluation and Management (E&M) Codes by Specialty" were used from the years 2009 to 2020. The interventional radiology data for inpatient E&M codes (99221-99223, 99231-99234, and 99238-99239) and outpatient EM codes (99201-99205, and 99211-99215) were analyzed and compared using R Studio statistical software.

CLINICAL FINDINGS/PROCEDURE DETAILS: Between 2009 and 2019, outpatient E&M utilization has increased an average of 19.67% per year and inpatient E&M utilization has increased at an average of 10.58% per year. In 2020, outpatient E&M billing decreased by 13%. Inpatient E&M billing, on the other hand, continued the traditional trend and increased by 11%.

Table 821.1

Year	E&M Inpatient-Allowed Charges (\$)	Percent Change from Prior Year (%)	E&M Outpatient-Allowed Charges (\$)	Percent Change from Prior Year (%)
2009	849,338	—	1,763,518	—
2010	1,386,336	+63.23	3,022,504	+71.39
2011	1,387,014	+0.05	3,203,273	+5.98
2012	1,156,155	-16.64	3,581,046	+11.79
2013	1,249,129	+8.04	4,587,822	+28.11
2014	1,619,581	+29.66	5,424,529	+18.24
2015	1,892,782	+16.87	6,631,584	+22.25
2016	2,155,381	+13.87	8,619,451	+29.98
2017	2,083,262	-3.35	9,592,770	+11.29
2018	2,016,643	-3.20	\$10,231,925	+6.67
2019	2,321,532	+15.12	10,622,634	+3.81
2020	2,571,074	+10.75	9,238,040	-13.03

CONCLUSION AND/OR TEACHING POINTS: Outpatient billing by IR during 2020, the year COVID-19 temporarily shut down many outpatient and elective healthcare facilities, decreased by a significant margin. However, non-procedural inpatient billing continued to increase at the same rate as the prior 10 years. A multitude of factors could be influencing this phenomenon, such as increased incidence of thrombi and emboli secondary to COVID-19, the often non-elective/emergent nature of inpatient interventional radiology consultations and procedures, and/or the need for specialists to compensate for the lack of outpatient billing opportunities. Future studies may aim to characterize the underlying origin of these findings.

Table 822.1

Inpatient CPT Code	Encounter Level:	2021 RVUs:	2021 (\$34.8931)	2022 RVUs:	2022 (\$34.6062)	2023p RVUs:	2023p (\$33.0775)
99221	Level 1	1.92	\$66.99	1.92	\$66.44	1.63	\$53.91
99222	Level 2	2.61	\$91.07	2.61	\$90.32	2.6	\$86.00
99223	Level 3	3.86	\$134.69	3.86	\$133.58	3.5	\$115.77
99231	Level 1	0.76	\$26.52	0.76	\$26.30	1	\$33.08
99232	Level 2	1.39	\$48.50	1.39	\$48.10	1.59	\$52.59
99233	Level 3	2	\$69.79	2	\$69.21	2.4	\$79.39
99234	Level 1	2.56	\$89.32	2.56	\$88.59	2	\$66.16
99235	Level 2	3.24	\$113.05	3.24	\$112.12	3.24	\$107.12
99236	Level 3	4.2	\$146.55	4.2	\$145.35	4.3	\$142.23
99238	Level 1	1.28	\$44.66	1.28	\$44.30	1.5	\$49.61
99239	Level 2	1.9	\$66.30	1.9	\$65.75	2.15	\$71.12

Abstract No. 822

Proposed 2023 Changes to CMS Inpatient E&M Reimbursement

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LEARNING OBJECTIVES: Educate interventional radiology (IR) departments on the financial impact of proposed 2023 Centers for Medicare & Medicaid Services (CMS) inpatient E&M reimbursement changes.

BACKGROUND: Financial viability in the inpatient environment is imperative for continued growth of IR as an independent clinical specialty. It is paramount that physicians maintain an understanding and awareness of CMS inpatient encounter reimbursement changes. Evaluation & Management (E&M) codes, which categorize inpatient encounters as “Initial hospital care” (Current Procedural Terminology [CPT] 99221-99223, Levels 1-3), “Subsequent hospital care” (CPT 99231-99233, Levels 1-3), “Osber/hosp same date” (CPT 99234-99236, Levels 1-3), and “Hospital discharge day” (CPT 99238-99239, Levels 1-2) represent increasing complexity of care with correspondingly increased relative value units (RVUs). Significant changes to these reimbursement values are proposed for 2023 in conjunction with a proposed decrease of the conversion factor by \$1.53.

CLINICAL FINDINGS/PROCEDURE DETAILS: The 2023 Medicare Physician Fee Schedule Proposed Rule includes both increases and decreases in work RVU values for inpatient E&M services most commonly used in IR. To analyze the financial impact of these changes, we have compared the 2023 proposed reimbursement for each individual level as they compare to previous years dating back to 2021.

CONCLUSION AND/OR TEACHING POINTS: The proposed 2023 changes to E&M CPT coding have resulted in both increases and decreases in reimbursement for the most commonly used codes in IR. There is an overall decrease in reimbursement for initial hospital care (CPT 99221-99223, Levels 1-3), and observation (CPT 99234-99236, Levels 1-3), across all levels of billing. An increase in reimbursement is demonstrated for subsequent hospital care (CPT 99231-99233, Levels 1-3),

and hospital discharge day (CPT 99238-99239, Levels 1-2), across all billing levels. These changes must be monitored closely to establish financial viability in the inpatient environment.

Abstract No. 823

Primer to Understanding Procedural Billing in Interventional Radiology

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LEARNING OBJECTIVES: Review the billable components and common codes associated with an interventional radiology (IR) patient visit from initial consultation to follow-up clinic.

BACKGROUND: Although radiology residency provides an abundance of opportunities to improve interpretative, clinical, and procedural skills, there is a lack of education regarding the financial components to a procedural subspecialty. Even for trainees not planning to pursue a career in private practice, knowledge in procedural billing will help trainees construct well-documented notes and procedural reports that will subsequently save time from billing audits in addition to supporting sustainable practice patterns. Ultimately, it will also capture and support the value IR brings to the larger department, practice, or healthcare system at large.

CLINICAL FINDINGS/PROCEDURE DETAILS: The learner will review the definition and purpose of Current Procedural Terminology (CPT) codes in relation to IR services. The learner will review the required components for billing a consultation CPT code for an IR procedure, including a proper history, physical examination, and medical decision making. We will differentiate the requirements and benefits of a consultation versus an office visit. Additionally, the learner will be able to identify the different criteria associated with each level of medical decision-making and their corresponding level of consultation CPT codes. For each large category of IR procedures, we will revisit the associated global period for which no additional reimbursement can be made. Finally, we will review the post-procedural follow-up visit CPT code and when it will and will not yield in a reimbursement.

CONCLUSION AND/OR TEACHING POINTS: Following this review, trainees will be able to better understand the financial components of an IR patient encounter from initial consultation to post-procedural clinic visit. Trainees will be better able to structure their inpatient and clinic notes to better capture the required components of a billable encounter.

Abstract No. 824

Peer Learning in Interventional Radiology: Getting By With a Little Help From Your Friends

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LEARNING OBJECTIVES: The adoption of peer review and peer learning processes has been met with friction and hesitancy as there is a stigma these systems will have punitive effects on the practicing radiologists. In reality, the peer learning process is an integral part of generating a just culture within a radiology department and a hospital enterprise as a whole. This exhibit aims to outline the peer learning process used at our institution and the mechanisms used to increase adoption and utilization of peer learning both from an educational and systems-wide perspective.

BACKGROUND: In the past, radiology used a “peer review” structure to promote quality and patient safety within radiologist reports. This relied on a computer opening up a colleague’s prior report and the radiologist indicating if they agreed with the report using a numerical scale. This structure was associated with remuneration and concerns about backlash from staff. To promote a culture of learning and patient safety, our interventional radiology (IR) department has moved to a peer learning model in which attending physicians are asked to review at least one or two of their peers’ cases per month for discrepancies and great calls. This information is then pooled by a patient care champion and reviewed at monthly QI conferences to promote learning, patient safety, and departmental growth.

CLINICAL FINDINGS/PROCEDURE DETAILS: Moving to a peer learning model our IR department has seen a greater buy-in to the QA and M&M process. To improve staff involvement we implemented various tactics which are applicable across hospital systems. First, we integrated our peer learning system (PeerVue) directly into the PACS so that its utilization was part of the daily workflow. We added the qualifier of great call to emphasize that Peer Learning does not only involve pointing out other staff members mistakes, but is also meant to celebrate successes. Finally, we use the information submitted to PeerVue in an anonymized fashion as the driving force for our QA/M&M conferences, which demonstrates to participating physicians that their work is being used for educational purposes and to effect change within the department.

CONCLUSION AND/OR TEACHING POINTS: Embracing the Peer Learning model within our IR department has been used to promote staff education and effect improvements in the realms of patient safety and education. This exhibit aims to demonstrate ways that any IR department can improve staff perception of the peer learning process and integrate it into their clinical, educational, and patient safety workflows.

Abstract No. 825

Clinical and Technical Review of Percutaneous Transhepatic Portal Vein Islet Cell Transplantation

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LEARNING OBJECTIVES: (1) Review clinical scenarios for pancreatic islet cell transplantation (ICT). (2) Describe the interventional radiology (IR)-related technical aspects of pancreatic ICT, focusing on liver track embolization. (3) Present the clinical outcomes of pancreatic ICT.

BACKGROUND: Percutaneous ICT is an emerging therapy for patients with type 1 diabetes. ICT may restore euglycemia, increase insulin

independence, and reduce incidence of severe hypoglycemic episodes. The procedure involves percutaneous transhepatic portal venous access, venography, delivery of harvested islet cells, measurement of portal venous pressures, and liver track embolization. The most common adverse event after ICT is bleeding associated with transhepatic portal venous access. Thus, informed selection of embolic material and deployment in the liver track is of critical importance when performing this procedure. This review aims to educate practicing interventional radiologists and trainees on the clinical and technical aspects of ICT and reviews multiple agents available for liver track embolization.

CLINICAL FINDINGS/PROCEDURE DETAILS: The preferred site for ICT is the portal venous system. Prior to ICT, recipients undergo liver color Doppler ultrasound to assess portal vein anatomy, and patency. A portal venous pressure less than 20 mm Hg is required to minimize risk of thrombotic or hemorrhagic events. Following percutaneous portal venous islet infusion, the access track is embolized. Embolization may be performed using several available materials, such as metallic coils, gelatin sponge, tissue fibrin glue, and microfibrillar collagen paste. Various studies have compared the technical effectiveness of each of these agents for closure and prevention of post-procedure bleeding; outcome of these studies will be reviewed in detail. After pancreatic ICT, 1and 2-year insulin independence achievement rates approximate 65% and 75%.

CONCLUSION AND/OR TEACHING POINTS: Percutaneous ICT shows promise as a therapeutic intervention for patients with type 1 diabetes and involves multi-disciplinary teams to improve patient outcomes. Because percutaneous transhepatic portal venous access is a procedure long performed by interventional radiologists, IR serves a critical role in the delivery of pancreatic ICT therapy. Firsthand knowledge of pancreatic ICT indications, approach, and outcomes can help optimize procedure success, but can also help pave the way for future cellular-based therapies.

Abstract No. 826

Transplant Hepatic Artery Stenosis in Liver Donations after Cardiac Death: Diagnosis to Intervention and Outcomes

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LEARNING OBJECTIVES: (1) Present pictorial examples of cases of hepatic artery stenosis (HAS) after liver transplant (LT). (2) Discuss propensity for this complication from liver donations after cardiac death (DCD) and potential mechanisms. (3) Understand the techniques available for treating HAS in this patient population and theoretical efficacy of those interventions in DCD transplants.

BACKGROUND: Hepatic artery stenosis is an infrequent but potentially devastating complication of LT, occurring more frequently in the DCD population as compared with donation after brain death (DBD). The DCD population is likely prone to HAS due to fragility of the vessels after injury to the hepatic artery vasa vasorum with warm ischemia time. Up to 9% of liver transplants can be complicated by critical HAS,

characterized as greater than 50% narrowing of the lumen, a complication which can lead to biliary necrosis and/or graft loss. Hepatic artery stenosis occurring within three months of LT is typically treated with endovascular therapy.

CLINICAL FINDINGS/PROCEDURE DETAILS: This single-center experience will demonstrate pictorial examples of post-transplant HAS with particular attention to this complication in DCD transplants. Early sonographic findings of HAS include low resistive indices, elevated peak systolic velocity, and tardus parvus waveforms in the distal hepatic artery branches.

For patients with HAS occurring greater than 7 days and less than 3 months after transplant, endovascular therapy is the treatment. Transplant hepatic artery angioplasty is technically challenging due to the tortuosity of the anastomosis. The degree of stenosis and length of the stenotic segment can also complicate interventions.

Warm ischemia time may result in increased risk of HAS in DCD livers as compared with DBD and demonstrates inferior primary patency as compared with DBD counterparts. The mechanism of reduced post treatment efficacy most likely relates to vasa vasorum injury and propensity for spasm and dissection.

CONCLUSION AND/OR TEACHING POINTS: Early onset HAS is a rare complication but carries high associated morbidity and risk of graft loss, particularly in DCD livers. Hepatic artery endovascular angioplasty and stent repair can be effective therapeutic interventions, but technical challenges including tortuous anatomic variant, degree of stenosis, and length of stenotic segment must be considered to avoid complication. These findings may have important implications in future management of DCD transplants such as lower threshold for angiogram in response to lab abnormalities or ultrasound findings.

Abstract No. 827

Selective Parathyroid Venous Sampling: Practical Pearls, Pitfalls and Evidence-Based Outcomes

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LEARNING OBJECTIVES: (1) Define the role and indications for parathyroid venous sampling (PVS) in the diagnosis and management of primary hyperparathyroidism (pHPT). (2) Examine the relevant clinical and vascular anatomy relevant to PVS. (3) Discuss pertinent procedural steps, technical challenges, and considerations. (4) Review interpretation of results relevant to treatment planning, and evidence-based outcomes.

BACKGROUND: Although surgical exploration is regarded as the gold standard of management of pHPT, as many as 5% to 10% of patients present with recurrent or persistent disease predominantly due to unsuccessful preoperative localization. Re-exploration carries significant technical challenges, high failure rates and increased risk of complications. Furthermore, minimally invasive parathyroidectomy has also been increasingly used to minimize the morbidity associated with an extensive bilateral neck exploration. Thus, meticulous preoperative planning and localization becomes crucial in the management of pHPT.

Although relatively rarely used, PVS may prove a vital tool when other non-invasive modalities are inconclusive.

CLINICAL FINDINGS/PROCEDURE DETAILS: A review of indications and rationale for patient selection will be discussed. Normal and ectopic parathyroid anatomy, including arterial supply and venous drainage with marked implications to localization will be examined. Procedural details will highlight the typical approach with a focus on recommended equipment, super-selective venous sampling tips, approach to altered anatomy in the re-operative patient, as well as other practical pearls, and discussion of pitfalls. Interpretation of results, evidence-based outcomes, and diagnostic utility will also be reviewed.

CONCLUSION AND/OR TEACHING POINTS: Preoperative planning and localization is of utmost importance in the surgical management of pHPT particularly in patients with recurrent or persistent disease after initial surgery. PVS can be an important intervention in the accurate localization of disease in the setting of discordant noninvasive methods, aiding to improve treatment outcomes.

Abstract No. 828

Superficial Venous Disease: A Primer for the Interventional Radiologist

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LEARNING OBJECTIVES: (1) Review indications and contraindications for GSV ablation. (2) Review existing management for chronic venous disease (CVD). (3) Review current devices for endovascular ablation.

BACKGROUND: The number of CVD cases continues to increase, along with burden on national healthcare budgets. CVD consists of a variety of clinical conditions involving valvular insufficiency within the superficial veins in the lower extremities, often resulting in venous leg ulceration, skin changes, and varicose veins. CVD can be treated by either surgical, phlebectomy or endovascular techniques. Endovenous treatments are favored due to similar or more effective results, shorter recovery times, lower complication rates, better cosmetic results, reduced postoperative pain and lower recurrence rate.

CLINICAL FINDINGS/PROCEDURE DETAILS: Indications for phlebectomy or ablation include patients' symptoms, as well as anatomic or pathophysiologic deformities. Anatomic changes include reflux time greater than 0.5 seconds, shallow location of the vein, or vein diameter within 2 to 20 nm. Symptoms may include cramps, pruritis, ankle swelling, or leg heaviness. Contraindications include acute deep vein thrombosis, acute skin infection at entry site, arterial insufficiency, or pregnancy.

Ambulatory phlebectomy is used on larger veins bulging above the surface of the skin and involves removing segments of veins through small incisions of the skin. Local anesthesia is used for procedural pain management.

Laser and radiofrequency ablation (RFA) are types of thermal ablation and have been deemed gold standard for management. Both are known for immediate technical success, long-term efficacy, and minimal complications. Both involve using a catheter to generate heat to

close off the vein; however, their heat sources differ. RFA is used in the great and small saphenous veins. Laser is used in patients with large, symptomatic varicose veins, and is known to have slightly more bruising than RFA.

Non-thermal ablations include ClariVein, VenaSeal, and Varithena devices. ClariVein uses a thin oscillating wire that releases a sclerosing medication that coats the vein wall. VenaSeal uses a medical glue to close the vein. Varithena uses an injectable Microfoam that will close off the vein

CONCLUSION AND/OR TEACHING POINTS: There has been a robust evolution in CVD treatments. Endovascular treatments have provided patients with additional options with shorter recovery times and lower complication rate. Trainees should be familiar with lower extremity vascular anatomy, indications for interventions, and post-intervention clinical management.

Abstract No. 829

Intravenous Bullet Retrieval: A Modern Approach to a Historically Well Described Phenomenon

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LEARNING OBJECTIVES: Advocate for endovascular bullet retrieval with multidisciplinary support. Appreciate the potential outcomes in retrieving an intravenous bullet.

BACKGROUND: Bullet embolization is rare with estimates from combat settings ranging from 0.3% to 1.1% of penetrating trauma. Although, surgical approaches are well documented, we advocate for endovascular retrieval with the support of a multidisciplinary team as the first-line approach. Presented is a case of an intravenous bullet located at the inferior vena cava (IVC)-right atrium (RA) junction.

CLINICAL FINDINGS/PROCEDURE DETAILS: A 39-year-old hemodynamically stable woman presented with a single gunshot wound to the epigastrium. Initial computed tomography angiography demonstrated an intraluminal bullet resting at the IVC-RA junction and a grade V liver laceration. Trauma surgery deferred open thoracotomy with extracorporeal membrane oxygenation due significant morbidity and mortality. Interventional radiology (IR) recommended endovascular retrieval with right femoral vein cutdown with anesthesia.

A 9-Fr right IJ sheath was placed and a 7-Fr EN Snare was advanced to the IVC-RA junction to guard against central migration. A 5-Fr right femoral vein sheath was placed and venography was performed. The right femoral vein sheath was upsized to 26-Fr and two 7-Fr EN Snares were introduced with one deployed central to the bullet to add another layer of protection. The other snare secured and moved the bullet into the right femoral vein in anticipation for retrieval. The right IJ sheath/snare were exchanged for an IVC filter introducer sheath and an infrarenal IVC filter was placed. The patient was transported to the OR where the bullet was successfully retrieved via a right femoral vein cutdown.

Post-operative course included acute right iliac and femoral vein thrombosis complicated by compartment syndrome requiring three-compartment fasciotomy. Therapeutic anticoagulation was

initiated and two days later, repeat venogram demonstrated extensive thrombus from the right popliteal vein to the right common iliac vein. This was not amenable to mechanical thrombectomy due to friability of the primary right femoral vein closure. In addition to continued surgical management, repeat venogram 2 weeks later demonstrated persisting right lower extremity thrombus, poor inflow, and maturing collateral veins. Anticoagulation was continued and encouragingly, the patient's fasciotomies were closed a month later. IR is currently monitoring for post thrombotic syndrome and will intervene if more aggressive therapy is required.

CONCLUSION AND/OR TEACHING POINTS: Intravenous bullet embolization is a rare, but well described phenomenon amenable to endovascular retrieval with multidisciplinary support.

Abstract No. 830

New Kids on the Block: Current Venous Thrombectomy Devices

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LEARNING OBJECTIVES: To review and familiarize the reader with the myriad of new thrombectomy devices approved for central and peripheral venous vasculature including indications for use, advantages and disadvantages, and practical tips for use.

BACKGROUND: Endovascular thrombectomy devices for treatment of acute clot in the setting of deep vein thrombosis, pulmonary embolism, as well as arteriovenous fistula (AVF) and arteriovenous graft (AVG) thrombosis have developed at a rapid rate over the past few years. Recent iterative improvements have been made on existing thrombectomy devices and completely new devices have been introduced.

CLINICAL FINDINGS/PROCEDURE DETAILS: The newest version of Inari Medical FlowTrieve 2 features a single expanding disc that covers a range of sizes, simplifying the choice of three different sizes with the previous generation. The more rigid basket of the ClotTrieve BOLD has greater radial strength than the original ClotTrieve for better wall apposition. Inari Medical FlowSaver and Penumbra Lightning Aspiration Tubing are ancillary devices used in combination with their respective thrombectomy devices to reduce intra-procedural blood loss. Penumbra CATD is a specifically designed for short access and sized for use in AVF and AVG declogging. AngioDynamics AlphaVac and BD Aspirex are new aspiration device used in the central and peripheral veins, respectively.

CONCLUSION AND/OR TEACHING POINTS: With improved technology comes new devices and associated learning curves. Choosing the correct thrombectomy device is sometimes a matter of preference but nonetheless important for achieving optimal results. Intervention should be guided by clinical grading systems when possible. In general, thrombectomy of acute clot is best achieved if performed within two weeks of onset, before chronic changes have occurred. Thrombectomy can often be aided by thrombolysis to soften and partially resolve clot.

Abstract No. 831

Contemporary Management of Pulmonary Embolism: What We Know (And a Lot of What We Don't)

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LEARNING OBJECTIVES: (1) Review the diagnosis, classifications, and medical management of pulmonary embolism (PE). (2) Review the current literature regarding the use of anticoagulation, thrombolytics, and mechanical thrombectomy. (3) Understand the pathophysiology of chronic thromboembolic pulmonary hypertension (CTEPH) and its implications for various treatment options. (4) Appreciate the value of ongoing clinical trials and implications for future directions in the management of venous thromboembolism (VTE).

BACKGROUND: VTE manifests as deep vein thrombosis and pulmonary embolism driven by hypercoagulability, endothelial injury, or venous stasis. The advent of new percutaneous endovascular treatment modalities in the last decade has shaped how interventional radiologists risk-stratify and manage pulmonary embolism. However, the device selection and course of treatment is not yet standardized. This educational exhibit serves to provide a thorough review of the current literature in the contemporary management of VTE, assessment of new technologies, and preliminary treatment algorithms for the suggested management of VTE in adult and pediatric patients from several institutions.

CLINICAL FINDINGS/PROCEDURE DETAILS: At the conclusion of this educational exhibit, the reader should (1) understand the current schema of clinical risk stratification of PE; (2) be familiar with the current care standard for the medical therapy of patients with PE; (3) understand the spectrum of novel devices and their safety, efficacy, and limitations for percutaneous catheter-directed thrombolysis and mechanical thrombectomy; (4) risk-stratify patients and identify treatment modalities based on the body of literature and experience from other institutions; (5) be familiar with upcoming clinical trials that will better guide the management for PE patients; and (6) understand how the pathophysiology of CTEPH may have a role in the chosen modality based on the presence or absence of patient risk factors.

CONCLUSION AND/OR TEACHING POINTS: With multiple treatment options for VTE at the interventional radiologist's disposal, a better understanding of the efficacy, safety, and indications for each therapy will aid the interventional radiologist in treating patients with PE.

Abstract No. 832

Provoked vs. Unprovoked: A Review of Our Current Understanding of Venous Thromboembolisms

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LEARNING OBJECTIVES: (1) Provide a conceptual framework for proper categorization of venous thromboembolisms (VTEs). (2) Understand the difficulties of proper categorization of VTEs and their implications. (3) Critically assess the utility of VTE categorization framework as it pertains to the management of VTE.

BACKGROUND: VTEs are a common cause of mortality and morbidity in the United States, estimated to affect anywhere from 350,000 to 900,000 individuals annually. After experiencing one VTE, patients are also more likely to experience another or several VTEs. Traditionally, VTEs have been thought of as either provoked or unprovoked. Provoked VTEs have some associated risk factor(s) implicated in the development of the thrombus, whereas unprovoked VTEs do not have any overt risk factors and thus have more obscure development and pathophysiology. Anticoagulation remains the mainstay treatment for VTEs in addition to other treatment methods such as thrombolysis, inferior vena cava filters, and thrombectomy and embolectomy. Choice and length of therapeutic intervention is largely dependent on physicians' assessment of VTEs but variability in the spectrum of VTE natural histories makes identification and categorization difficult. In this educational exhibit, we examine the challenge in categorizing VTEs as either provoked or unprovoked and its implication on therapeutic outcomes.

CLINICAL FINDINGS/PROCEDURE DETAILS: (1) Define provoked and unprovoked VTEs. (2) Discuss some of the most common causes for VTEs. (3) Provide a conceptual framework for categorization of VTEs relative to their risk of recurrence.

Detail the utility of this conceptual framework as it pertains to the interventional radiologist.

CONCLUSION AND/OR TEACHING POINTS: Proper management of VTEs extends past categorization of a VTE as provoked or unprovoked. Length of anticoagulation therapy should reflect a multidisciplinary clinical evaluation of a patient's risk of recurrent VTEs.

Abstract No. 833

A Pictorial Review of Sharp Recanalization Techniques Including the Balloon-targeted Extra-anatomic Sharp recanalizaTion (BEST) Technique

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LEARNING OBJECTIVES: (1) Review conventional and advanced techniques for sharp recanalization. (2) Learn how to perform Balloon-targeted Extra-anatomic Sharp recanalizaTion (BEST) to reestablish neck vascular access in patients who have an occluded right internal jugular vein.

BACKGROUND: Many patients with end-stage renal disease (ESRD) develop central occlusion and rely on last-resort hemodialysis (HD) access sites such as femoral, translumbar, or transhepatic catheters. Several commonly used sharp recanalization techniques have been described to reestablish neck vascular access. This is a pictorial review of these techniques and we also provide a description of BEST technique to reestablish neck access in patients who no longer have a right internal jugular vein.

CLINICAL FINDINGS/PROCEDURE DETAILS: Sharp recanalization procedures begin by obtaining access both proximal and distal to the occlusion and performing venography to determine the anatomy. Central venous occlusions can often be crossed using the front or back end of a guidewire to create a channel. Advanced techniques have also been described in cases that fail conventional techniques such as advancing a long Chiba needle or radiofrequency ablation wire via intravascular access and using an angioplasty balloon or snare as a target.

The BEST technique is an advanced technique in which the back end of a guidewire or more commonly a long Chiba needle is used to intentionally perforate the right brachiocephalic vein at the level of occlusion into the soft tissue of the mediastinum. The guidewire is then advanced into the neck soft tissues in patients who no longer have an IJ vein or IJ remnant. Once a guidewire is positioned, a balloon is advanced into the soft tissues of the neck at or above the level of the clavicle. Ultrasound or fluoroscopic triangulation is used to percutaneously puncture the balloon using a 21-gauge needle. A guidewire is then advanced through the needle into the punctured balloon and fed through as the punctured balloon is withdrawn through the femoral access sheath. Cone-beam computed tomography can be used to confirm no vital structures were traversed before the tract is dilated. A dialysis catheter is then left in place at the newly obtained neck access site.

CONCLUSION AND/OR TEACHING POINTS: There are several commonly used and advanced techniques described for sharp recanalization of occluded central veins. The BEST technique is an advanced technique for obtaining HD access in the neck in centrally occluded patients without an internal jugular vein.

Abstract No. 834

Central Venous Catheter Placement in Adults with Fontan Circulation: Review of the Anatomy and Physiology Pertinent for an Interventional Radiologist

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LEARNING OBJECTIVES: (1) Review the various congenital heart defects and associated corrective surgeries. (2) Understand the physiologic differences and implications on central venous catheter placement. (3) Impact on the above with regards to procedure planning and access site

BACKGROUND: Congenital heart disease (CHD) affects 40,000 births per year in the US, and nearly 25% of these are critical enough to require surgery or intervention. Originally developed in 1971 for patients with tricuspid atresia, the Fontan procedure is now the most common operation performed for patients with any type of single ventricle including hypoplastic left heart syndrome, atrioventricular canal defects and pulmonary atresia with intact ventricular septum. Not only has the breadth of pathologies treatable with Fontan procedures expanded, long-term survival has also steadily improved to a predicted 30-year survival rate. As of 2010 it was estimated that over 1.4 million adults are living with CHD in the United States alone.

As patient age and Fontan circulation becomes a more common variant, it is critical that interventional radiologists familiarize themselves with the three most common Fontan connections (classic atriopulmonary Fontan connection, intra-atrial conduit and extracardiac Fontan). To date there has been little published on the placement of tunneled central venous catheter and peripherally inserted central catheters in patients with Fontan anatomy and what does exist relates to pediatric and neonatal patients.

CLINICAL FINDINGS/PROCEDURE DETAILS: This exhibit will review the role and challenges of central venous catheter placement in patients with CHDs who underwent subsequent Fontan procedures. This will start by reviewing single ventricle CHD, the three most common Fontan connections and the associated changes to circulatory patterns. The challenges in work-up and management of any complication following venous catheter placement in this patient population will be reviewed. Finally, through a case series, we will outline techniques for safe and efficient placement of central venous catheters in this patient population.

CONCLUSION AND/OR TEACHING POINTS: (1) Patients status post Fontan procedures for congenital heart defects have non physiologic blood flow. (2) Work-up and management of these patients can be difficult and pose clinical and procedural challenges. (3) Understanding all this is important for successful central venous catheter placement.

Abstract No. 835

Endovascular Biopsy of Intracaval Mass Using Clamshell Forceps: Anatomy, Indications and Approach

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LEARNING OBJECTIVES: (1) Review endovascular biopsy techniques for intracaval masses. (2) Discuss inferior vena cava anatomy and associated intravascular lesions. (3) Demonstrate endovascular clamshell forceps biopsy technique with a pictorial review of cases.

BACKGROUND: Endovascular biopsy of suspected intravascular or infiltrating perivascular tumors involving the inferior vena cava (IVC) is a recognized technique, but one that is often underused compared with open or percutaneous biopsy. Although endovascular methods such as transcatheter brush biopsy, scoop biopsy, needle biopsy, and aspiration biopsy, have been described to biopsy intracaval tumors, no standard approach exists. This is largely due to variability in mass

location, extent of the lesion, risk of injury to adjacent structures (including the vessel wall), possible tumor dissemination, and available local expertise. The interventional radiologist must account for these factors when determining the safest approach for biopsy. An effective endovascular option is the use of flexible clamshell forceps, which can obtain high-quality samples for histopathological analysis, diagnosis, and treatment planning through a safe, minimally invasive venous access.

CLINICAL FINDINGS/PROCEDURE DETAILS: This exhibit will (1) discuss two cases of intracaval tumor thrombus requiring biopsy for treatment planning, (2) review the pre-biopsy work-up to include anatomy, imaging, and important considerations used to determine the safest approach and biopsy technique, (3) present a pictorial summary to highlight the technical details of using clamshell forceps to safely obtain tissue via a transfemoral approach, and (4) review alternative endovascular techniques to biopsy suspected intraluminal venous tumors.

CONCLUSION AND/OR TEACHING POINTS: (1) Biopsy of intracaval masses is challenging because of the intravascular location of the mass and the central location of the IVC. (2) Surgical biopsy and biopsy methods that traverse the IVC wall are high risk for the patient. (3) Several endovascular biopsy techniques exist to safely obtain tissue from intravascular lesions. (4) Endovascular biopsy using clamshell forceps from a femoral approach is low risk and can successfully obtain adequate tissue samples for pathologic diagnosis.

Abstract No. 836

Imaging and Intervention for Radiation-Induced Iliofemoral Stenosis and Occlusion

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LEARNING OBJECTIVES: (1) Identify cross-sectional imaging findings of radiation-induced iliofemoral venous stenosis or occlusion. (2) Correlate cross-sectional imaging with venographic and intravascular ultrasound findings. (3) Discuss potential complications and management strategies for recanalization of iliofemoral venous obstruction related to radiation therapy.

BACKGROUND: Radiation therapy has a well-established role in cancer care. Venous stenosis and occlusion are complications which can be seen in patients who undergo radiation as part of their cancer therapy. While superior vena cava obstruction in the post-radiation setting is a commonly described phenomenon, iliofemoral occlusion is a less frequently discussed but important complication that affects many patients following pelvic radiation therapy.

CLINICAL FINDINGS/PROCEDURE DETAILS: Common imaging features include hourglass-shaped venous stenosis or occlusion of variable length seen on cross sectional and angiographic imaging. On intravascular ultrasound, extensive perivascular echogenicity may be seen and blend into the surrounding tissues, correlating with the area of post-treatment change.

Procedural considerations include the selection of a stent with high radial force to mitigate the risk of restenosis given the extensive perivenous fibrosis present in these patients. Given the friable nature of tissue that has previously been exposed to radiation, there may be a higher rate of intraprocedural vascular injury; therefore, operators should be able to recognize and respond to intraprocedural complications promptly. Careful thought must be given to the choice between deployment of a stent or a stent graft.

CONCLUSION AND/OR TEACHING POINTS: Many patients have a history of radiation therapy for cancer care. A familiarity with the common imaging features seen in post-radiation venous stenosis and their procedural implications can equip interventional radiologists to improve their care of this patient population.

Abstract No. 837

Intracardiac Echocardiography (ICE) and Intravascular Ultrasound (IVUS): Two Powerful but Underused Tools that Expand the Role of Interventional Radiology, Especially in Pericardiac/Intracardiac Interventions

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LEARNING OBJECTIVES: (1) Review the utility of intracardiac echocardiography (ICE)/intravascular ultrasound (IVUS) in interventional radiology (IR) procedure. (2) Demonstrate specific clinical situations in which ICE or IVUS provides vital image guidance.

BACKGROUND: Intracardiac echocardiogram, an expansion of intravascular ultrasound, is a powerful, but often underused tool in the field of IR. With an increasing breadth and complexity of procedures, IR physicians are frequently asked to intervene in situations where fluoroscopic guidance does not provide sufficient visualization, such as intracardiac targets or radiolucent materials such as thrombi. ICE can play a critical role in cases involving retrieval of radiolucent foreign bodies or intracardiac thrombus that cannot be visualized on traditional fluoroscopy.

CLINICAL FINDINGS/PROCEDURE DETAILS: A pictorial review of three cases in which ICE or IVUS as successfully used are presented. The first case was a 66-year-old woman with a retained radiolucent foreign body where ICE visualization allowed the precise localization of the foreign body and successful retrieval with lower radiation dose. The second case was a 30-year-old man with a catheter-related septic right atrial thrombus resistant to systemic antibiotics and catheter removal. ICE was used to direct suction thrombectomy which successfully removed infected chronic thrombus with minimal blood loss. The patient successfully cleared the bacterium after the removal of the thrombus. The third case was a 50-year-old woman with a mobile right atrial thrombus and PFO with a right-to-left shunt, thus highly concerning for paradoxical systemic embolism. ICE was used to precisely localize the clot and to guide suction thrombectomy with minimal interatrial manipulation. The patient recovered well without any complications.

CONCLUSION AND/OR TEACHING POINTS: IVUS and ICE are powerful tools that are infrequently used by interventional radiologists, though they can provide vital real-time image guidance and significantly lower the procedure time and patient dose. Interventional radiologists should become more familiar with applications IVUS and ICE as great additional tools, particularly when working close or inside the heart.

Abstract No. 838

Finding the “Invisible” Object: Evaluation and Retrieval of Radiolucent Intravascular Foreign Bodies

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LEARNING OBJECTIVES: (1) To present cases of radiolucent intravascular foreign bodies. (2) Describe the clinical and imaging evaluation of these intravascular foreign bodies, for the purpose of identification and/or removal. (3) Discuss decision making and techniques for removal of intravascular foreign bodies difficult to visualize by fluoroscopy.

BACKGROUND: Interventional radiologists receive requests for evaluation and retrieval of intravascular foreign bodies (IFBs). Successful removal can mitigate potential adverse events. Though most IFB are seen by computed tomography (CT), not all are readily visible on fluoroscopy. Limited visibility can result in difficulty identifying the IFB. While radiographically distinct IFB may be identified as endovascular devices, radiolucent IFBs have a broader differential, which includes procedural (endovascular and non-endovascular), extrinsic, and physiologic etiologies. The safety, feasibility, and necessity of removal must be considered, especially for objects not intended for intravascular use. Review of clinical and imaging data can help ascertain the identity of an IFB. Removal is challenging due to limited visibility; a combination of fluoroscopy, sonography, and anatomic knowledge can provide guidance.

CLINICAL FINDINGS/PROCEDURE DETAILS: A pictorial review of several cases from our institution illustrates the evaluation, assessment, and retrieval of IFB not readily visible by fluoroscopy and/or radiography. The imaging appearances of objects suspected to represent IFBs on CT are shown, including an ingested object, a presumptive unraveled coil, and a fibrin sheath. Technical considerations during removal are presented in the following cases: (1) a linear pulmonary arterial object, of unknown etiology and chronicity and (2) a plastic tubule in the central veins visualized using intravascular ultrasound. Factors that may affect the risk-benefit ratio of removing radiolucent IFBs are discussed.

CONCLUSION AND/OR TEACHING POINTS: The identification and removal of radiolucent intravascular foreign bodies are technically challenging. This presentation demonstrates a range of objects that these IFB may represent, as well as the importance of characterization prior to any removal attempts. The viewer will be introduced to intravascular techniques and considerations for removal of these “invisible” IFBs.

Abstract No. 839

Current State of Adrenal Vein Sampling: Toward a Unified Protocol

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LEARNING OBJECTIVES: To explain the role of adrenal vein sampling (AVS) in the work-up of primary aldosteronism (PA), describe standard variations in procedural steps and discuss the need for a unified protocol.

BACKGROUND: AVS is considered the gold standard for subtyping PA into unilateral or bilateral disease; a diagnostic step which has great implications for management as treatment for unilateral disease is adrenalectomy, while for bilateral disease, management is medical. Recent data suggests that PA is far more common than previously recognized, comprising up to 10% of the underlying etiology in patients with hypertension. With the widespread prevalence of hypertension, this implies a growing need for interventionalists capable of performing this procedure with a high success rate. Sampling success is most often limited by the innate difficulty in cannulating the diminutive right adrenal vein. Even with experienced interventionalists capable of successful cannulation, there are a wide variety of procedural and interpretation protocols. Without a unified, standardized procedural and interpretation protocol, research into the accuracy and reproducibility of this procedure, steps toward optimizing procedural success and the ability to train interventionalists skilled in this procedure, is severely limited. It is time to evaluate the current protocols and move toward a more unified approach.

CLINICAL FINDINGS/PROCEDURE DETAILS: In this exhibit, we will discuss (1) the basic endocrine science behind AVS; (2) general, required steps to the AVS procedure; (3) the two major technical variations (a) sampling performed with cosyntropin stimulation, without cosyntropin stimulation or both and (b) sequential or simultaneous sampling; (4) typical and atypical interpretation cutoff values for sampling performed with and without cosyntropin stimulation and cutoff data; and (5) the data necessary to take the next steps in either creating a standardized procedure protocol or a generalized interpretation schema that can be used for whichever protocol is performed.

CONCLUSION AND/OR TEACHING POINTS: AVS is pivotal in determining the definitive treatment for PA, a significantly morbid disease process which is more prevalent than previously thought. There is a growing need for skilled interventionalists who can successfully perform this procedure thus a need for unified standardized procedural and interpretation protocol. With a standardized protocol, interventional radiology will be able to provide improved AVS research that are accurate, reliable, reproducible and can be passed on to the next generation of interventionalists.

Abstract No. 840

Treatment of Uterine Arteriovenous Malformations: A Primer

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LEARNING OBJECTIVES: (1) Discuss the etiology, diagnosis, and management of uterine arteriovenous malformations (UAVMs). (2) Technical review describing commonly used devices, approaches, and post-procedural management. (3) Provide an overview of outcome data regarding embolization of UAVMs.

BACKGROUND: UAVM is a potentially life-threatening condition which can cause menorrhagia requiring transfusion. UAVMs can be congenital or more often acquired in the setting of gynecologic procedures, specifically dilation and curettage (D&C). The reported incidence of UAVM is variable and may represent as little as 2% of pelvic hemorrhages. Other presenting symptoms can include pain or recurrent miscarriage. Beta-HCG is recommended in the setting of prior pregnancy to rule out retained products of conception or gestational trophoblastic disease. High clinical suspicion or screening pelvic Doppler sonography showing evidence of UAVM including echogenic tissue or vascular tortuosity with elevated peak systolic velocities can prompt further imaging in conjunction with interventional radiology consultation.

CLINICAL FINDINGS/PROCEDURE DETAILS: Treatment depends on multiple patient characteristics including desired fertility and includes expectant management (EM), uterine artery embolization (UAE), and surgery. Clinical interventional radiology evaluation is necessary in determining which patients can undergo EM and who requires procedural intervention. UAE has high clinical success, and Gelfoam embolic has lower infertility risk due to its temporary nature. Counseling is an important component of comprehensive patient care in deciding on treatment algorithm and close follow-up is needed in this patient population to ensure UAVM resolution. We describe the clinical management of UAVM and present 2 cases of expectant management and 4 cases of Gelfoam embolization for the treatment of UAVM. Pre-procedure evaluation with diagnostic ultrasound and magnetic resonance imaging evaluation, diagnostic arteriography and outcomes data will also be discussed.

CONCLUSION AND/OR TEACHING POINTS: The treatment of uterine arteriovenous malformations ranges from expectant management to embolization to hysterectomy, with clinical indications for each option. UAE is a successful and safe treatment option for UAVMs that fail expectant management and can help prevent life-threatening hemorrhage while preserving future fertility. The viewer will gain a better understanding of the endovascular techniques and peri-procedural management required for appropriate care.

Abstract No. 841**Guilty as Charged: Using Selective Ovarian and Adrenal Vein Sampling to Localize Neoplastic Hyperandrogenism**

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LEARNING OBJECTIVES: (1) Appropriately identify clinical scenarios in which to perform selective adrenal and ovarian vein sampling (SOAVS). (2) Describe relevant normal anatomy, variant anatomy, and fluoroscopic landmarks. (3) Discuss technical aspects of the procedure including catheter type, confirmation of catheter positioning, and appropriate laboratory tests. (4) Understand test results to localize the cause of hyperandrogenism.

BACKGROUND: SOAVS is an uncommon procedure used for localization of androgen secreting tumors when advanced imaging is unable to identify a source and dexamethasone test does not suppress androgen. It is a notoriously difficult procedure with successful cannulation of all 4 veins occurring less than 50% of the time in literature reports. Given the rarity of the procedures in modern day interventional radiology practice we aim to present a comprehensive overview of SOAVS in an interactive manner.

CLINICAL FINDINGS/PROCEDURE DETAILS: After providing a general overview of patient selection, important anatomic considerations, catheter selection and positioning, and result interpretation we shift to an interactive learning format. Using a QR code participants are able to practice their procedural decision making through sample images drawn from 5 cases performed at our institution. Interspersed between procedural decision making are questions reviewing the presented information.

CONCLUSION AND/OR TEACHING POINTS: SOAVS can play an important role in localization of imaging occult neoplastic hyperandrogenism. In these rare circumstances, knowledge of how to perform this technically challenging procedure can help successfully guide surgical treatment.

Abstract No. 842**Magnetic Resonance Imaging–Guided Transurethral Ultrasound Ablation (TULSA) of Prostate: Initial Experience at WellSpan Health**

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LEARNING OBJECTIVES: Transurethral Ultrasound Ablation (TULSA) is a minimally invasive magnetic resonance imaging (MRI)–guided thermal ablation method used for targeted treatment of prostate tissue. This educational exhibit covers the basics of the TULSA technology and devices, ideal patient population, procedural workflow, and summary of early oncologic and functional outcomes.

BACKGROUND: TULSA uses directional ultrasound to ablate a physician-defined region of the prostate while actively protecting the urethra, urinary sphincter, and rectum. In patients with prostate cancer, TULSA combines real-time MRI and robotically driven ultrasound, to

achieve comparable disease control to radiation therapy or prostatectomy. Although TULSA has been primarily investigated for localized prostate cancer, men with symptomatic benign prostatic hyperplasia can benefit from a combination treatment where the transition zone is targeted to alleviate lower urinary tract symptoms. Given the transurethral approach with continuous cooling of urethra and rectum, TULSA uniquely provides a favorable safety profile when treating patients with radiorecurrent disease.

CLINICAL FINDINGS/PROCEDURE DETAILS: The TULSA procedure follows a patient-centered approach where the planned ablation fraction (focal to whole gland) is defined based on the disease characteristic and anatomical structures that can be preserved (ejaculatory ducts, neurovascular bundles, sphincters, etc.). During patient screening it is important to rule out extra-prostatic disease based on prostate-specific membrane antigen (PSMA) positron emission tomography, large (> 3 mm) calcifications obstructing the intended ultrasound beam path, and targets beyond 3 cm from the urethra. WellSpan Health has treated 25 patients since March 2021 with follow-up appointments at 3, 6, 9, and 12-months post-procedure with 12 months being the optimal time for evaluation with MRI. Pad-free continence was maintained by all patients. All patients potent at baseline ($n = 13$) regained potency by the 9-month follow-up visit. Median (IQR) PSA decreased from 5.9 (5.1–6.8) ng/mL to 0.2 (0.1–1.8) ng/mL at 3 months, and no patient experienced biochemical recurrence (Phoenix criteria).

CONCLUSION AND/OR TEACHING POINTS: The precise treatment control offered by TULSA results in a safe and effective option for men with localized prostate cancer with promising oncologic outcomes. Critical lessons and teaching points include patient preparation, considerations on treating radio-recurrent disease, tissue, and work-up of patients with intermediate to high-grade lesions with PSMA scans. Early functional, oncologic and safety outcomes are reported as well as preliminary tumor recurrence data.

Abstract No. 843**Computed Tomography–Guided Pelvic Muscle Botulinum Injections for High-Tone Pelvic Floor Dysfunction: A Pictorial Guide**

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LEARNING OBJECTIVES: (1) Identify indications for pelvic muscle botulinum injection. (2) Understand the anatomy of pelvic floor muscles, nerves, and arteries. (3) Review anatomic considerations while performing injections. (4) Review current data regarding efficacy and potential complications.

BACKGROUND: High-tone pelvic floor dysfunction (HT-PFD) is an underrecognized and undertreated component of chronic pelvic pain (CPP). Twenty-three percent of patients with CPP have associated HT-PFD. While often deemed idiopathic, the condition may result as the sequela to a gynecologic, urologic, or colorectal medical condition. Treatment options include pelvic physiotherapy, biofeedback, and neuropathic pain modulators. In patients who have failed conservative

therapy, botulinum toxin injections into the pelvic floor muscles has emerged as an adjunct treatment. A recent meta-analysis showed botulinum toxin therapy is the most highly efficacious option for long-term pain control in these patients.

CLINICAL FINDINGS/PROCEDURE DETAILS: To perform pelvic muscle botulinum injections, patients are positioned prone and sedated. The procedure is executed under computed tomography (CT) guidance. An initial planning CT is obtained and the bilateral piriformis muscles, obturator muscles, and levator ani muscles are marked. A 23-gauge × 15-cm Chiba needle is then placed into each muscle, for a total of 6

needles. Often this procedure is paired with a pudendal nerve block, in which case a 22-gauge × 15-cm Chiba needle is placed in each pudendal canal. Once all needles are placed, 300U of botulinum toxin A is injected, divided among the 6 muscles. The pudendal nerves are each treated with 5 mL of 0.5% bupivacaine and 40 mg of triamcinolone.

CONCLUSION AND/OR TEACHING POINTS: Pelvic muscle botulinum injections are an effective tool in the management of HT-PFD with high efficacy in the appropriate patient and favorable complication profile. The procedure is straightforward with high technical success given understanding of possible pitfalls.

Scientific Session 30 | Late-breaking Abstracts

Monday, March 6, 2023

3:00 PM–4:30 PM

Abstract No. LBA1

The Effects of a Pressure-Enabled Drug Delivery Microcatheter on Radiotracer Distribution Compared with a Standard Microcatheter in Radioembolization: An Interim Analysis

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PURPOSE: To quantify differences in the delivery of 99m-technetium-labeled macroaggregated albumin(^{99m}Tc-MAA) to tumor and normal liver between a 2.4 Fr standard microcatheter (SMC) compared with a 2.4 Fr Pressure-Enabled Drug Delivery (PEDD) microcatheter (TriNav[®] Infusion System; TriSalus Life Sciences Inc., Westminster, CO) in pre-radioembolization mapping procedures.

MATERIALS AND METHODS: Five patients with either hepatocellular carcinoma (HCC) (n = 1) or colorectal liver metastases (CLM) (n=4) undergoing radioembolization completed this ongoing IRB-approved investigator-initiated prospective randomized-controlled study. Each patient underwent two mapping procedures, one with a 2.4 Fr SMC and the other with a 2.4 Fr PEDD microcatheter. Microcatheter tip position was consistent between the two mapping procedures. The sequence of device used for ^{99m}Tc-MAA delivery was randomized. Procedures were evaluated for technical success of positioning of the delivery catheter and associated catheter-related complications. A SPECT/CT was performed after each mapping procedure and Tumor to Normal (T:N) ratio was calculated for each mapping procedure using MIMpacs SurePlan LiverY90 version 7.0.4 (MIM Software, Inc. Beachwood, OH) of all tumors within the target region.

RESULTS: Both the SMC and PEDD microcatheter were successfully navigated and positioned to the appropriate position for radiotracer delivery with no associated catheter-related complications. The T:N ratio for HCC in a single patient was 27% lower with the PEDD microcatheter compared to the SMC. 3 of the 4 CLM patients experienced an increase in the T:N ratio with the PEDD microcatheter. The T:N ratio over the 4 CLM patients increased by an average of 64%, ranging from -26% to 195%, with the PEDD microcatheter compared to the SMC.

CONCLUSION: Interim analysis demonstrates 100% technical success in the positioning of both the SMC and PEDD catheter for delivery of radiotracer without associated catheter-related complications. Evaluation of T:N ratio demonstrates a trend toward improved T:N ratio with the PEDD microcatheter in CLM patients, though patient sample size remains small.

Table LBA1.1

Patient	Disease	Tumors	Smallest (cm)	Largest (cm)
2	HCC	1	N/A	2.6
3	CLM	8	1.5	3.3
4	CLM	7	1	7.1
5	CLM	6	0.8	3.8
6	CLM	9	1.2	4.5

Abstract No. LBA2

Effect of Pharmacomechanical Catheter-Directed Thrombolysis on Pulmonary Segmental Artery Occlusions: Insights from the CTPA Core Laboratory Analysis of the RESCUE Trial

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PURPOSE: The RESCUE study was an IDE trial evaluating the effect of pharmacomechanical catheter-directed thrombolysis (PM-CDT) with the Bashir Endovascular Catheter in patients with acute intermediate-risk pulmonary embolism (PE). This study reports the post hoc analysis of the core laboratory data assessing the effect of PM-CDT on segmental pulmonary arteries (PA) occlusions.

MATERIALS AND METHODS: A substantial reduction in distal vascular volume in patients with acute PE is a significant predictor of 30- and 90-day mortality. The likely cause of this reduction is total and subtotal occlusions of the segmental PA branches. To date the effect of PM-CDT on the total and subtotal occlusions of these branches is not known. We used the baseline and 48-hour post treatment contrast-enhanced chest computed tomography pulmonary angiography (CTPA) of patients enrolled in the RESCUE trial with symptomatic PE and right-ventricular-to-left-ventricular diameter (RV/LV) ratio ≥ 0.9 . The core-laboratory assessed data from the RESCUE trial was used and the primary endpoint of this analysis was the change in the number of segmental PA branches with total or subtotal occlusions after 48 hours compared to baseline before PM-CDT.

RESULTS: 106 patients enrolled across 18 United States sites were used for this analysis. The total dose of recombinant tissue plasminogen activator (r-tPA) was 14 mg in bilateral PE and 7 mg in unilateral PE over 5 hours, delivered via the expanded Bashir catheter. At 48 hours post therapy, the number of segmental PA that had total or subtotal occlusions decreased from 31.9% to 8.7% ($p < 0.0001$) a 72.5% reduction. This reduction was also noted in the proximal PA branches with a reduction from 28.7% to 11.0% ($p < 0.0001$) a 61% reduction. The reduction in segmental artery occlusion correlated significantly with magnitude of reduction in RV/LV ratio ($p=0.0021$).

CONCLUSION: In this prospective study of intermediate-risk PE, PM-CDT with the Bashir catheter and low- dose tPA was associated with a marked reduction in total and subtotal occlusion of segmental

pulmonary arteries. Future randomized controlled studies should consider assessment of this outcome to better evaluate the mechanism of right ventricular off-loading in these patients.

Abstract No. LBA3

Comparison of Carbon Dioxide Flush and Saline Flush to Saline Flush Alone in TEVAR and TAVI Procedures to Reduce Cerebral Ischemia

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PURPOSE: Thoracic endovascular repair (TEVAR) and transcatheter aortic valve implantation (TAVI) have a high risk of post-procedure stroke, which can be caused by air embolism. To address gaseous emboli, carbon dioxide is known to be more soluble in water, resulting in fewer air bubbles, and can be used to flush devices prior to standard saline flush. Therefore, this study was aimed to evaluate the safety and efficacy of using carbon dioxide to flush endovascular graft and cardiopulmonary bypass devices in patients undergoing TEVAR or TAVI procedures.

MATERIALS AND METHODS: 23 patients (14 TAVI and 9 TEVAR) were randomized into 2 groups: A) carbon dioxide + saline flush B) saline flush only. All participants underwent a baseline brain MRI within 30 days of their procedure. During the procedure, the carbon dioxide flush was performed by connecting the endovascular graft or TAVI device to the gas cylinder with reduction valve. The endovascular graft or TAVI device was held at 40 degrees and the device was flushed for five minutes at 120 kpa. The endovascular graft or TAVI device was flushed with at least 60mL of 0.9% normal saline. The remainder of the pre-procedure, procedure, and post-procedure care were based on the standard of care for TEVAR or TAVI. A follow-up brain MRI was performed 1 to 7 days after their procedure. Cerebral ischemia was quantified by total number of positive lesions on Diffusion Weighted Imaging (DWI).

RESULTS: Within patients treated with TAVI, the mean number of positive lesions in the carbon dioxide + saline flush group was 8 ± 2.58 , while the saline group had an average of 9.28 ± 9.14 . For patients treated with TEVAR, the mean number of positive lesions in the carbon dioxide + saline flush group was 1 ± 0.56 , while the saline group had an average of 1.8 ± 1.92 . Analysis using a two-tailed *t* test revealed that carbon dioxide and saline, compared to saline alone, in both TEVAR and TAVI procedures was not significantly different with respect to *P* value > 0.05.

CONCLUSION: The results in this study suggest that using carbon dioxide to flush the endovascular graft and cardiopulmonary bypass devices in patients receiving TEVAR or TAVI procedure does not reduce the number of silent infarctions. Carbon dioxide flushing is not required if device is flushed carefully with saline alone.

Abstract No. LBA4

Cooled Radiofrequency Ablation vs. Standard Medical Management for Chronic Sacroiliac Joint Pain

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PURPOSE: Low back pain (LBP) is one of the leading causes of physician visits and disability in the United States, with a lifetime prevalence rate ranging between 60 and 80%. It is estimated that up to 30% of chronic LBP originates from the sacroiliac joint (SIJ).

MATERIALS AND METHODS: This study was registered on ClinicalTrials.gov (NCT03601949) on July 26, 2018. Eligible participants were randomized in 1:1 ratio at each site to receive either CRFA (treatment group) or physician prescribed SMM (control group). Blinded outcome assessors conducted all follow-up visits. The primary endpoint was at 3 months, with follow-up visits performed up to 12 months from treatment. Subjects in the SMM group were permitted to cross-over (XO) and received CRFA at the 3-month timepoint, provided that they requalified for the study.

Endpoints measured included NRS pain scores, PGIC, ODI, SF-36, and (EQ-5D-5L).

Responders were defined as participants who had a $\geq 30\%$ decrease in average daily NRS pain score (OR a 2-point decrease in NRS) coupled with a PGIC score $\geq \text{###}$.

RESULTS: The previously reported primary 3-month endpoint found that CRFA was superior to SMM in the management of chronic SIJ pain. At the 12-month timepoint, subjects within the CRFA cohort reported a mean NRS decrease of $2.7 (\pm 2.5)$ and the XO cohort reported a mean NRS decrease of $2.6 (\pm 2.8)$ (Table 1).

57.4% of subjects in the original CRFA cohort were deemed responders at the 12-month timepoint, compared to 55.6% of subject in the XO cohort.

Table LBA4.1

	Baseline		1 Month		6 Month		12 Month	
	CRFA	XO	CRFA	XO	CRFA	XO	CRFA	XO
NRS Pain Score								
N	95	89	94	86	75	72	61	63
Mean (SD)	6.4 (± 1.4)	6.1 (± 1.5)	4.1 (± 2.4)	3.3 (± 2.2)	3.6 (± 2.4)	3.6 (± 2.5)	3.5 (± 2.6)	3.4 (± 2.5)
P-Value	0.1485		0.0373		0.9564		0.7624	
Responder Rate (%)								
n/N (%)			39/94 (41.5)	45/86 (52.3)	41/75 (54.7)	37/72 (51.4)	35/61 (57.4)	35/63 (55.6)
P-Value			0.1455		0.4237		0.8380	

With respect to PGIC, at the 12-month timepoint, 67.2% of subjects in the CRFA cohort reported being “improved”, compared with 65.1% of subject in the XO cohort.

Other endpoints (ODI, SF-36 and EQ-5D-5L) also demonstrate clinically significant improvements for patients in the original CRFA cohort as well as the XO cohort.

CONCLUSION: CRFA treatment resulted in statistically significant, clinically meaningful, and durable improvements in both the original CRFA cohort as well as the XO cohort 12 months following a single CRFA treatment. Given the difficulty of managing SIJ pain, and the lack of effective, minimally invasive treatment options, CRFA appears to provide clinical benefit and durability for this patient population.

Abstract No. LBA5

An Early Feasibility Study to Evaluate Safety of Trans-arterial Radioembolization for Recurrent Glioblastoma

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PURPOSE: Glioblastoma is the most common primary brain tumor with an approximate median survival of 15 months. Current treatment for new diagnosis of glioblastoma consists of surgical resection, followed by chemoradiation: external radiotherapy up to 60 Gy and temozolomide. However, recurrence occurs in nearly all patients. Given that no consensus therapy exists for recurrent glioblastoma, current NCCN recommendation is that, whenever possible, patients with recurrent disease be enrolled in a clinical trial. Intra-arterial radioembolization with glass yttrium-90 microspheres has been successfully used to treat various gastrointestinal malignancies, where higher doses of radiation are delivered compared to external radiotherapy. The purpose is to present a clinical trial protocol for a novel recurrent glioblastoma treatment: A first-in-human Feasibility Study to Evaluate the Safety of

the TheraSphere Glioblastoma Device (Boston Scientific, Marlborough, MA) in Patients with Recurrent GBM (FRONTIER).

MATERIALS AND METHODS: Target enrollment is 12 patients. All patients undergo multidisciplinary evaluation, including neuro-oncology, neurosurgery, and interventional radiology. Key inclusion criteria include patients with recurrent disease between 1cm to 5cm per RANO criteria located in the non-dominant hemisphere in a non-eloquent region and an accessible neurovascular anatomy for single intra-arterial treatment based on a mapping (diagnostic) angiogram. Full eligibility criteria is listed on clinicaltrials.gov (NCT05303467). Briefly, all eligible patients undergo baseline MRI and CT perfusion imaging, followed by mapping angiography. Next, intraprocedural fusion of acquired CBCTs and baseline MRI images is used to determine microcatheter treatment location from where perfused region preferentially covers tumor (T1 enhancing region). Finally, on treatment day, TheraSphere is infused from the same microcatheter location to deliver 40 ± 4 Gy to the treatment volume.

RESULTS: As of December 2022, 3 eligible patients were identified from a multidisciplinary tumor board, of whom 2 opted to participate in the clinical trial. Both patients underwent pre-procedural MRI confirming unilateral recurrent disease. Both patients underwent mapping angiography to ascertain treatment location, which originated from a single middle cerebral arterial (MCA) segment in both cases. Additionally, maximal flow rate for infusion without reflux was determined during this angiogram. Both patients underwent successful endovascular radiotherapy. Unique to yttrium-90 radioembolization, both patients underwent post-treatment PET/MR to confirm localization of microspheres relative to tumor and to assess post-treatment dosimetry. No clinically significant adverse events were noted during early follow-up.

CONCLUSION: A novel first-in-human paradigm to treat recurrent glioblastoma with glass yttrium-90 radioembolization has been proposed. Follow-up imaging and neurologic assessments on all patients are necessary to confirm safety and evaluate potential efficacy.