

# Quality Improvement Guidelines for Adult Diagnostic Neuroangiography

## Cooperative Study between ASITN, ASNR, and SIR

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NEUROANGIOGRAPHY is a safe and effective technique for evaluating various intracranial and extracranial disorders. The diagnostic information obtained by neuroangiography, combined with other clinical and noninvasive imaging findings, can be used to plan or evaluate results of treatment.

Participation by the angiographer in preprocedural selection, intraprocedural monitoring, and postprocedural follow-up and management of the patient is an integral part of neuroangiography and will increase the success rate of the procedure.

These guidelines are written to be used in institution-wide quality improvement programs to assess the practice of neuroangiography. The most important processes of care are (a) patient selection, preparation, and education; (b) performing the procedure; and (c) monitoring the patient. The outcome measures or indicators for these processes are indications, success rates, and complication rates. Outcome measures are assigned threshold levels.

### DEFINITION AND PROCEDURAL OVERVIEW (1-3)

Neuroangiography is a process by which the intracranial and extracranial head and neck circulation is evaluated. (Spinal and selective intracranial angiography will be addressed by a separate document.) It consists of placement of a catheter selectively into extracranial cervical vessels using imaging guidance, followed by contrast material injection to delineate anatomy. The catheter is usually inserted via a common femoral arterial access site, but other access sites (eg, axillary, brachial) may be used in selected cases. Aortic arch flush injections may be performed to delineate the origins and/or tortuosity of the extracranial cervical vessels prior to selective catheterization. However, unless severe occlusive disease prohibits safe selective catheterization, a selective study should be performed. Selective catheter placement optimally evaluates the extracranial and intracranial circulation and better defines occlusive morphology, tandem occlusive lesions, and coincident and/or contributory pathology. Evaluation of the intracranial circulation is an essential component of the angiographic study of occlusive extracranial cerebrovascular disease. The injection of contrast media must be at a rate and volume that safely and adequately opacifies the

vascular territory of interest. Optimal positioning, magnification, and filming rates are necessary to provide sufficient information regarding the disease and vascular territory being studied. Several projections may be necessary to best demonstrate the targeted area, but a minimum of two orthogonal projections is essential. Findings are acquired and stored either on conventional film or digitally on computerized storage media. Imaging and image recording must be consistent with the As Low As Reasonably Achievable (ALARA) radiation safety guidelines (2). Image-based diagnosis and treatment planning requires integrating the angiographic findings within the context of the patient's history, physical findings, and prior imaging studies. Therefore, the neuroangiographer must be clinically informed and understand the specific questions to be answered by neuroangiography prior to the procedure in order to plan and perform it safely and effectively.

The physician performing the neuroangiogram must fully appreciate the benefits, alternatives, and risks of the procedure. He/she must have a thorough understanding of extracranial and intracranial vascular anatomy (including congenital and developmental variants and common collateral pathways), the angiographic equipment, radiation safety considerations, physiologic monitoring equipment, and

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have access to an adequate supply of catheters, guide wires, and personnel to safely perform the procedure. The physician must understand the principles of prevention of thromboembolic phenomena with anticoagulation and catheter flushing, the need for adequate hydration, puncture site hemostasis, and management of neuroangiographic complications. Furthermore, the performing physician must be able to detect and understand the clinical significance of unsuspected findings.

While practicing physicians should strive to achieve perfect outcomes (eg, 100% success, 0% complications), in practice all physicians will fall short of this ideal to a variable extent. Thus indicator thresholds may be used to assess the efficacy of ongoing quality improvement programs. For the purpose of these guidelines, a threshold is a specific level of an indicator that should prompt a review. "Procedure thresholds" or "overall thresholds" reference a group of indicators for a procedure, for example, major complications for selective neuroangiography. Individual complications may also be associated with complication-specific thresholds. When measures such as indications or success rates fall below a (minimum) threshold, or when complication rates exceed a (maximum) threshold, a review should be performed to determine causes and to implement changes, if necessary. Thresholds may vary from those listed here; for example, patient referral patterns and selection factors may dictate a different threshold value for a particular indicator at a particular institution. *Thus, setting universal thresholds is very difficult and each institution is urged to alter the thresholds as needed to higher or lower values, to meet its own quality improvement program needs.*

### INDICATIONS (3–10)

1. Define presence/extent of vascular occlusive disease and thromboembolic phenomena.
2. Define etiology of hemorrhage (subarachnoid, intraventricular, parenchymal, craniofacial).
3. Define presence, location, and anatomy of intracranial aneurysms and vascular malformations.
4. Evaluate vasospasm related to subarachnoid hemorrhage.

5. Define presence/extent of trauma to cervicocerebral vessels (eg, dissection, pseudoaneurysm).
6. Define vascular supply to tumors.
7. Define presence/extent of vasculitis (infectious, inflammatory, drug-induced).
8. Diagnose and/or define congenital or anatomic anomaly (eg, vein of Galen fistula).
9. Define presence of venous occlusive disease (eg, dural sinus, cortical, deep).
10. Outline vascular anatomy for planning and determining the effect of therapeutic measures.
11. Perform physiologic testing of brain function (eg, WADA).

The threshold for these indications is 99%. When fewer than 99% of procedures are performed for these indications, the institution will review the process of patient selection. There are no absolute contraindications to adult diagnostic neuroangiography. Relative contraindications include iodinated contrast media allergy, hypotension, severe hypertension, coagulopathy, renal insufficiency, and congestive heart failure. Patient management should address these relative contraindications prior to the procedure. Patients with diabetes who are taking metformin (Glucophage; Bristol-Myers Squibb, Princeton, NJ) should discontinue its use at the time of angiography and for the following 48 hours until renal function has been assessed as adequate.

### SUCCESS RATE (11–13)

A successful examination is defined as sufficient selective neuroangiographic technical evaluation and image interpretation to establish or exclude pathology of the extracranial and intracranial circulation. Successful neuroangiography for the evaluation of atherosclerotic disease is performed in one sitting. Rarely, more than one sitting may be necessary due to limitation of vascular access, contrast media dose limit, patient intolerance, inadequate anesthesia, or comorbid illness such as congestive heart failure, which obviates prolonged supine positioning. Evaluation of certain conditions such as intracranial hemorrhage may require multiple studies to define

or exclude pathology. Success rate for neuroangiography is as follows:

	Reported rate	Threshold
Neuroangiography Success Rate	98%	98%

The rate of success is related to the patient's age, severity of atherosclerosis, and the presence of hypertensive disease.

### COMPLICATIONS (14–71)

The risks of neuroangiography are generally higher in patients with advanced age, severe atherosclerosis, pre-existing symptomatic cerebrovascular disease, acute subarachnoid hemorrhage, certain vascular dysplasias such as Ehlers-Danlos syndrome, and possibly in those with a history of migraine headache. The risks are related to the length of the procedure, number of catheter exchanges, catheter size, extent of catheter manipulation, and amount of contrast media used. Femoral introduction of the diagnostic catheter is considered safer than retrograde axillobrachial catheterization and direct carotid/vertebral puncture. Nonionic low-osmolality contrast media are generally safer than ionic, high-osmolality contrast media in patients with a previous history of contrast media hypersensitivity or nephropathy. The risk of contrast media-induced nephropathy is greater in patients with pre-existing acute or chronic azotemia, particularly in association with diabetes.

### Neurologic

Neurologic complications that occur within 24 hours of the angiogram are, by definition, attributed to the angiogram and are defined by the duration and severity of the neurological deficit (**Table 1**). A deficit lasting less than 24 hours is a transient ischemic attack. Deficits lasting longer than 24 hours are considered strokes. Strokes may be divided based on reversibility into reversible and permanent strokes. A deficit which resolves within 7 days is defined as a reversible stroke, and one lasting longer than 7 days is defined as a permanent stroke. Permanent strokes range in severity from trivial to life-threatening. In order to

**Table 1**  
**Neurologic Complications**

	Reported Rate	Suggested Complication-specific Threshold
Reversible neurologic deficit (including TIA and reversible stroke)	0–2.3%	2.5%
Permanent neurologic deficit	0–5%	1%

**Table 2**  
**Modified Rankin Disability Scores**

0 = Grade 0:	No signs or symptoms
1 = Grade 1:	No significant disability; able to carry out all the usual activities of daily living (without assistance). Note: This does not preclude the presence of weakness, sensory loss, language disturbance, etc., but implies that these are mild and do not or have not caused patient to limit his/her activities (eg, if employed before, is still employed at the same job).
2 = Grade 2:	Slight disability; unable to carry out some previous activities, but able to look after own affairs without much assistance (eg, unable to return to prior job; unable to do some household chores, but able to get along without daily supervision/help).
3 = Grade 3:	Moderate disability, requiring some help but able to walk without assistance (eg, needs daily supervision; needs assistance with small aspects of dressing hygiene; unable to read or communicate clearly. Note: ankle-foot orthotic or cane does not imply needing assistance).
4 = Grade 4:	Moderately severe disability; unable to walk without assistance and unable to attend bodily needs without assistance (eg, needs 24-hour supervision and moderate-maximum assistance on several activities of daily living, but still able to do some activities by self, or with minimal assistance).
5 = Grade 5:	Severe disability; bedridden, incontinent, and requiring constant nursing care and attention.
6 = Stroke death	
9 = Unknown (not obtainable from history or no follow-up)	

**Table 3**  
**Major Complications (Non-Neurologic)**

	Reported Rate	Suggested Complication-specific Threshold
Renal failure	0–0.15%	0.2%
Arterial occlusion requiring surgical thrombectomy or thrombolysis	0–0.4%	0.2%
Arteriovenous fistula/pseudoaneurysm	0.01–0.22%	0.2%
Hematoma requiring transfusion or surgical evacuation	0.26–1.5%	0.5%

evaluate the outcome of patients following cerebral angiography, an objective measure of stroke severity

should be made. The Modified Rankin Disability Score (Table 2) is easily performed and allows stratification of

stroke severity that can be compared with patient status prior to angiography.

**Non-Neurologic**

Non-neurologic complications can be stratified on the basis of outcome. Major complications result in: admission to a hospital for therapy (for outpatient procedures), an unplanned increase in the level of care admission to a hospital for therapy (for outpatient procedures), an unplanned increase in the level of care resulting in prolonged hospitalization, permanent adverse sequelae, or death (Table 3). Minor complications result in no sequelae; they may require nominal therapy or a short hospital stay for observation (generally overnight) (Appendix A). The complication rates and thresholds below refer to major complications. Any death for which the onset of cause is within 24 hours of the procedure or a puncture-site infection should be reviewed as part of the institution-wide quality improvement program.

Published rates for individual types of complications are highly dependent on patient selection and are based on series comprising several hundred patients, which is a volume larger than most individual practitioners are likely to treat. It is also recognized that a single complication can cause a rate to cross above a complication-specific threshold when the complication occurs in a small volume of patients, for example, early in a quality improvement program. In this situation, the overall procedure threshold is more appropriate for use in a quality-improvement program.

**OVERALL PROCEDURE THRESHOLD**

All major complications resulting from Adult Diagnostic Neuroangiography . . . 2%.

This threshold refers to any complication which requires additional therapy, prolonged hospitalization, or causes permanent adverse sequelae as defined in Appendix A, B.

## APPENDIX A

Society of Interventional Radiology  
Standards of Practice Committee  
Classification of Complications by  
Outcome

## Minor Complications

- A. No therapy, no consequence
- B. Nominal therapy, no consequence; includes overnight admission for observation only.

## Major Complications

- C. Require therapy, minor hospitalization (< 48 hours)
- D. Require major therapy, unplanned increase in level of care, prolonged hospitalization (> 48 hours).
- E. Permanent adverse sequelae
- F. Death.

## APPENDIX B

## Methodology

Reported complication-specific rates in some cases reflect the aggregate of major and minor complications. Thresholds are derived from critical evaluation of the literature, evaluation of empirical data from standards of practice committee member practices, and, when available, the HI-IQ® system national database.

Consensus on statements in this document was obtained utilizing a modified Delphi technique (72,73). Technical documents specifying the exact consensus and literature review methodologies are available upon request from the Society of Interventional Radiology, 10201 Lee Highway Suite 500, Fairfax, VA 22030.

## References

1. Cardella JF, Casarella WJ, DeWeese JA, et al. Optimal resources for the examination and endovascular treatment of the peripheral and visceral vascular systems: AHA intercouncil report on peripheral and visceral angiographic and interventional laboratories. *Circulation* 1994; 89:1481-1493.
2. National Council on Radiation Protection and Measurements. Implementation of the principle of as low as reasonably achievable (ALARA) for medical and dental personnel. NCRP Report No. 107. Bethesda, MD: National Council on Radiation Protection and Measurements, 1990.
3. Ullrich CG, Moore AV, Parsons RG. The arteriographic diagnosis of extracranial cerebrovascular disease. In: Robicsek F, ed. *Extracranial cerebrovascular disease: diagnosis and management*. New York, NY: MacMillan, 1986; 108-140.
4. Aletich VA, Debrun GM, Monsein LH, Nauta HJW, Spetzler RF. Giant serpentine aneurysms: a review and presentation of 5 cases. *AJNR* 1995; 16: 1061-1072.
5. Batson RC, Sottiturai VS. Management of asymptomatic carotid stenosis. *Int Surg* 1984; 69:239-246.
6. Biller J, Hingtgen WL, Adams HP, Smoker WRK, Godersky JC, Toffol GJ. Cervicocephalic arterial dissections: a ten year experience. *Arch Neurol* 1956; 43:1234-1238.
7. Connolly JE, Brownell DA, Levine EF, McCart PM. Accuracy and indications of diagnostic studies for extracranial carotid disease. *Arch Surg* 1985; 120:1229-1232.
8. Douglas DJ, Schuler JJ, Buchbinder D, Dillon BC, Flanigan DP. The association of central retinal artery: occlusion and intracranial carotid artery disease. *Arch Surg* 1988; 208:85-90.
9. Dukes HT, Veith RG. Cerebral angiography during migraine prodromal and headache. *Neurology* 1964; 14: 636-639.
10. Meyer JP, Walsh J, Barrett J, et al. Analysis of 18 recent cases of penetrating injuries to common and internal carotid arteries. *AJS* 1988; 156:96-99.
11. Dion JE, Gates PC, Fox AJ, Barnett HJM, Blom RJ, Moulin D. Clinical events following neuroangiography: a prospective study. *Stroke* 1987; 18:997-1004.
12. Uchino A. Selective catheterization of the brachiocephalic arteries via the right brachial artery. *Neuroradiol* 1988; 30:524-527.
13. Vitek JJ. Femoro-cerebral angiography: analysis of 2,000 consecutive exams, special emphasis on carotid artery catheterization in older patients. *AJR* 1973; 118:633-646.
14. Allen JH, Parera C, Potts DG. The relation of arterial trauma to complications of cerebral angiography. *AJR* 1965; 95:845-857.
15. Amagasa M, Yoshimoto T, Mizoi K, Suzuki J. Early cerebral angiography after aneurysm rupture: analysis of 197 cases. *J Neurosurg* 1986; 65:776-778.
16. Byrd L, Sherman RL. Radiologic contrast-induced acute renal failure: a clinical and pathophysiological review. *Medicine* 1979; 58:270-279.
17. Cali RL, Berg R, Rama K. Bilateral ICA agenesis: a case study and review of the literature. *Surgery* 1993; 113:227-233.
18. Canhao P, Ferro JH, Pinto AN, Melo TP, Campos J. Perimesencephalic and non-perimesencephalic subarachnoid hemorrhage with negative angiograms. *Acta Neurochir (Wien)* 1995; 132:4-19.
19. Crnic DM, Seifert FC, Ranniger K. Arterial injury in dogs after multiple percutaneous catheterizations at the same site of entry. *Radiology* 1973; 108: 295-299.
20. Davies KN, Humphrey PR. Complications of cerebral angiography in patients with symptoms of carotid territory ischaemia screened by carotid ultrasound. *J Neurol Neurosurg Psychiatry* 1993; 56:967-972.
21. Diaz-Buxo JA, Wagoner RD, Hattery RR, Palumbo PJ. Acute renal failure after excretory urography in diabetic patients. *Ann Intern Med* 1975; 83:155-158.
22. Dion JE, Gates PC, Fox AJ, Barnett HJM, Blom RJ. Clinical events following neuroangiography: a prospective study. *Acta Radiol* 1986; 369(suppl): 29-33.
23. Fisher M, Ahmadi J, Zee CS, Terry R, Weiner JM. Arteriography of carotid bifurcation: oblique projections. *Neurology* 1985; 35:1201-1204.
24. Fox AJ. Carotid endarterectomy trials. *Neuroimaging Clin North Am* 1996; 6:931-938.
25. Ginsberg LE, Stump DA, King JC, Deal DD, Moody DM. Air embolus risk with glass versus plastic syringes: in vitro study and implications for neuroangiography. *Radiology* 1994; 191: 813-816.
26. Grzyska U, Freitag J, Zeumer H. Selective cerebral intraarterial DSA. *Neuroradiology* 1990; 32:296-299.
27. Hankey GJ, Warlow CP, Sellar RJ. Cerebral angiographic risk in mild cerebrovascular disease. *Stroke* 1990; 21: 209-222.
28. Hankey GJ, Warlow CP, Molyneux AJ. Complications of cerebral angiography for patients with mild carotid artery territory ischaemia being considered for carotid endarterectomy. *J Neurol Neurosurg Psychiatry* 1990; 53:542-548.
29. Hass WK, Fields WS, North RR, Kricheff II, Chase NE, Bauer RB. Joint study of extracranial arterial occlusions. II. Arteriography, techniques, sites and complications. *JAMA* 1968; 203:961-968.
30. Heiserman JE, Dean BL, Hodak JA, et al. Neurologic complications of cerebral angiography. *AJNR* 1994; 15:1401-1407.
31. Hellmann DB, Roubenoff R, Healy RA, Wang H. CNS angiography: safety and predictors of a positive result in 125 consecutive patients evaluated for

- possible vasculitis. *J Rheum* 1992; 19:568-572.
32. Henry PY, Larre P, Aupy M, Lafforgue JL, Orgogozo JM. Reversible cerebral arteriopathy associated with the administration of Ergot derivatives. *Cephalalgia* 1984; 4:171-178.
  33. Hessel HJ, Adams DF, Abrams HL. Complications of angiography. *Radiology* 1981; 138:273-281.
  34. Hughes DE, Patel U, Forbes WStC, Jones AP. Comparison of hand injection with mechanical injection for digital subtraction cerebral angiography. *Br J Radiol* 1994; 67:786-789.
  35. Jackson A, Stewart G, Wood A, Gillespie J. Transient global amnesia and cortical blindness after vertebral angiography: further evidence for the role of arterial spasm. *AJNR* 1995; 16:955-959.
  36. Jacobson BS, Paulin S, Schlossman D. Thromboembolism of leg following percutaneous catheterization of femoral artery for angiography: signs & symptoms. *Acta Radiol* 1969; 8:97-108.
  37. Jungreis CA, Lunsford LD, Barker D. Angiographic complications during stereotactic radiosurgery for cerebral AVMs. *AJNR* 1992; 13:946-948.
  38. Katzenschlager R, Ugurluoglu A, Ahmadi A, et al. Incidence of pseudoaneurysm after diagnostic and therapeutic angiography. *Radiology* 1995; 195:463-466.
  39. Kothbauer K, Schroth G, Seiler RW, Do DD. Severe symptomatic vasospasm after rupture of AVM. *AJNR* 1995; 16:1073-1075.
  40. Kurokawa Y, Abiko S, Okamura T, et al. Pulmonary embolism after cerebral angiography: 3 case reports. *Neurol Med Chir* 1995; 35:305-309.
  41. Lang EK. Prevention and treatment of complications of arteriography. *Radiology* 1967; 88:950-956.
  42. Lang EK. A survey of complications of percutaneous retrograde arteriography: Seldinger technique. *Radiology* 1963; 81:257-263.
  43. Latchaw RE. The use of nonionic contrast agents in neuroangiography: a review of the literature and recommendations for clinical use. *Invest Radiol* 1993; 28:S55-S59.
  44. Leow K, Murie JA. Cerebral angiography for cerebrovascular disease: the risks. *Br J Surg* 1988; 75:428-430.
  45. Lichtenstein DA, Klapholz L, Vardy DA, et al. Chronic radiodermatitis following cardiac catheterization. *Arch Dermatol* 1996; 132:663-667.
  46. Mani RL, Eisenberg RL, McDonald EJ, Pollock JA, Mani JR. Complications of catheter cerebral angiography: analysis of 5000 procedures. 1. Criteria and incidence. *AJR* 1978; 131:861-865.
  47. Markus H, Loh A, Israel D, Buckenham T, Clifton A, Brown MM. Microscopic air embolism during cerebral angiography and strategies for its avoidance. *Lancet* 1993; 341:784-787.
  48. Marshall NW, Noble J, Faulkner K. Patient and staff dosimetry in neuroradiologic procedures. *Br J Radiol* 1995; 68:495-501.
  49. Mathis JM, Barr JD, Jungreis CA, et al. Temporary balloon test occlusion of ICA experience in 500 cases. *AJNR* 1995; 16:749-754.
  50. Mattos MA, Hodgson KJ, Faught WE, et al. Carotid endarterectomy without angiography: is color-flow duplex scanning sufficient? *Surgery* 1994; 116:776-783.
  51. McIver J, Steiner TJ, Perkin GD, Grealhagh RM, Rose FC. Neurological morbidity of arch and carotid arteriography in cerebrovascular disease: the influence of contrast media and radiologist. *Br J Radiol* 1987; 60:117-122.
  52. Miller JDR, Grace MG, Russell DB, Zacks DJ. Complications of cerebral angiography and pneumography. *Radiology* 1977; 124:741-744.
  53. Nakstad P, Bakke SJ, Kjartansson O, Nyhus S. Intra-arterial DSA of the carotid arteries. *Neuroradiology* 1986; 28:195-198.
  54. Norbash AM, Busick D, Marks MP. Techniques for reducing interventional neuroradiologic skin dose: tube position rotation and supplemental beam filtration. *AJNR* 1996; 17:41-49.
  55. Numaguchi Y, Fleming MS, Hasuo K, Puyau FA, Nice CM. Blood-brain barrier disruption due to cerebral angiography: CT findings. *JCAT* 1984; 8:936-939.
  56. Olivecrona H. Complications of cerebral angiography. *Neuroradiology* 1977; 14:175-181.
  57. Patterson RH, Goodell H, Dunning HS. Complications of carotid arteriography. *Arch Neurol* 1964; 10:513-520.
  58. Saitoh H, Hayakawa K, Nishimura K, et al. Rupture of cerebral aneurysms during angiography. *AJR* 1995; 16:539-542.
  59. Shope TB. Radiation-induced skin injuries from fluoroscopy. *RadioGraphics* 1996; 16:1195-1199.
  60. Shuaib A, Hachinski VC. Migraine and the risks of angiography. *Arch Neurol* 1988; 45:911-912.
  61. Skalpe IO. Complications in cerebral angiography with iohexal (Omnipaque) and meglumine metrizoate (Isopaque cerebral). *Neuroradiol* 1988; 30:69-72.
  62. Slingenberg EJ. Complications during intravascular diagnostic manipulations in the Ehlers-Danlos syndrome. *Neth J Surg* 1980; 32:56-58.
  63. Spies JB, Berlin L. Complications of femoral artery puncture. *AJR* 1998; 170:9-11.
  64. Theodotou BC, Whaley R, Mahaley MS. Complications following trans-femoral cerebral angiography for cerebral ischemia. *Surg Neurol* 1987; 28:90-92.
  65. Thomson KR, Thomson SMcA. Complications of cerebral angiography in a teaching hospital. *Australas Radiol* 1986; 30:206-208.
  66. Warnock NG, Gandhi MR, Bergvall U, Powell T. Complications of intraarterial DSA in patients investigated for cerebral vascular disease. *Br J Radiol* 1993; 66:855-858.
  67. Waugh JR, Sacharias N. Arteriographic complications in the DSA era. *Radiology* 1992; 182:243-246.
  68. Earnest F IV, Forbes G, Sandok BA, et al. Complications of cerebral angiography: prospective assessment of risk. *AJNR* 1983; 4:1191-1197.
  69. Eisenberg RL, Bank WD, Hedgcock MW. Neurologic complications of angiography in patients with critical stenosis of the carotid artery. *Neurology* 1980; 30:892-895.
  70. Feild JR, Robertson JT, DeSaussure RL Jr. Complications of cerebral case angiography in 2000 consecutive cases. *J Neurosurgery* 1962; 19:775-781.
  71. van Swieten JC, Koudstaal PJ, Visser MC, Schouten HJA, van Gijn J. Inter-observer agreement for the assessment of handicap in stroke patients. *Stroke* 1988; 19:604-607.
  72. Fink A, Koseffcoff J, Chassin M, Brook RH. Consensus methods: characteristics and guidelines for use. *Am J Public Health* 1984; 74:979-983.
  73. Leape LL, Hilborne LH, Park RE, et al. The appropriateness of use of coronary artery bypass graft surgery in New York State. *JAMA* 1993; 269:753-760.

The clinical practice guidelines of the Society of Interventional Radiology, the American Society of Interventional and Therapeutic Neuroradiology, and the American Society of Neuroradiology attempt to define practice principles that generally should assist in producing high quality medical care. These guidelines are voluntary and are not rules. A physician may deviate from these guidelines, as necessitated by the individual patient and available resources. These practice guidelines should not be deemed inclusive of all proper methods of care or exclusive of other methods of care that are reasonably directed towards the same result. Other sources of information may be used in conjunction with these principles to produce a process leading to high quality medical care. The ultimate judgment regarding the conduct of any specific procedure or course of management must be made by the physician, who should consider all circumstances relevant to the individual clinical situation. Adherence to the Quality Improvement Program will not assure a successful outcome in every situation. It is prudent to document the rationale for any deviation from the suggested practice guidelines in the department policies and procedure manual or in the patient's medical record.