PRO AND CON

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Pro: Vascular Stents in the Radiology Suite—An Anesthesiologist Is Needed

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ALTHOUGH ENDOVASCULAR REPAIR represents a less stressful and less invasive treatment for aneurysmal and occlusive disease than open surgery, the authors believe that the comorbidities present in vasculopathies and the potential for complications during these procedures mandate the presence of well-trained anesthesiologists. In this way, patients will receive maximal benefit from the procedures.

INCREASE IN ENDOVASCULAR PROCEDURES

Recent results from randomized trials and registries have shown that short-term morbidity and mortality are reduced after endovascular aortic stent grafting compared with traditional open surgery. The survival benefits do not persist for long,[1] however, and many patients return for secondary procedures for endoleak and other complications. The short-term benefits of endovascular repair have been associated with an increase in the use of endovascular techniques for the treatment of aortic aneurysms. Recently, the US Public Health Service has recommended screening for abdominal aortic aneurysm (AAA) and surgical repair of large AAAs ($\geq$5.5 cm) in men age 65 to 75 years who have ever smoked. This may well lead to an increased number of patients who present for elective repair.[2] Elective repair is preferred because rupture continues to be associated with dismal outcomes.[3] In New York State, in 2 years, there was an increase from approximately 10% of AAAs repaired with endovascular techniques in 2000 to more than 50% in 2002.[4] The use of carotid angioplasty and stenting (CAS) may also improve patient outcome compared with traditional carotid endarterectomy.[5]

SICKER PATIENTS PREVIOUSLY DENIED TRADITIONAL SURGERY

Given the lower rates of major morbidity after endovascular repair, the patient pool has increased because it now includes those candidates previously considered "too sick for open surgery." The comorbidities in this group include congestive heart failure, chronic obstructive pulmonary disease, and renal insufficiency.[6] Endovascular procedures require aggressive use of contrast dye to help with stent deployment and the resultant contrast nephropathy in patients with preexisting renal dysfunction. Aggressive fluid hydration, the use of N-acetylcysteine, sodium bicarbonate infusions, and adequate perfusion pressure may help reduce the severity of renal dysfunction, but the performance of all of these maneuvers requires not just skilled nursing care but the presence of an anesthesiologist. Aggressive hydration may or may not increase the risks of perioperative lung dysfunction. Indeed, a randomized trial in patients considered "too sick" for open surgery suggested that endovascular aortic repair (EVAR) has no benefit over not intervening because of a 9% mortality at 30 days despite much higher costs.[7]

GOALS OF ANESTHESIA FOR ENDOVASCULAR ANEURYSM REPAIR

As in open AAA repair, the primary goal of perioperative management in EVAR is to preserve organ function. Even when performed under local/sedation, preparation for EVAR must anticipate significant blood loss and fluid requirements. In a series of 47 patients (at one of the most experienced centers in the United States), the average blood loss was 623 mL (range, 100-2,500 mL), and fluid requirements averaged 2,491 mL.[8] Therefore, the choice of a local or regional anesthetic may still require placement of invasive monitors in patients.

At the time of deployment, mild hypotension and lack of patient movement are important goals. In early generations of the thoracic stents, brief asystole was required to prevent wind socking of the stent into the heart. This was achieved with high doses of intravenous adenosine (36-mg bolus). Resumption of cardiac activity was monitored with the use of transesophageal echocardiography (TEE). Back-up included transcutaneous pacing, as well as the availability of epinephrine infusions. With the advent of a newer generation of stents, the wind-socking problem has resolved. TEE is useful in monitoring left ventricular function during stent deployment and may be useful to detect complications such as pericardial tamponade and dissections when patients receive general anesthesia. However, more recently, mild hypotension is used, which can be induced with infusions of vasodilators such as nitroglycerin.[9] In the patient receiving regional anesthesia or local/sedation, brief

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induction of general anesthesia with a small bolus of propofol and mask ventilation may be indicated. These interventions are clearly facilitated by the presence of experienced anesthesia practitioners.

A variety of anesthetic techniques have been used for EVAR, including general, epidural, combined epidural/spinal,[10] spinal, and continuous spinal.[11] Because most EVAR is associated with less hemodynamic stress, endocrine stress, and cytokine release; decline in respiratory function; and prolonged convalescence compared with open repair, regional anesthesia may have less incremental benefit in EVAR. Of course, controversy persists even for open AAA repair as to whether or not regional anesthesia improves outcome.[12]

GOALS OF ANESTHESIA DURING CAS

Although CAS is a relatively simple technique procedurally (performed percutaneously through the femoral vessels) and can be performed with light sedation, close central nervous system monitoring is required to detect new-onset strokes as a result of plaque embolization. Because the anesthesiologist is well trained in monitoring vital signs routinely, the responsibility of observing mental status changes is best served by anesthesia personnel while the rest of the team concentrates on proper stent placement. Additionally, the more proximal the procedure, the higher the incidence of vagal-induced bradycardia, which at times may be severe. Again, the anesthesiologist is just the person to monitor this event and perform an intervention in a timely manner.

BENEFITS OF SEDATION AND LOCAL OVER GENERAL ANESTHESIA OR REGIONAL ANESTHESIA

Several retrospective studies suggest that surgeon-administered local anesthesia plus sedation has benefits over regional or general anesthesia for EVAR.[13,14] Positive fluid balance, the need for vasopressors, and intensive care unit utilization appear to be reduced with local/sedation. Others have found no difference in overall rates of cardiac and pulmonary morbidity and mortality after EVAR with general versus local anesthesia and sedation. Rather than the anesthetic technique, "the presence of two or more preoperative cardiac risk factors significantly increases the risk of a major postoperative cardiac event."[15] Therefore, the authors believe that patient comorbidity and procedural complexity should guide the selection of which cases should receive care from anesthesiologists.

One limitation of retrospective series is that, at least in the authors' experience, local/sedation tends to be chosen for simpler procedures with favorable anatomy, whereas neuraxial blockade or general anesthesia is chosen for longer, more complicated cases. Alternatively, general anesthesia may be chosen early in a surgeon's "learning curve," when it can be anticipated that cases may take longer and the chance for complications is greater. Later, with experience, local/sedation may become the predominant technique. In the absence of randomized studies, the authors believe that the choice of technique should be individualized and should incorporate the preferences of surgeon/interventionalist, anesthesiologist, and patient.

MORE EXTENSIVE, LONGER PROCEDURES

In initial series, many patients were considered to have anatomic exclusions that prevented EVAR. However, the growth in use of fenestrated grafts and intervention in the thoracic aorta have expanded the use of EVAR. These procedures may involve the use of fenestrated grafts and may take many hours. Although the avoidance of open repair is laudable, complex EVARs may have a higher rate of complications and take much longer, compelling patients to lie still for long periods. Orthopnea, osteoarthritis, and agitation may require a level of sedation beyond "conscious" sedation. If the level of sedation needed becomes too deep, airway compromise, hypotension, or both, may occur.

Anesthesiologists have a number of new (and not so new) tools in the armamentarium to facilitate sedation, including drugs like propofol, ketamine, and dexmedetomidine, and depth-of-consciousness monitors.[16] The lobbying for the use of propofol supervised by non-anesthesia personnel raises concerns about risk to patients. In the gastroenterology literature, low rates of "mild" hypoxemia (1% of patients with SpO_2 $<90\%$) were found in 1 study[17] and an overall sedation-related morbidity of 0.18 % for endoscopist-administered propofol sedation.[18] Of note, these gastrointestinal procedures do not involve the sort of blood loss and/or hemodynamic changes that may accompany endovascular interventions. The authors do not believe that nonanesthesiologists are as well prepared to do sedation well in these often critically ill patients; they are easily overdosed. This was documented in a series of 136 emergency room patients, in whom propofol sedation was associated with a 10% complication rate, including hypotension, hypoxemia, and apnea; 1 patient required intubation.[19]

The ability to "rescue" elderly patients from complications has been associated with the presence of board-certified anesthesiologists,[20,21] emphasizing the vital role that anesthesiologists play in perioperative care. Although anesthesia may have become safer, it is certainly not without risk and should not be "practiced" occasionally in the midst of performing procedures. Recent studies have shown that the introduction of "rapid-response" teams reduces postsurgical morbidity, intensive care unit care, and mortality. The authors believe that vasculopaths similarly deserve continuous care from physicians who are experts in sedation, airway management, invasive monitoring, and resuscitation—in other words, anesthesiologists.

COMPLICATIONS DURING ENDOVASCULAR REPAIR

The need for conversion to open repair is approximately 2% for EVAR.[22] Rupture may also rarely occur during EVAR. In a case report, intraoperative monitored rupture, despite rapid inflation of a proximal balloon to effectively "cross-clamp" the aorta, was associated with hemorrhagic shock typical of ruptures occurring outside the hospital. In this patient, endotracheal intubation was performed after rupture because a regional anesthetic technique was originally chosen.[23] In this case, transesophageal echocardiography (TEE) was used to guide the resuscitation. Numerous series have documented the utility of TEE during endovascular repair, particularly of thoracic dissections.[24] The authors are more likely to provide general anesthesia for patients with complicated anatomy (especially

iliac arteries) because conversion to open repair or retroperitoneal dissection might be more likely.

The authors' experience with intraoperative rupture suggests that relying on an "anesthesia standby" approach may not be helpful. If the procedure is performed in a remote location (cardiac catheterization, interventional radiology) without anesthesia personnel at hand, excessively long delays before airway control and volume resuscitation could jeopardize patients' well-being. Anesthesiologists are most experienced in resuscitation and transfuse a large percentage of blood provided in the hospital.[25] Interestingly, several groups have reported successful EVAR with local/sedation in patients who presented to the hospital with a ruptured AAA.[26,27] These procedures actively involved anesthesiologists who placed arterial and central venous catheters and used these monitors to provide adequate but limited volume resuscitation before stent deployment (mean arterial pressure 50-60 mmHg) and titrated analgesic infusions (including the ultra short-acting opiate remifentanil) to minimize patient movement. The authors believe this care is most safely and effectively provided by anesthesiologists.

The use of "off-site" facilities for endovascular repair may also be inefficient for anesthesia and surgeon staffing. Endovascular repair is best performed in dedicated endovascular suites within or adjacent to traditional operating rooms. Such a location facilitates conversion to open surgery or the management of ruptures; patients may benefit from the brief but prompt and meaningful presence of multiple anesthesia providers in a "code" situation.

After thoracic endovascular repair, complications such as paraplegia may result; outcome may be better if intrathecal drains are placed.[28] Iatrogenic cardiac tamponade from catheters has also been reported, as well as that resulting from the disease process (ie, proximal dissection). Acute proximal dissection is a surgical emergency requiring cardiopulmonary bypass and hypothermic arrest. Even though with experience these complications may be a thing of the past, currently they require general anesthesia with invasive monitoring. In all of these situations, the presence of experienced cardiovascular anesthesiologists is necessary. Again, TEE may prove to be indispensable during stenting of thoracic aortic dissections. In 1 series, TEE was decisive for guidewire repositioning (not possible with fluoroscopy) in 10% of patients. TEE also "demonstrated new intimal tears in the thoracic aorta in 7 patients, whereas only 2 of the 7 new tears were detectable at angiography ($p = 0.024$); in 6 of 7 patients the new distal tears were subsequently resolved with placement of additional stents. Overall, TEE and angiography furnished decisive information to determine successful procedural changes in 16 of 42 patients (38%). There were no in-hospital deaths, and pre-discharge spiral computed tomograms showed a good outcome of stent-graft implantation in 37 of 42 patients (88%); with 5 residual type I endoleaks, all previously detected with TEE but impossible to eliminate with either balloon molding or further stent implantation. All but 2 patients (95%) are currently alive at mean follow-up of 30 $\pm$ 18 months.[24] The authors believe that cardiovascular anesthesiologists should provide this complex care, and the certification process that has allowed the credentialing of perioperative echocardiographers should be applauded.[29]

Carotid angioplasty and stenting may produce severe bradycardia. Atropine premedication (0.5-1.0 mg)[30] or temporary transvenous pacemakers[31] have been described to alleviate this problem. The authors do not, however, recommend preemptive atropine use, just watchful monitoring as anesthesiologists are best prepared to do. Tachycardia-induced myocardial ischemia is a concern with atropine premedication, although the opposite has been found (fewer cardiac events with atropine premedication).[30] Only 10% of patients in this series became tachycardic (heart rate >100), and the percentage did not differ between patients randomized to atropine pretreatment or not. A heart rate of 100 beats/min, however, may be too high a threshold for vasculopaths, given that trials showing the cardioprotective effects of beta-blockers have generally kept heart rate <80 beats/min.[32] Approximately 60% of patients in both groups received perioperative beta-blockade. The authors believe that such hemodynamic adjustments are best performed by anesthesiologists so that surgeons/proceduralists can dedicate themselves to the intricacies of the procedure, thereby providing patients with the best possible technical outcome.

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