Anesthesia for aortic operations

Alexander Romagnoli, M.D.
John R. Cooper, Jr., M.D.
Houston, Texas

The aorta is the largest, single most important artery through which all blood flows at high velocity and pressure to all parts of the body. This vessel is often affected by aneurysmal dilatation of varying etiology and severity, as well as coarctations, all of which need surgical correction. Aneurysms if untreated will eventually rupture and cause sudden death. Coarctations put a severe strain on the left ventricle, causing failure and also distal hypoperfusion.

Surgical excision and grafting is the therapy of choice in the treatment of aortic aneurysms and may often be performed under emergency conditions when dissection or rupture is in progress.

Preparation for anesthesia begins with the preoperative visit which includes an evaluation of the lesion to ascertain surgical requirements (*Table 1*) and also includes an assessment of concurrent conditions, which are often serious and may greatly affect the recovery of the patient (*Table 2*). Preoperative sedation can be accomplished with diazepam (Valium), meperidine (Demerol), and scopolamine, but is largely a matter of individual preference. However, one must consider the advanced age of many of these patients, and avoid respiratory or circulatory depression (*Table 3*).

Induction of anesthesia should be smooth; pen-

Table 1. Types of aortic aneurysms at Texas Heart Institute, 1979

	Number	%
AVR and ascending AA	34	14
Ascending aortic aneurysm	16	6
Aortic arch aneurysm	7	3
Thoracic aortic aneurysm	27	11
Thoraco-abdominal aneurysm	9	4
Abdominal aortic aneurysm	154	62
Total	247	

AVR, = aortic valve replacement, AA = aortic aneurysm.

Table 2. Other diseases in patients with aortic aneurysms

Hypertension (> 150/90 mm Hg)	42%
Coronary artery disease (ECG, angina, CHF)	66%
Cerebrovascular disease	14%
Other occlusive vascular disease (extremities)	22%
Other aneurysms	4%
COPD	23%
Diabetes	8%
Chronic renal disease	3%

CHF = congestive heart failure, COPD = chronic obstructive pulmonary disease.

Table 3. General conduct of anesthesia

Preoperative assessment
Premedication—preoperative blood pressure control
Anesthesiologist and assistant
Quick smooth induction
Light anesthesia—close monitoring
Controlled sympathetic reflexes
Early emergence

tothal, diazepam, narcotics, nitrous oxide and adequate muscle relaxants are the agents of choice. Ethrane or halothane may be added if indicated. Great care must be taken in obtunding the sympathetic reflexes during intubation to avoid sudden and excessive rise in heart rate and blood pressure. Arrhythmias, as well as sudden dissection or rupture of the aneurysm could occur. Propranolol also is helpful in this respect. Maintenance is generally achieved by continued use of narcotics, halothane, or ethrane. Monitoring includes electrocardiogram (lead II and V_5): continuous display of systemic blood pressure (often from two arteries simultaneously, above and below the operative site); frequent blood gas, electrolyte, hematocrit, and blood glucose sampling, urinary output, and body temperature measurement from the pharynx or rectum or both. Electroencephalography is not mandatory, but is helpful in the determination of the depth of anesthesia and in early signs of cerebral ischemia. We believe the Swan-Ganz catheter is of little value intraoperatively and its use may delay the procedure, increase the discomfort of the patient, and cause serious complications. The anesthesiologist must anticipate problems, especially with fluid and blood replacement as blood loss may be sudden and massive (*Table 4*).

The anesthesiologist is faced with different problems as a consequence of surgical technique, which is determined by the location and extent of the aneurysmatic dilatation. For didactic clarity the aortic operations are discussed here in four parts: (1) ascending (from the aortic valve to the inominate artery; (2) arch (from innominate to left subclavian); (3) descending thoracic (from distal to the left subclavian to the diaphragm); (4) abdominal (from the diaphragm to the bifurcation). It is not our purpose to review in detail the various

Table 4. Anesthesia techniques

Endotracheal anesthesia
Endobronchial anesthesia in thoracic aneurysm operations
Epidural in abdominal aneurysm operations
Hypothermia (profound) with circulatory arrest in arch aneurysm operations
Hypothermia (light) in thoracic aneurysm operations

surgical techniques; however, the specific technique employed can have a major effect on anesthetic management (*Table 5*). Good communication with the surgical team before and during operation is essential. The four general types of aneurysms and their anesthetic management will be discussed.

In ascending aneurysms the technique is one of ordinary cardiopulmonary bypass with ascending aortic or femoral arterial cannulation. Since severe dilatation of the ascending aorta often causes aortic valve insufficiency due to dilatation of the anulus, aortic valve replacement is often a part of the procedure (*Table 6*). Coronary artery reimplantation or bypass grafting may also be performed either because of preexisting coronary disease or because of compromise of the coronary ostia. Anesthetic management of these cases is the same as for a simple aortic valve replacement.

Arch aneurysms are probably the most potentially serious lesions and have the highest mortality, even in the best of hands, due to possible impairment of cerebral blood flow during the procedure (*Table 7*). At the Texas Heart Institute we have used with gratifying success, a deep hypothermia technique with extracorporeal cooling to 18 to 16 C, drainage of all blood into the oxygenator, and then circulatory arrest. The surgeon has approximately 60 minutes to perform the operation before resuming cerebral perfusion. Monitoring is of the utmost importance and acid-base balance is critical during rewarming. The anesthesiologist is responsible for the cooling as well as the rewarming. We currently have an 18% mortality rate with this technique.

Descending thoracic aneurysms are repaired by clamping the aorta from distal to the left carotid artery to just past the end of the aneurysmatic dila-

Table 5. Surgical techniques affecting conduct of anesthesia

Cardiopulmonary bypass for ascending aneurysm lesions
Cardiopulmonary bypass for arch lesions with carotid perfusion
Bypass with profound hypothermia and circulatory arrest for arch lesions
Cross-clamping for thoracic aneurysms of the aorta
Cross-clamping with bridge graft for arch and thoracic aneurysms
Femoral vein—femoral artery for thoracic and thoraco-abdominal aneurysms
Left atrium or femoral artery for thoracic and thoraco-abdominal aneurysms
Cross-clamping of abdominal aorta for abdominal aneurysms

Table 6. Ascending aorta

Requirement	Complications
Cardiopulmonary bypass	Cerebral embolisms
	Acid-base balance
	Cardiovascular stability
	Blood replacement
	Renal failure
	Myocardial infarction
	Clotting difficulties
	Respiratory insufficiency

Table 7. Arch operations

Requirements	Complications
Monitoring electrocardiogram	Cerebral embolism
Monitoring cerebral blood pressure	Cerebral ischemia
EEG	Myocardial infarcts
Nasopharyngeal temperature	Hemorrhage
Monitoring body blood pressure	Renal failure
Hypothermia	Respiratory insufficiency
Rewarming	Clotting difficulties
Heparinization	
Maintenance of body fluids	

tation followed by excision and tube grafting (*Table 8*). Both the left heart bypass and extracorporeal shunts have been abandoned at the Texas Heart Institute in favor of simple clamping above and below the lesion.

An advantage to this simple surgical technique is a much reduced incidence of intrapulmonary hemorrhage from the left lung. This probably results from the lower heparin doses needed in the absence of cardiopulmonary bypass. We have also stopped using endobronchial tubes. But no results of surgical techniques are as difficult to control from the point of view of the anesthesiologist as are the hemodynamic changes during clamping and declamping the descending aorta. On clamping, the blood pressure rises steeply, and must be controlled quickly to prevent a cerebrovascular accident, serious left ventricular strain, and pulmonary hypertension. Halothane inhalation or nitroprusside infusion or both plus propranolol are our agents of choice. We try to maintain adequate organ flow while not exceeding a blood pressure of 150/90 mm Hg nor below 100/60 mm Hg. The pressure below the clamps as measured in the dorsalis pedis artery ranges from 0 to 22 torr (*Table 9*).

Table 8. Thoracic descending

Requirements	Complications
Arrhythmia control	Neurologic deficit (paraplegia)
Blood pressure control	Hemorrhage
Body temperature	Clotting difficulties
Body perfusion	Renal failure
Diuresis	Myocardial infarction
Acid-base balance	Aortic declamping shock
Electrolytes	Intrapulmonary bleeding
Blood replacement	Respiratory insufficiency
Heparinization	

At the completion of the grafting procedure sudden, profound hypotension often occurs. This has been named aortic declamping shock. Myocardial depression had been blamed, but it has been shown that no such depression exists, and that hypotension can be prevented and corrected by adequate volume loading and vasoconstrictors (*Table 10*).

With these methods mortality is low but postoperative paraplegia remains a problem. It has proved to be independent of the operative technique used and solely the result of anatomic considerations dependent on the location and size of the great radicular artery. Para-

Table 9. Blood pressure above and below clamping of thoracic aorta

		Proximal	Distal
Coarctation	torr	160–85	23
		145–80	54
		150–85	18
		155–80	36
Mean		152–82	33
Thoracic aneurysm		260–160	12
		240–135	8
		245–150	24
		235–140	4
		240–155	10
		255–160	6
Mean		245–150	10

Table 10. Unclamping abdominal aorta (declamping shock)

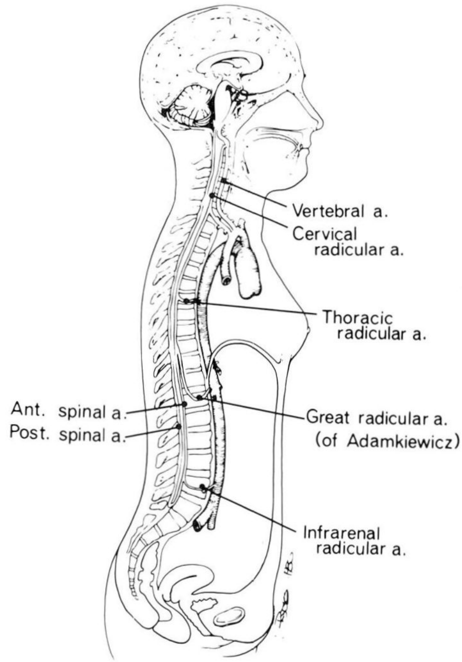
Postulates:	Washout of acid metabolites
	Sequestration of blood
	Vasodepressor substances
Probables:	Empty vascular bed
	Reactive hyperemia
Transient blood volume—vascular bed difference	
↓ SVR, ↓ Regional blood flow	

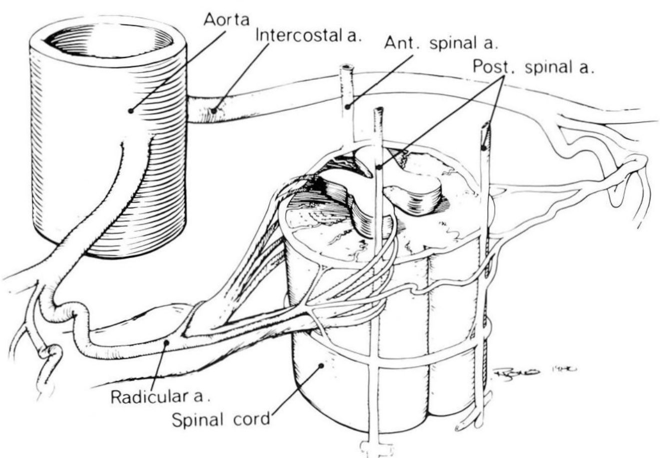
SVR = systemic vascular resistance.

plegia following this operation is approximately 6% (*Figs. 1 and 2*).

Excision of abdominal aortic aneurysms is by comparison the easiest of these procedures and usually presents fewer difficulties for the anesthesiologist, with the exception of blood replacement (*Table 11*). We believe it is important to induce diuresis when the renal arteries are involved in the repair.

Operations for coarctation of the aorta are generally done in children and no special problems are presented because the collateral circulation is well





Figs. 1 and 2. Demonstration of blood supply to the spinal cord. The great radicular artery may originate from T_{11} down to L_1 when it is involved in the aneurysm and excised; a spinal deficit will result.

Table 11. Abdominal aorta

Requirements	Complications
ECG monitoring	Aortic declamping shock
Blood pressure control	Lower extremity embolism
Diuresis	Hemorrhage
Acid-base balance	Renal failure
Electrolytes	Mesenteric failure
Blood replacement	Neurologic failure
Heparinization	Respiratory insufficiency

Table 12. Incidence of postoperative complications

Renal complications	31%
Respiratory distress syndrome	26%
Coagulation defects	10%
Postoperative bleeding	17%
Myocardial infarction	13%
Spinal cord ischemia	5%–8%
Mortality rate	9%–83%

developed. During repair we have found adequate perfusion of the lower part of the body recording pressures as high as 54 torr below the clamp.

In emergency situations the patient may be brought to the operating room with severe hypotension or hypertension. In the first instance anesthesia must be induced immediately. Measures to replace blood loss are totally inadequate until hemorrhage is controlled by clamping the proximal aorta. In the second instance, when dissection and rupture are imminent, blood pressure must be lowered before anything else is done. Since it is the sudden systolic pressure rise that enhances dissection rather than the height of the systolic spike, propranolol is useful for treatment because it specifically slows the systolic flow (decreases the dP/dT). Trimetaphan, nitroprusside, and alpha methyldopa are also widely used. Some object to using only nitroprusside on theoretical grounds as it does not affect dP/dT. The combination of medical and surgical therapy has improved results with an 80% or better long-range survival rate. The operative mortality rate is quite low, and is directly related to the preoperative condition of the patient (*Table 12*).

Summary

Anesthesia for surgery of the aorta is varied due to many different problems that result from the anatomic position of the aneurysm and the preoperative condition of the patient. The anesthesia should be light to avoid myocardial depression and the monitoring meticulous. The body fluid and electrolyte replacement must be exact. However, since the incidence of this type of aortic disease is rare, only specialized institutions are equipped and trained to administer anesthesia successfully and handle its related problems.