Abdominal Aortic Aneurysmectomy With Graft Bypass

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The aorta is vital to the proper functioning of every organ system in the human body. The coronary arteries, the vessels of the head and central nervous system, and the gastrointestinal, renal, and genitourinary arteries all originate from the aorta. Disease in any segment of the aorta, therefore, can have profound consequences on bodily function. The aorta is susceptible to four major disease processes: aneurysm, dissection, arteriosclerotic occlusive disease, and aortitis.[1]

Arterial aneurysms encountered in the abdominal aorta are among the most common and dangerous kinds of aneurysms. Although recognized for many years, it was not until 1951 that Dubost performed the first successful resection of an aortic abdominal aneurysm and replaced it with an aortic allograft. Since then, thousands of abdominal (infrarenal) aortic aneurysms (AAAs) have been resected, extending the lives of many.[2]

Approximately 15,000 deaths each year are attributed to AAAs, making it the 13th leading cause of death in the United States. Of those diagnosed with AAA, the majority are men older than 60 years of age; more than half have associated hypertension. The incidence of AAA is increased in cigarette smokers.[3] More than 95% of AAAs are due to atherosclerosis.[2] Almost all AAAs are located below the renal arteries and extend distally to include variable portions of the common iliac arteries. Rupture of an abdominal aneurysm is the greatest threat and may lead to rapid death because of shock and hypotension.

This article will define an AAA, examine details of the circulatory structure, and explain the different classifications and morphologic types of abdominal aneurysms. Resection and replacement of the diseased abdominal aorta with a prosthetic graft in order to prevent rupture, relieve symptoms, and restore sound arterial continuity will provide the primary focus.

Description and Function of Circulatory Structures

An artery is a vessel that carries blood away from the heart. Arteries have walls constructed of three coats or tunics and a hollow core, called a lumen, through which blood flows (Figure 1). The inner coat, or tunica interna (intima), is composed of a lining of endothelium (simple squamous epithelium) that is in contact with the blood. The middle coat, or tunica media, consists of elastic fibers and smooth muscle. The outer coat, the tunica externa (adventitia), is composed principally of elastic and collagenous fibers.

Due to the structural makeup of the tunica media, arteries have two major properties: elasticity and contractility. The smooth muscle of the tunica media is innervated by sympathetic branches of the autonomic nervous system.

Arteriolae are very small, nearly microscopic arteries that supply blood to the capillaries. They play a key role in regulating blood flow from arteries to capillaries.

Capillaries are microscopic blood vessels through which materials are exchanged between blood and tissue cells. Capillary walls are composed of only a single layer of cells (endothelium); they have no tunica media or tunica externa.

Venules collect blood from capillaries and then drain it into veins.

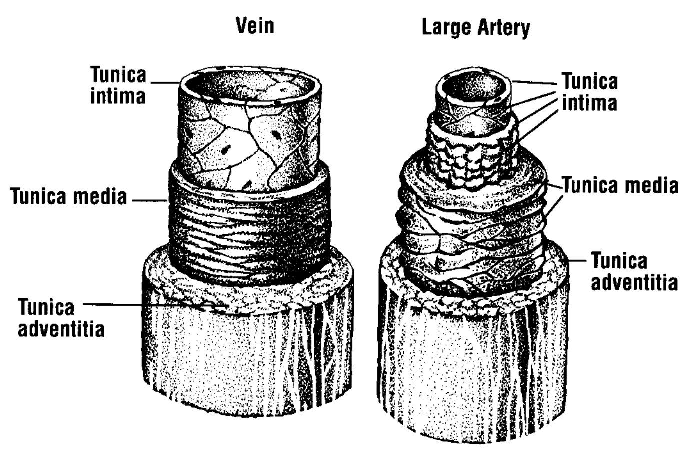

Figure 1. Circulatory structures of a vein and a large artery. (Adapted from *Dorland's Pocket Medical Dictionary.*)

Veins return the blood to the heart. They consist of the same three tunics as arteries, but have less elastic tissue and smooth muscle. Veins contain valves that prevent the backflow of blood.

The coronary arteries are the first arteries to arise from the aorta, followed by vessels of the head and central nervous system and then the gastrointestinal, renal, and genitourinary arteries.

The abdominal aorta is the continuation of the thoracic aorta, beginning just below the celiac axis (common hepatic, left gastric, and splenic arteries) and ending at the level of the fourth lumbar vertebra. The average length is 15 cm with an average diameter of 2 cm at its origin and slightly smaller at its lower end (Figure 2).[1]

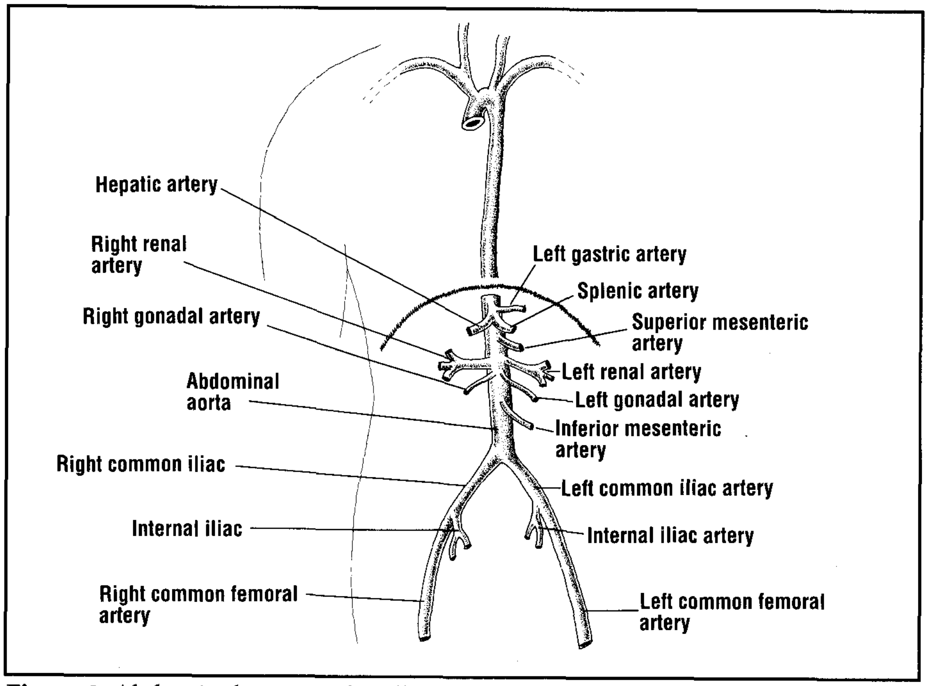

Figure 2. Abdominal aorta and axillary arteries.

Descriptions of Aneurysms

An abnormal dilation of an artery resulting from structural weakening of the vessel's wall is called an aneurysm. The strength of an arterial wall is in the elastic tissue of the tunica media. Destruction of this layer by any disease diminishes the strength of the vessel wall.

Arterial dilations (aneurysms) may be classified according to cause, shape, location, or structure. Structurally, a true aneurysm is the dilation of an artery to more than twice its normal size causing vessel wall layers to stretch and thin. Atherosclerotic aneurysms are true aneurysms. Dilation is associated with elongation of the artery. A false aneurysm, or pseudoaneurysm, is a pulsatile hematoma, not contained by the vessel wall layers but confined by a fibrous capsule. False aneurysms are caused by disruption of the vessel wall or of the anastomotic site between graft and vessel, with blood contained by surrounding tissue.[4] Three morphologic types are used to classify aneurysms by shape: fusiform, in which the aneurysm encompasses the entire circumference of the aorta and assumes a spindle shape; saccular, in which only a portion of the circumference is involved and in which there is a neck and an asymmetric outpouching of the aneurysm; and dissecting, in which an intimal tear permits a column of blood to dissect along the media of the vessel. This is often called a dissecting hematoma.[1] The cause of the aneurysm may be degenerative, inflammatory, mechanical, or congenital. An aneurysm may be classified as central, peripheral, splenic, renal, or cerebral depending upon its location in the body.

The distal abdominal aorta is the most common site of aneurysms, which is fortunate, because elective aneurysmectomy at this level carries practically no greater risk than any major abdominal operation. Aneurysms of the abdominal aorta are usually fusiform and arise just distal to the renal arteries. While they may be limited to the aorta, in most instances they involve the iliac arteries to a variable extent, either unilaterally or bilaterally.[5]

Role of Atherosclerosis

Atherosclerosis is the major degenerative disease of the human arteries and plays a significant role in aneurysm formation. Research suggests that this involutional process begins at a very young age and is present in most individuals to some degree regardless of race or geography. Atheromas are the masses of plaque containing lipids, cholesterol, connective tissue (synthesized collagen and elastin), and proteins, occurring in atherosclerosis. Atheromas are usually found adjacent to arterial bifurcations (aortoiliac and femoral arteries) and the origins of major arterial branches (femoral and proximal popliteal arteries).

The possibility of suffering from atherosclerosis and its complications increases when one or more biochemical, physiologic, and environmental conditions, known as risk factors, is present in an individual. Major risk factors include hypertension, hyperlipidemia, cigarette smoking, diabetes mellitus, and obesity. Males are also more susceptible to this disease than are females. Presumed risk factors include physical inactivity, advancing age, certain behavioral patterns and personality types, hardness of the drinking water, and a family history of premature atherosclerosis.[6]

Symptoms and signs normally develop gradually, as the atheroma slowly encroaches upon the vessel lumen. Clinical findings occur distal to the obstructive lesion in tissues in which circulation depends on the

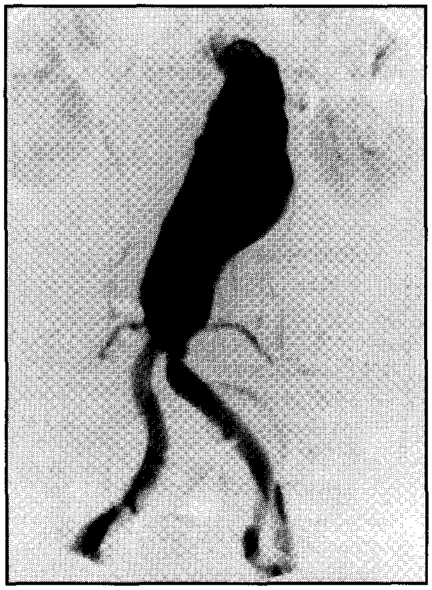

Figure 3. Angiogram of abdominal aortic aneurysm.

Table 1. Instruments, Supplies, and Equipment

Instruments
Basic laparotomy set
Major vascular set
- Forward and reverse aneurysm clamps
- Glover clamps (2)
- Spoon clamps (2)
- Hydrogrip clamps (straight and curved in large and small sizes)

All purpose clamps (2)
Peripheral clamps (2)
Hypogastric clamps (2)
Kidney pedicle clamp
Ring-handle bulldog clamps (two each of angled, curved, and straight)
Partial occlusion clamps (2)
Potts-Smith scissors (45°, 60°)
Vascular needle drivers (6", 10", 12")
Fine dissecting scissors (6", 8")
Suction tips (general surgery, abdominal suction, and vascular suction tips)
Nerve hooks (fine and blunt)
Self-retaining abdominal retractor
Hemoclip appliers

Equipment
Fiberoptic headlight
Electrosurgery unit
Hyper-hypothermia unit
Cell saver machine
Suction unit system (2)
Doppler unit

Supplies
Sterile gowns (3)
Laparotomy sheet
3/4 sheet
Sterile gloves
Sterile hand towels
Double-basin setup
Lap tape sponges (15)
Sponges (Raytex) (10)
Electrosurgery pencil with extender blade
Vessel loops (4)
Umbilical tapes (3)
Red Robinson catheter (10Fr)
20 cc syringe
60 cc catheter tip syringe
60 cc leur lock tip syringe
18 gauge needle
22 gauge angio-catheter (2)
Absorbable gelatin sponge
Sterile prep tray
Foley catheter tray
Blades (one each of 10, 11, 15, and 20)

Vascular Prosthesis/Suture
Straight tube graft (12 mm to 24 mm)
Bifurcated grafts (14 mm x 8 mm to 24 mm x 12 mm)
Size 3-0, 4-0, 5-0, and 6-0 synthetic, nonabsorbable, double-armed vascular sutures

Drugs/Medications
Heparin sodium (1,000 U/ml of IV normal saline)
Cephalosporin antibiotic (1 g/1,000 ml of normal saline)
Thrombin (20,000 U/ml)
Protamine sulfate (neutralizes heparin)

affected artery.[6]

Gradual occlusion of the terminal aorta may cause impotence in males and intermittent claudication in the buttocks and thighs, known as Leriche's syndrome. Claudication in the calves is due to narrowing or occlusion of the femoral arteries or their branches in addition to occlusion of the aortic bifurcation.[6]

Clinical Manifestations

The majority of AAAs are asymptomatic and are discovered in the course of a routine physical examination. A pulsating abdominal mass is the most frequent physical sign of an AAA. Other abdominal symptoms range from vague discomfort in the epigastrium to excruciating pain. Severe pain in the flanks or back suggests leakage, often rupture, of the aneurysm and is usually accompanied by signs of blood loss.

Diagnostic studies that include plain film, ultrasonography, and computed tomography are frequently used to provide the surgeon with information regarding the size and location of the aneurysm. Arteriography is also a very useful method of diagnosis and is considered essential for evaluation of obstruction in the iliac and femoral arteries (Figures 3 and 4).

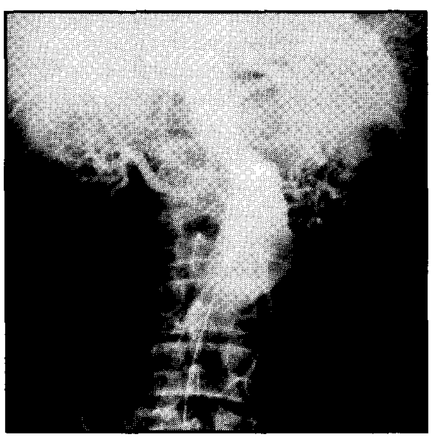

Figure 4. X-ray film showing abdominal aortic aneurysm.

Special Considerations During Surgery

AAA repair requires surgical technologists to work closely with the other operating room staff to ensure an operating environment that fosters a collective team effort, which is vital to the success of the operation.

Surgical technologists must follow the progress of the procedure closely and assist the surgeons by anticipating their needs as the operation progresses. Back table and mayo tray setups should facilitate quick and easy access to instruments and supplies. This allows surgical technologists to keep up with the surgeons throughout the procedure and minimizes the amount of time it takes to complete the operation.

During the procedure, the surgical technologist will have to manage several drugs and solutions on the back table such as an antibiotic irrigating solution, heparinized irrigating solution, and thrombin-soaked gelatin sponges.

Solution and drug containers must be properly marked to ensure that surgical technologists provide the surgeon with the correct solution or drug. Separate basins should also be used to moisten lap sponges and to soak instruments. This is especially important when there is sterile water on the field.

Included in the setup for abdominal aortic aneurysmectomy are a basic laparotomy instrument set, a major vascular instrument set, and other supplies and equipment (Table 1).

The major vascular instrument set should contain an assortment of clamps designed to partially or completely occlude the flow of blood through a vessel without crushing it. Exactly which vascular clamps will be used on a given case is based on the surgeon's preference.

Preoperative Preparation

Hemodynamic monitoring is essential in assessing the patient's circulatory status. Monitoring may include an arterial line for blood pressure and arterial blood gas; central

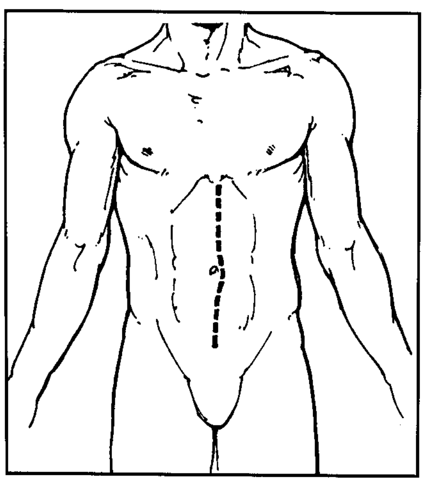

Figure 5. Midline incision.

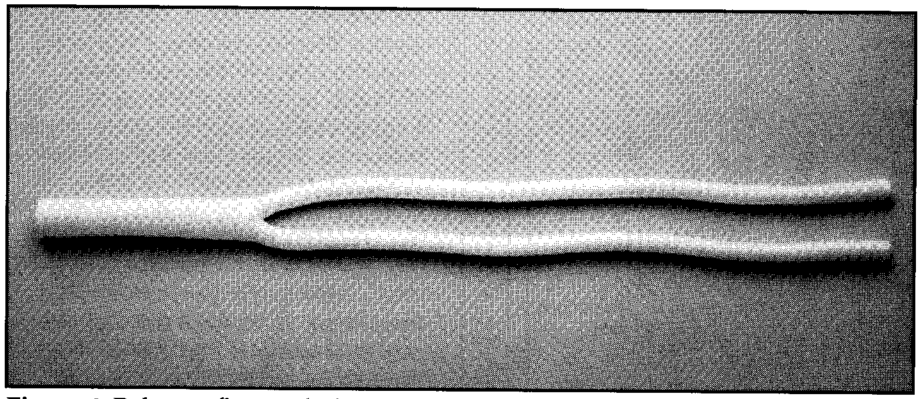

Figure 6. Polytetrafluoroethylene graft. (GORE-TEX® Stretch Vascular Graft. ©1991 W.L. Gore & Associates, Inc.)

venous pressure for cardiac preload; and a Swan-Ganz catheter for pulmonary artery pressures, left ventricular function, and cardiac output. Pulse oximetry is also used to monitor the oxygenation of the patient's arterial blood.

Typed and cross-matched blood should be available in the blood bank prior to the procedure. In addition, a cell saver can be used intraoperatively for autologous transfusion of shed blood.

The hyper-hypothermia unit should be used to help maintain the patient's core body temperature during the procedure.

Fiberoptic headlights provide the operating surgeon with effective, deep cavity illumination.

Two complete suction unit systems should be available with one serving as the primary unit and the other serving as a backup unit. Suction unit systems are used to remove blood and fluid from the operative field as well as from various suction/drainage devices, such as a cell saver, used during the procedure.

A Doppler unit is used to assess blood flow through a vessel when a pulse can not be palpated manually.

Patient Preparation

The patient is placed on the operating table in the supine position with both arms extended on arm boards and administered a general anesthetic by a combination intravenous-inhalation induction with endotracheal intubation. Cool IV bags wrapped in hand towels or pillow cases are placed under the knees. The patient is catheterized with a Foley catheter to monitor renal function during the procedure. The patient is shaved, prepped, and draped from axilla (nipple line) to mid-thigh. Sterile, self-adhering antimicrobial drapes can be applied directly to the incision site if the surgeon so chooses.

Operative Technique

The surgeon may use either a midline incision or a transverse incision for an abdominal aortic aneurysmectomy. The midline incision extends from the xiphoid process to just above the symphysis pubis (Figure 5). The transverse incision extends from flank to flank with the

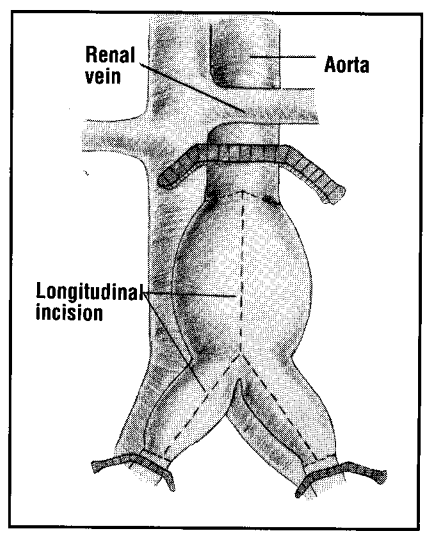

Figure 7. Aortic aneurysm incision site.

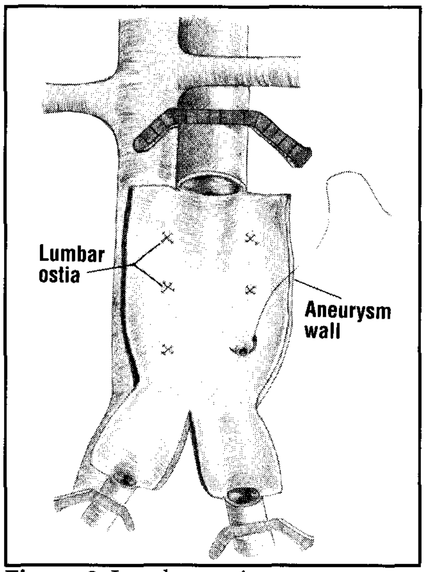

Figure 8. Lumbar ostia oversewn with figure eight stitches.

curve of the incision falling either above or below the umbilicus.

Both incisions provide excellent access to the peritoneal cavity and abdominal viscera for exploration as well as retroperitoneal exposure for aortic aneurysm repair. Personal preference of the surgeon will dictate which incision is used.

For the purposes of this article, the standard operation is performed through a midline incision.

Once the midline incision has been made and the abdominal organs palpated, the omentum, transverse colon, and small intestines are displaced from the abdominal cavity and covered with moist lap tape sponges or a warm, moist towel. An intestinal bag can also be used to cover and protect the intestines during the procedure.

A self-retaining retractor with a variety of malleable and right-angle blades (short and long) is used to retract the intestines. Moist lap sponges should be used to protect the wound edges from the retractor components.

The retroperitoneal space is opened by an incision through the posterior parietal peritoneum beginning at the ligament of Treitz and carried inferiorly into the pelvis. The dissection is carried down to the aneurysm.

The left renal vein is identified as it crosses the aorta. This structure is an important landmark, because it indicates the level of the renal arteries as well as the level of the "neck" of the aneurysm. It is at this level that the aorta is dissected free for control. Dissection is carried down to the adventitia of the anterior wall and sides of the aorta. After the proximal aorta is freed, attention is directed to the iliac arteries distal to the aneurysm. Only a small segment of the anterior and lateral surfaces of the iliac vessels must be exposed for identification and application of a clamp. Once the proximal aorta and distal iliac vessels are controlled, the appropriate graft is selected.[5] If the common iliac arteries are not aneurysmal, a straight tube graft is used. If the disease extends into the iliac vessels, a bifurcated graft is indicated.

Knitted double velour, woven double velour, and polytetrafluoroethylene (PTFE) graft materials are routinely used for repair of aortic aneurysms (Figure 6).

Each type of graft is available in a wide range of straight and bifurcated sizes allowing the surgeon to select a graft that closely matches or anatomically fits the dimensions of the native vessels he or she is attempting to bypass. Again, the preference of the surgeon will dictate which type of graft material is used on a given case. No type of graft has proven itself superior in aortic aneurysm repair. However, woven double velour, unlike knitted double velour and PTFE grafts, must be preclotted prior to being sewn into the patient. The surgeon draws approximately 50 cc of unheparinized blood from the patient then saturates the grafts with the blood until it is sufficiently preclotted.

Heparin sodium, an anticoagulant, is then administered intravenously to the patient (100U/kg body weight). Several minutes are allowed to give the heparin time to circulate, after which the neck of the aorta above the aneurysm is clamped with a large vascular clamp and the common iliacs are clamped distally with the appropriate size of vascular clamps. An extensive longitudinal incision is made on the ventral surface of the aneurysm, slightly right to the midline (Figure 7).[7] A number 11 or 15 blade on a long knife handle is used to start the incision and then lengthened with heavy curved scissors or the bovie pencil. Suction (cell saver) should be

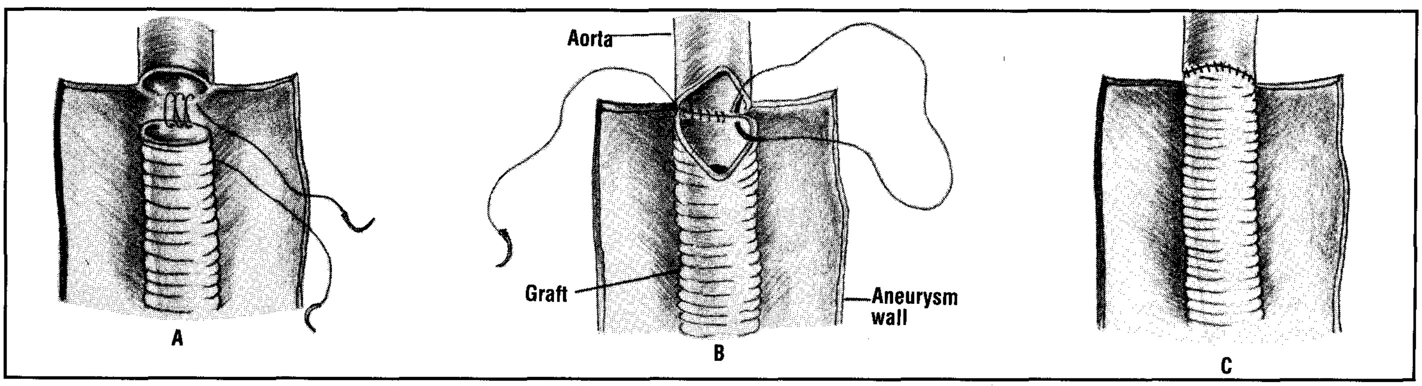

Figure 9. Anastomotic procedure. A, Start of proximal anastomosis; B, Posterior anastomosis; C, Completed proximal anastomosis.

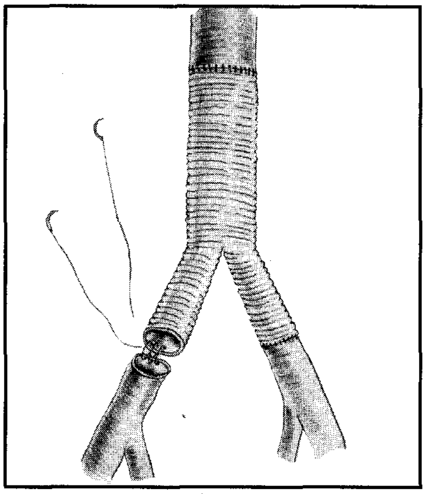

Figure 10. Aortoiliac distal anastomosis.

applied at the time of incision to clear away any blood contained in the aneurysm. Thrombi and atheromas are removed and the lumbar ostia, if found to be backbleeding, are oversewn using a figure eight stitch with a size 2-0 or 3-0 synthetic, nonabsorbable suture (Figure 8). Using a running stitch of size 3-0 synthetic, nonabsorbable double-armed suture, the proximal anastomosis between the aorta and upper end of the graft is completed (Figure 9). Upon completion, a small amount of blood is flushed through the graft to test the suture line for leaks. Any leak discovered is corrected at this time.[7]

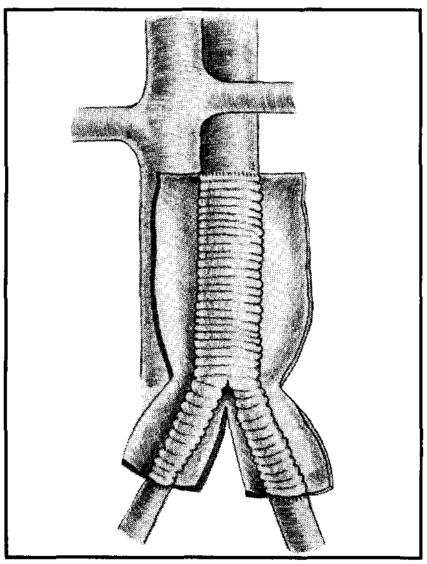

Figure 11. Completion of all anastomoses.

The distal anastomosis is performed above the bifurcation of the common iliacs in a similar fashion to that of the proximal aorta if the iliac vessels are relatively normal. Should the aneurysm involve the iliac arteries, then an end-to-side anastomosis is performed between the bifurcated ends of the graft and the iliac arteries (Figure 10). A running stitch of size 4-0 synthetic, nonabsorbable double-armed suture is used to accomplish the anastomosis (Figure 11). As each of the individual common iliac anastomosis is completed, the graft is flushed antegrade and then retrograde to remove clots and debris. Once the graft is in place, the vascular clamps are slowly removed to restore blood flow distally and to test the suture lines.

Additional sutures may be required to control any bleeding at the anastomotic sites. After hemostasis is secured, the graft and wound are irrigated with an antibiotic solution.[5] The native vessel wall is sewn around the graft with a size 0 or 2-0 absorbable suture (Figure 12). The wall of the aneurysm acts as an ideal barrier between the duodenum and the graft.[5] Following this, the posterior parietal peritoneum is closed using a size 0 or 2-0 absorbable suture. The small bowel, colon, and omentum are placed back in the abdomen and the wound is closed in layers. The fascia is closed with either interrupted or continuous stitches of size 1 nonabsorbable suture. Small bleeders in the subcutaneous layer are cauterized with the bovie pencil. The skin is approximated with staples and sterile dressings are applied to the wound.

Perioperative and Postoperative Complications

Patients undergoing aneurysm repair are subject to the general complications of any major abdominal operation. The most common specific complication during the operation is hemorrhage that results from injury to vessels during dissection to expose the neck of the aneurysm and iliac arteries.[5]

Complications that may occur in the early postoperative period after

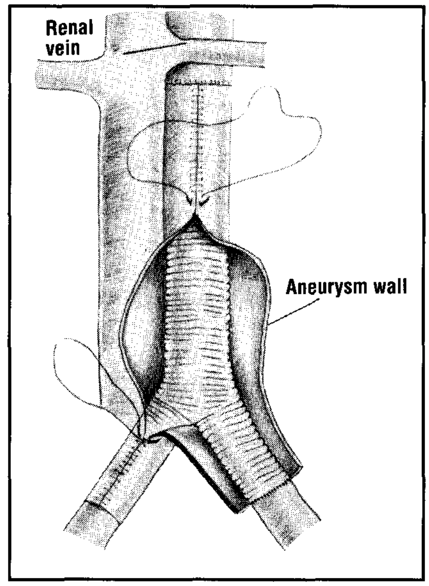

Figure 12. Closure of aneurysm wall over graft.

abdominal aortic aneurysmectomy include bleeding, distal embolism or thrombosis, renal failure, ischemic colitis, duodenal obstruction, and paraplegia.[5]

Infection of the aortic prosthesis, the last complication specific to aortic surgery, usually occurs months to years following aortic aneurysm resection and is of dire consequence.[5]

Postoperative complications may result from the primary disease, the operation itself, or other unrelated factors. Occasionally, one complication will result from a previous one (ie, myocardial infarction following massive postoperative bleeding). Good postoperative care must include repeated evaluation of the patient by the operating surgeon and other health care professionals responsible for the patient's care.[8]

Postoperative Care

Following surgery to repair an AAA, patients are transferred from the operating room to a surgical intensive care unit (SICU). In the early postoperative period, abnormalities of pulmonary function and hemodynamic stability are the primary determinates of the need for more care than can be provided in the recovery room.[4] The duration of

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