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Each year, about 200,000 people in the United States are diagnosed with aortic aneurysm.[1] An aneurysm is a localized, abnormal, permanent dilation of a blood vessel, occurring when a segment of the vessel wall becomes weakened. The pressure of the blood flowing through the vessel creates a bulge, or ballooning, at the weakened site, causing the arterial diameter to increase to more than 1.5 times the normal diameter.[2] Sudden dissection or rupture of an aortic aneurysm is a life-threatening medical emergency. This article describes thoracic and abdominal aortic aneurysms, their causes, and the perioperative nurse's role in surgical procedures for aortic aneurysms.

Pathophysiology

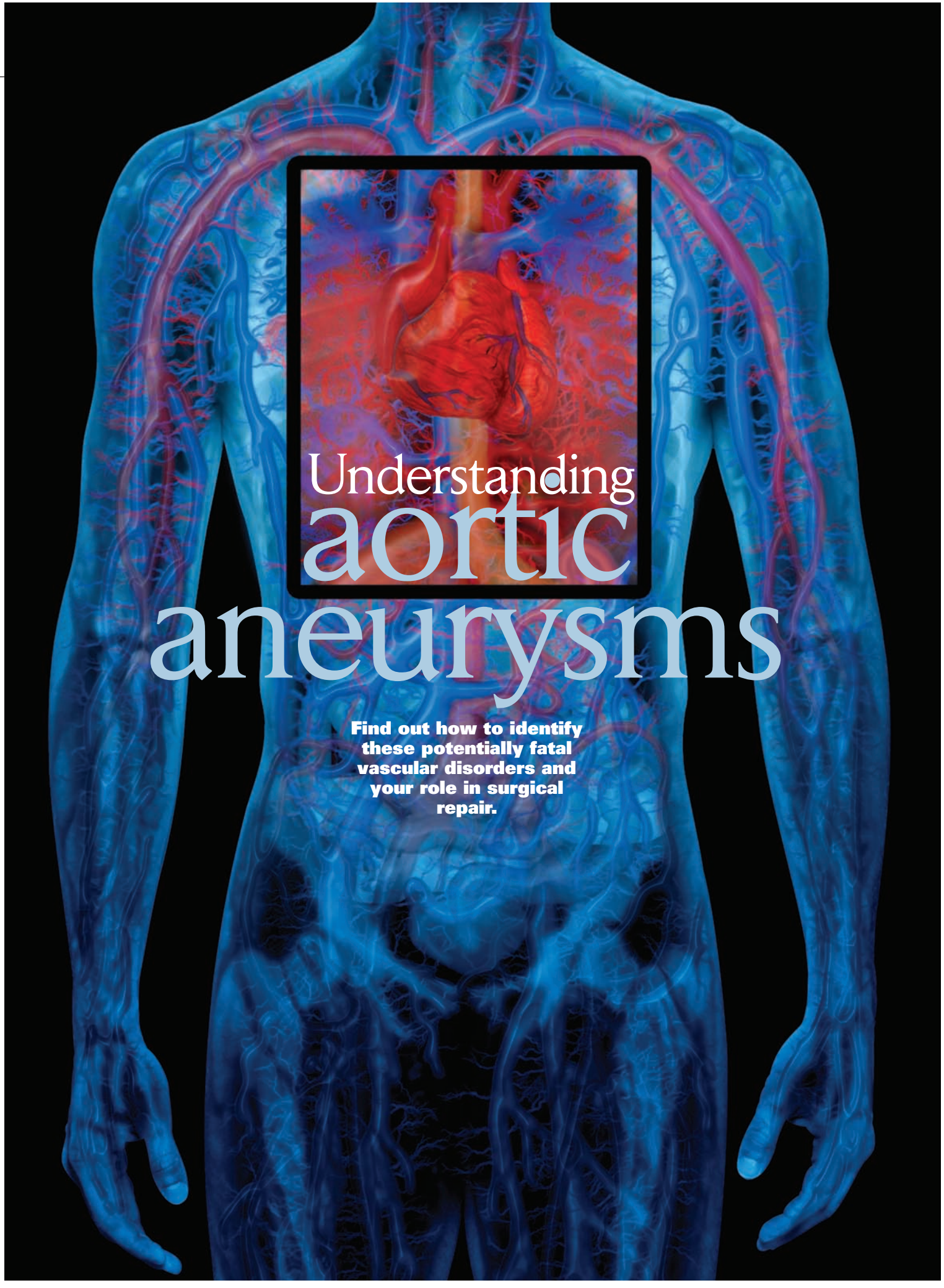
Aneurysms commonly affect the aorta, ventricular walls of the heart, and peripheral arteries, but the aorta is particularly susceptible to aneurysm formation because of constant stress on its walls. The major blood vessel supplying the body, the aorta measures about 3 cm in diameter at the upper part of the left ventricle, narrowing to 2 cm or less in diameter as it reaches the abdomen.

Arterial vessel walls have three layers: the inner layer (intima), the middle layer (media), and the outer layer (adventitia) (see *The artery wall*).

Aneurysm formation results from degeneration and weakening of the normally elastic medial layer. Vascular dilation can also result from the effect of blood streaming across an obstructive vascular plaque, which creates turbulence and weakens the arterial wall. Turbulence of flow at vessel bifurcation also may contribute to aneurysm formation. According to Laplace's law, the aneurysm will become progressively larger regardless of cause.[3] Wall tension is directly related to the radius of the vessel and intra-arterial pressure. As the vessel dilates and the diameter enlarges, the wall tension rises, causing further dilation. Hypertension also contributes to wall tension.

True aneurysms involve all three layers of the vessel wall. Although the dilated arterial wall remains intact, it becomes distorted and composed mainly of fibrous tissue. True aneurysms are classified according to their appearance: Most are *fusiform,* with a uniform appearance and dilation involving the entire vessel circumference. These aneurysms typically grow slowly but progressively; a large fusiform aneurysm may affect most of the ascending aorta.[4]

Saccular aneurysms are less common, and appear as a localized, balloon-shaped outpouching that involves only a portion of the vessel wall (see *Types of aortic aneurysms).*



Understanding aortic aneurysms

Find out how to identify these potentially fatal vascular disorders and your role in surgical repair.

Aortic aneurysms result from conditions that cause degradation or abnormal production of elastin and collagen, the structural components of the aortic wall. The most common cause of aortic aneurysm is degenerative disease caused by arteriosclerosis or atherosclerosis. Hypertension is a major contributing factor in the development of some types of aortic aneurysms. Abdominal aortic aneurysms occur most commonly in men over age 65, most of whom are asymptomatic at the time of diagnosis.[5,6]

Risk factors associated with degenerative aortic aneurysms include aging, smoking, hypertension, hypercholesterolemia, hyperlipidemia, male gender, and family history.

Other causes of aortic aneurysms include inherited or developmental diseases, infections, vasculitis, and trauma. Cystic medial necrosis (also called cystic medial degeneration) is the degeneration of collagen and elastic fibers in the tunica media as well as the loss of medial cells that become replaced by mucoid material. This condition is common in patients with Marfan syndrome, Ehlers-Danlos syndrome, and hypertension.[6] Infectious causes of aortic aneurysms are less common and include syphilis, tuberculosis, and other bacterial infections.

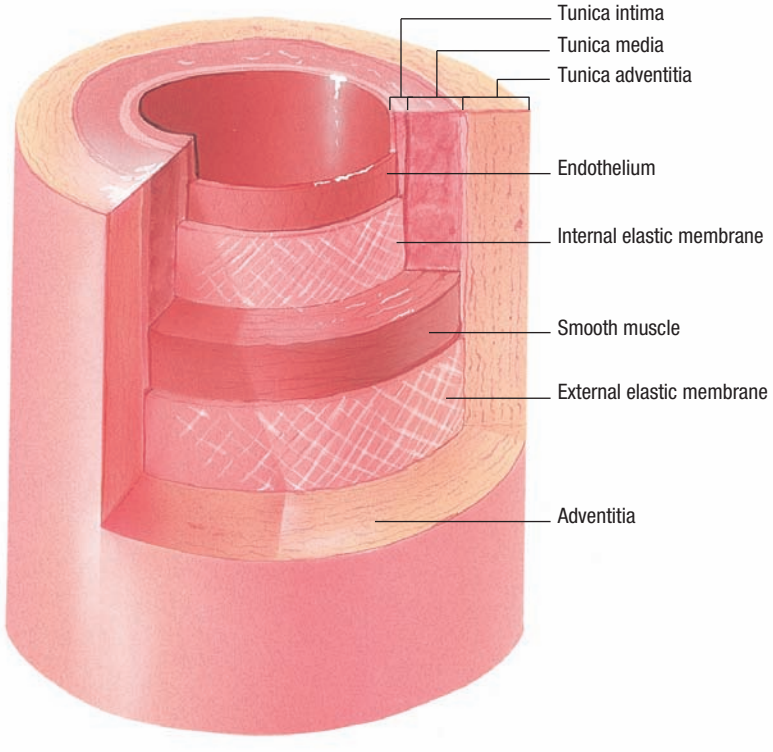
Pseudoaneurysms (also known as false aneurysms) are usually the result of trauma that disrupts the intimal and medial layers (other causes include spontaneous vessel wall dissection and iatrogenic causes such as arterial catheterization). The vessel wall remains contained by the adventitia, thrombus, or surrounding soft tissue (most pseudoaneurysms are saccular in appearance). The risk of rupture is higher with pseudoaneurysms because the vessel wall is no longer supported by the strong medial layer.

The artery wall

The walls of the arteries are composed of three layers:

- The tunica intima, the inner layer, is a thin layer consisting of endothelial cells that provide a smooth inner lining for the vessel.
- The tunica media, the middle layer, is composed of smooth muscle and elastic fibers that give the vessel strength and let it constrict and dilate to accommodate bloodflow. In the large arteries, including the aorta, the majority of the vessel wall is composed of the middle layer.
- The tunica adventitia, the outermost layer, is composed of connective tissue that supports the vessel.

Cross section



Source: The Anatomical Chart Company.

A hidden killer

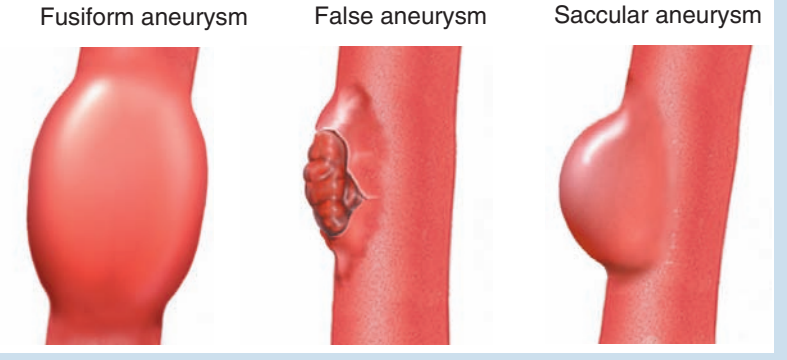
Aortic aneurysms are asymptomatic in most patients. Improvements in noninvasive diagnostic tests over the years have improved incidental

discovery of many small to medium size (3 to 5 cm diameter) asymptomatic aneurysms. Symptoms, when they develop, usually are related to expansion or rupture of the aneurysm, and the risk of rupture is proportional to the size of the aneurysm. For example, a patient may develop dysphagia, dyspnea, or persistent chest, back, or abdominal pain as an aneurysm expands and presses on surrounding organs. An aneurysm that impairs bloodflow to an extremity can cause ischemia. Sudden, severe pain may point to aortic dissection or rupture.

Types of aortic aneurysms

Aortic aneurysms may be true aneurysms, involving all three layers of the vessel wall, or pseudoaneurysms (false aneurysms) that involve only the intimal and medial layers of the vessel wall.

Aneurysms may also be classified according to their appearance: Fusiform aneurysms have a uniform appearance and dilation involves the entire circumference of the vessel. Saccular aneurysms are localized, balloon-shaped outpouchings; dilation involves a portion of the vessel circumference.



Source: Anatomical Chart Company. *Atlas of Pathophysiology*. 3rd ed. Philadelphia, PA: Lippincott Williams & Wilkins; 2010:39.

Abdominal aortic aneurysm

The most common site for aneurysm formation is the abdominal aorta. These aneurysms, found below the diaphragmatic border, are caused by atherosclerosis and their incidence increases with the patient's age. Ninety percent of abdominal aortic aneurysms (AAAs) originate below the renal arteries and extend to the aortic bifurcation.[4,7] Occasionally the iliac arteries are also involved. Rarely do these aneurysms extend above the renal arteries.

Most AAAs are asymptomatic. During abdominal examination, you may notice an AAA as a palpable, pulsating mass with a bruit, usually located in the umbilical region to the left of midline. The onset of symptoms is usually ominous and indicates expansion of an aneurysm, chronic retroperitoneal bleeding, or impending rupture. Patients may complain of severe abdominal or back pain. Pain intensity often correlates with severity and size of the aneurysm. Epigastric discomfort, nausea, vomiting, or digestion difficulties may represent duodenal obstruction from a large aneurysm. Femoral pulses may be diminished in some patients.

Thoracic aortic aneurysm

Thoracic aortic aneurysms (TAAs) account for less than 10% of all aortic aneurysms.[4,8] These aneurysms can affect the ascending aorta above the aortic valve, the descending thoracic aorta beyond the left subclavian artery, and the aortic arch. The most common causes are atherosclerosis and chest trauma from motor vehicle accidents. Patients with connective tissue disorders such as Marfan syndrome should be closely monitored for TAA development because these disorders cause cystic medial necrosis, a weakening and dilation of the ascending aorta.[1] The average growth rate of TAAs is 0.1 to 0.2 cm in diameter per year; the rate is greater for those aneurysms associated with Marfan syndrome.[6]

Typically, TAAs are asymptomatic, so they're frequently discovered incidentally on chest X-ray. When symptoms do occur, they're usually due to expansion and compression or erosion of adjacent structures by the aneurysm. For example, neck vein distension and edema of the head, neck, and arms may indicate superior vena cava compression. Aneurysmal dilation of the ascending aorta may result in heart failure due to aortic regurgitation. Laryngeal nerve compression will present as hoarseness. Substernal chest pain and neck pain are also associated with TAAs.

A TAA of the aortic arch can cause symptoms and neurologic signs similar to those of a transient ischemic attack or stroke. Angina is associated with an aneurysm in the ascending aortic arch.

Aortic dissections

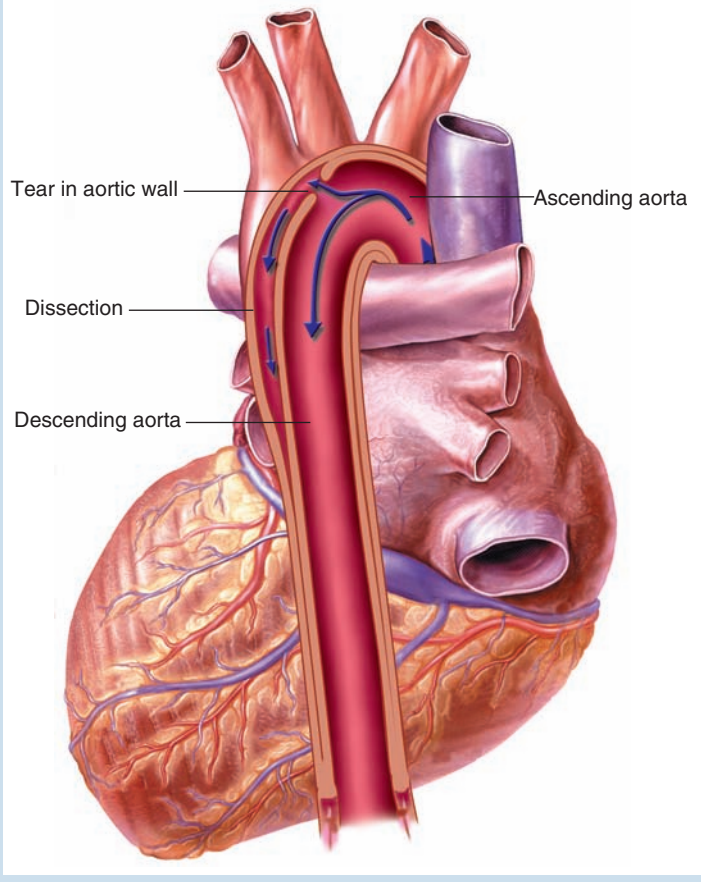
The most common and most lethal complication involving the aorta is acute aortic dissection, a longitudinal separation of the medial layers of the aorta by a column of blood.[9] The dissection begins at a tear in the aortic wall (see *A closer look at a dissecting aortic aneurysm*). Blood pumped through this tear creates a false lumen that rapidly becomes larger than the true aortic lumen. The false lumen typically extends all the way to the iliac bifurcation. Mortality is very high for patients with aortic dissection.

Suspect aortic dissection in a patient who has sudden onset of excruciating, sharp, and unrelenting pain in the chest, neck, back, or abdomen that may be accompanied by syncope.[9-11] Clinical indicators include murmur of aortic regurgitation, alteration in peripheral pulses, and the risk factor of hypertension. Look for a widened mediastinum on the chest X-ray.[9] If the dissection involves the coronary arteries, the patient may have cardiac ischemia.

Complications of a dissection will manifest according to its location. A dissection involving the aortic root may present as cardiac tamponade; listen for muffled heart sounds and decreasing BP. Dissection of the aortic arch may result in neurologic deficits including altered mental status. When the renal arteries are involved, resulting manifestations and complications may include elevated serum creatinine, decreased urine output, prerenal failure, and severe hypertension that are difficult to manage.[1]

Diagnostic studies used to confirm the diagnosis of acute aortic dissection include transesophageal echocardiogram (TEE) and contrast medium-enhanced computed tomography (CT).[9]

A closer look at a dissecting aortic aneurysm



Source: Anatomical Chart Company. *Atlas of Pathophysiology*. 3rd ed. Philadelphia, PA: Wolters Kluwer/Lippincott Williams & Wilkins; 2010:39.

Other complications

Two common complications of aneurysms are thrombus formation and aneurysm rupture. Because of stagnant blood flow, layers of clot typically develop along the walls of aneurysms. These mural thrombi become a potential source of emboli and spontaneous aneurysm thrombosis.

Aneurysm rupture is catastrophic and associated with a poor prognosis. Rupture usually results in bleeding into the retroperitoneal space, where a tamponade effect is exerted by adjacent structures. Patients with aneurysm rupture typically have acute abdominal or back pain and signs of hemorrhagic shock. These patients need immediate surgical resection of the aneurysm.

Diagnostic tests and treatment

If an aneurysm is suspected, the following diagnostic tests may be obtained:

- Chest X-ray to visualize TAAs; findings include widening of the mediastinal shadow and displacement or compression of the trachea or left mainstem bronchus.
- Abdominal ultrasound to delineate transverse and longitudinal dimensions of AAA; may also detect mural thrombi (thrombi that adhere to the vessel wall) in large vessels.
- TEE to identify specific location and extent of ascending or descending thoracic aneurysms and to visualize a dissecting aneurysm
- Contrast-enhanced CT or magnetic resonance imaging (MRI) to provide precise measurements of aneurysm size as well as local anatomic relationships of the visceral and renal vessels; the CT scan is readily available, quick, and requires less contrast than an aortogram.
- Angiography to visualize precise size and location of an aneurysm.

Medical treatment is indicated for slow-growing aneurysms, especially in the early stages. Medical treatment includes management of cardiovascular risk factors including hypertension, dyslipidemia, smoking, obesity, and inactivity. Antihypertensive agents and long-term beta-blockers are prescribed to lower BP and reduce the mechanical forces thought to contribute to aortic wall dilation. Antiplatelet agents such as aspirin are given daily to lower the risk of stroke and myocardial infarction. Patients with aortic aneurysms may also have risk factors for cardiovascular disease and may have coexisting peripheral arterial disease (PAD) and coronary artery disease. Intermittent claudication pain in patients with PAD is treated to help activity tolerance. HMG-CoA reductase inhibitors (statins) are a common adjunct to help lower blood lipid levels. Also encourage the patient to eliminate modifiable risk factors such as smoking, and encourage healthy lifestyle changes such as exercise and weight loss for overweight and obese patients.

Aneurysm size is carefully monitored for expansion at least every 6 to 12 months using palpation, abdominal X-rays, ultrasound, or CT scans.[1,11] Once the diameter of the aneurysm reaches or exceeds 5.5 cm, the risk of rupture or dissection increases. At this point, elective surgery may be indicated.

When surgery is needed

Indications for surgical repair of aortic aneurysms include:[6,9,11,12]

- aneurysm diameter greater than 5.5 cm
- aneurysm diameter of 4 to 5 cm in young patients who are otherwise healthy and have less surgical risk, and also in women because AAAs have been shown to rupture at a smaller diameter in women when compared to men[7]
- rapidly expanding aneurysm (growth rate greater than 0.5 cm over a 6-month period)
- symptomatic aneurysm of any size.

The type of surgery selected for aortic aneurysm depends on whether the patient can tolerate the surgery; the patient's current medical condition and overall cardiopulmonary, circulatory, renal, and gastrointestinal function; and the type and characteristics of the aneurysm. The procedures are:

- *Traditional surgery,* which requires general anesthesia and can be done as open surgery (in which a large midline incision that may run from chest to abdomen) or laparoscopic surgery. The aneurysm is removed and the damaged portion of the blood vessel is replaced with a prosthetic graft.

This surgery may involve cross-clamping the aorta, which can place the patient at risk for emboli, ischemia, and hemodynamic changes. Physiologic responses to cross-clamping are varied depending on the patient's preoperative left ventricular function, overall circulatory system health, and level of the cross-clamp. The surgical team must be precise and proficient with careful monitoring of clamp time and blood volume loss. Hypertension proximal to the clamp may result from increased afterload, and can be minimized by administering vasodilators or increasing the depth of anesthesia. Prolonged cross-clamp time can cause neurologic deficits and ischemia to distal tissues (renal, hepatic, intestinal). A cross-clamp time greater than 30 minutes is defined as significant.[13]

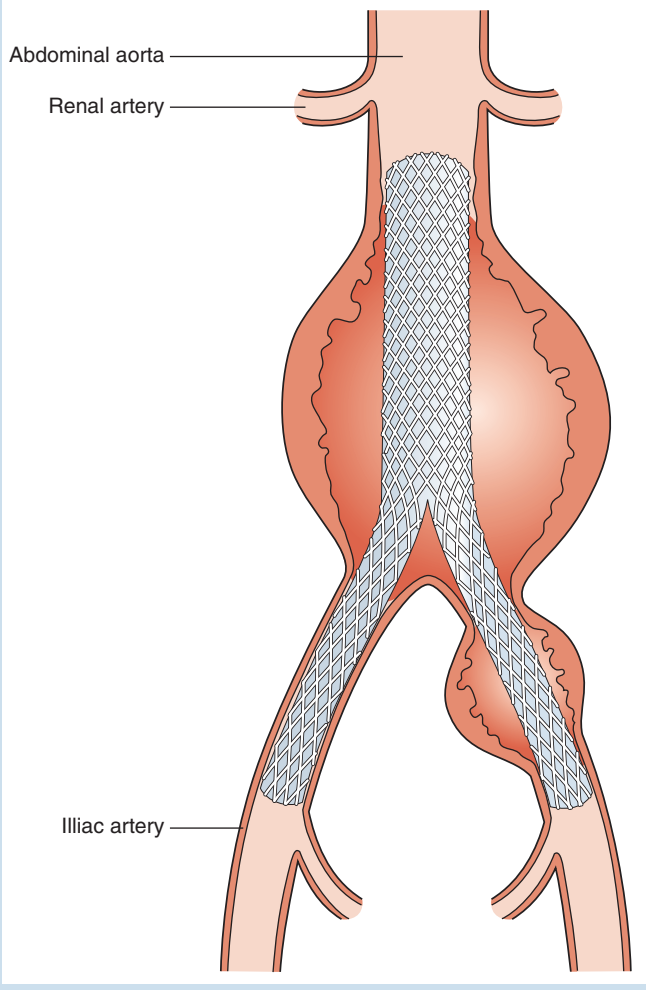
- *Endovascular aneurysm repair (EVAR),* in which a stent is inserted through an artery in the groin. This is a relatively new procedure, first described in the literature in 1991 and originally used as a less invasive approach for patients not eligible for open repair surgery. The stent graft is inserted inside the aorta and provides a bridge between the healthy sections of the aorta above and below the aneurysm.[5,14] By covering the aneurysm, this stent prevents tension on the vessel wall where the aneurysm is located and can actually support regression of the

aneurysm (see *Endovascular aneurysm repair*). The most common complications for this approach are stent failure and stent migration, both of which can lead to additional invasive procedures.

Three recent studies comparing outcomes after endovascular and open repair of AAAs showed a decreased 30-day mortality with the endovascular approach.[5,6] The endovascular approach also was associated with a shorter hospital stay, faster recovery period, and early survival advantage. However, the mortalities for both groups were essentially the same 2 years postprocedure and remained there for the remaining 6 years of observation. The endovascular group also required more frequent monitoring after discharge, additional interventions, and had more graft-related complications, which translated to higher costs.

Endovascular aneurysm repair

The stent graft, inserted inside the aorta, helps to reinforce the vessel wall, and provides a bridge between the healthy sections of the aorta above and below the aneurysm.



Source: Smeltzer SC, Bare BG, Hinkle JL, Cheever KH. *Brunner & Suddarth's Textbook of Medical-Surgical Nursing*. 12th ed. Philadelphia, PA: Lippincott Williams & Wilkins; 2010:870.

Preparing for surgery

Before the patient undergoes surgery, evaluate the patient's medical history and perform medication reconciliation. Patients who take anticoagulants are at risk for excessive blood loss during the procedure. Note the presence of any medical conditions (such as cardiac or pulmonary dysfunction) that may affect the use of anesthetic agents. Large doses of I.V. contrast might be contraindicated in patients with renal insufficiency. Review the patient's cardiac clearance values and lab results (including platelet levels, hemoglobin, hematocrit, blood urea nitrogen, creatinine levels, prothrombin time, and partial thromboplastin time). Alert the healthcare team of any abnormalities in these values, which may point to problems that could affect clinical outcomes.[15] Be sure that the patient's current chest X-ray, CT scan, and MRI reports are in the chart and available to the surgeon.

To reduce the risk of aneurysm rupture preoperatively, keep the patient on bed rest, maintain a calm environment, and reduce psychological stress. Tell the patient not to strain during defecation (administer stool softeners as needed), and not to hold his or her breath. Also tell the patient not to elevate or cross his or her legs, which restricts peripheral blood flow and increases pressure in the aorta and iliac arteries. Administer antihypertensive agents and beta-blockers as prescribed. Beta-blockers decrease perioperative cardiovascular morbidity and mortality by decreasing the heart's workload and oxygen demand. Monitor patients for any ECG changes or sign of myocardial ischemia.

Perioperatively, the surgical team will assess the patient for any risk of infection during surgery. Antibiotics will be administered as prescribed and according to

Surgical Care Improvement Project protocol. The OR suite will maintain appropriate airflow and air exchange, reduce OR traffic, and maintain required room temperature and humidity levels.

The patient will be monitored and evaluated for response to medications delivered intraoperatively. Check with the blood bank to ensure blood products are available as ordered. Hemostatic agents and anticoagulants are administered as required by procedure.

Fluid warmers and active warming measures may be needed to maintain the patient's core body temperature. Because of the high amount of insensible fluid loss during an open abdominal surgery, accurate accounting for fluid balance is critical. Monitor I.V. fluid intake, urine output, blood loss (weigh sponges) and irrigation fluid losses.

Mechanical prophylaxis for venous thromboembolism (with sequential compression devices and compression stockings) is used to support perfusion and decrease the patient's risk of venous stasis. Mark pedal pulses before skin preparation so that if a pulse check is requested, it can be assessed immediately.[16]

As per the Universal Protocol, confirm with the surgeon the type and size of graft or stents needed to complete the procedure. All surgical instrumentation and/or radiologic equipment must be checked and operational before the patient enters the OR. All equipment necessary for conversion to an open procedure must be available in the room for EVAR or hand-assisted laparoscopic aortic aneurysm procedures.

The EVAR procedure requires a fluoroscopy unit, angiographic supplies, and a device for delivering I.V. contrast dye under high pressure. Be sure to have appropriate radiologic protective equipment for the patient and staff.

Postoperative nursing care

After the procedure, the patient may be transferred to the postanesthesia care unit or may go directly to the ICU. In the immediate postoperative phase, monitor the patient for adequate ventilation and tissue perfusion, signs and symptoms of hemorrhage, and administer medications to relieve pain and anxiety. Patients who've had an open aortic aneurysm repair will usually spend at least the first 24 hours in an ICU or step-down unit. Carefully monitor the patient's hemodynamic status and perfusion; an arterial line typically is used to monitor BP, and cardiac status may be evaluated using a pulmonary artery catheter.

Postoperative pain is managed much in the same way as with other abdominal surgeries: I.V. opioids are used in the first 24 hours, followed by oral opioids. Epidural and intrathecal opioids typically aren't required, and these catheters if present, usually are removed in the immediate postoperative period once the patient's pain is effectively managed. Combination therapies, such as nonsteroidal anti-inflammatory drugs and acetaminophen, should also be considered as adjunct medications to help reduce opioid requirements.

Priorities postoperatively include monitoring and preventing complications commonly associated with major surgery: respiratory compromise, hemodynamic instability, infection, and ileus. The goal is to return patients to their normal preoperative function and daily activities as soon as possible. Patients receiving general anesthesia are at risk for pulmonary complications such as atelectasis, pneumonia, and pulmonary embolism. Encourage patients to use incentive spirometry, to cough and perform deep breathing, and to splint the surgical site as needed. Also encourage early ambulation, and turn the patient to maximize ventilation/perfusion match.

Closely monitor patients for the respiratory depression effects of opioids; evaluate respiratory rate, oxygen saturations, breath sounds, and respiratory effort. Supplemental oxygen may be administered in the immediate postoperative period if indicated.

Carefully monitoring the patient's BP and hemodynamic status will alert you to signs and symptoms of a possible graft rupture, hemorrhage, or graft occlusion. Indicators of blood loss include a drop in BP or urine output, an increased heart rate, and any change in mental status. Monitor and assess the patient's abdomen for distension, pain, or an increasing girth. Elevate the head of the bed 45 degrees to relieve abdominal tension and to prevent pressure on the graft site. Report any numbness, tingling, or decrease in pulse in the lower extremities.

Graft occlusion due to thrombus formation or embolization is another serious potential complication of aneurysm repair. Symptoms depend on the site of the graft and the end organs perfused by the affected blood vessels. For example, after TAA repair, signs of occlusion may include coronary or cerebral ischemia, ischemic colitis, or spinal cord

ischemia. Signs of occlusion after an AAA repair include prerenal failure or acute tubular necrosis (indicating decreased renal perfusion) or changes in peripheral pulses or circulation.

As with any surgical procedure, infection is always a concern. Monitor the incision or puncture sites for any sign of redness, poor wound healing, or pus formation. Administer antibiotics as prescribed postoperatively. Teach the patient to care for the incision and explain the importance of taking all medications as prescribed upon hospital discharge.

By understanding the risk factors, pathophysiology, and management of aortic aneurysms, you can help patients receive optimal care. **OR**

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