Home Study Program
The modified Bentall procedure for aortic root replacement

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The Bentall procedure is a surgical repair of an ascending aortic aneurysm or an aortic root aneurysm that is accompanied by aortic valve incompetence. Less commonly, this procedure is used to repair aortic dissection affecting the aortic root and valve. The procedure uses a composite aortic graft (i.e., a vascular tube graft with an attached mechanical or biologic valve) to replace the proximal ascending aorta and the aortic valve. Circulation to the coronary arteries is maintained by implanting the proximal end of the coronary arteries into openings made in the aortic graft.

This procedure was first described by H. H. Bentall, MD, and A. DeBono, MD, in 1968 and is still performed today with some modifications. Currently, a full-thickness “button” of aorta surrounding the coronary ostia (i.e., where the proximal coronary arteries attach to the aorta) is removed, making it easier to implant the proximal coronary arteries into the aortic vascular graft.

Anatomy and Physiology
The heart is a muscular, four-chambered pump that provides the power to move blood through the circulatory system. The heart is about the size of an adult’s fist, located slightly to the left of the midline of the mediastinum, directly behind the sternum (Figure 1). The four chambers of the heart consist of the right and left atria and ventricles. Oxygenated blood from the heart exits through the aorta to enter systemic circulation.

The aorta exits from the left ventricle, arches upward and then down through the thorax and abdomen, and branches into the iliac arteries. The diaphragm separates the thoracic and abdominal portions of the aorta. The thoracic aorta is subdivided further into the ascending aorta, aortic arch, and descending aorta.

The aorta is the largest artery in the body and it supplies blood to all major arteries in the body. Like all arteries, the aorta consists of three layers: the tunica intima, the tunica media, and the tunica adventitia. The tunica intima is the innermost layer, consisting of endothelial cells and elastic tissues that give the aorta its elasticity and strength. The tunica media is the middle layer that contains smooth muscle tissue and elastic fibers. The tunica adventitia is the outermost layer, consisting of connective tissue. The aortic root includes the section of the ascending aorta that exits...
from the heart, the aortic valve, and the coronary ostia (i.e., openings where the coronary arteries enter the aorta). The left and right main coronary arteries branch off from the ascending aorta to supply the heart muscle with oxygenated blood (Figure 2).

**The Heart Valves.** The purpose of the heart valves is to ensure that blood flows through the heart in one direction. The valves open and close passively, as a result of differences in the pressure gradients between the heart chambers. As blood accumulates in the heart’s chambers, the pressure behind the valve increases until it is greater than pressure beyond the valve. The valve opens allowing blood to flow through the valve and then closes as the pressure in front of the valve rises. There are four heart valves: the aortic and pulmonic valves (i.e., semilunar valves) and the mitral and tricuspid valves (i.e., atroventricular valves). The mitral valve has two cusps; the other three valves are each composed of three cusps. The aortic valve is attached to the aortic wall and left ventricular muscle.

**The Cardiac Cycle.** The term cardiac cycle refers to the contraction and relaxation phase of one heartbeat. An average cardiac cycle is about 0.8 seconds. Systole is the phase of the cardiac cycle associated with ventricular contraction and ejection of blood into systemic circulation, which accounts for one-third of the cardiac cycle. The atria contract to complete filling of the ventricles that began passively filling during systole. As the aortic and pulmonic valves open, the mitral and tricuspid valves close, producing the first heart sound, S1. The aorta stretches and expands, temporarily storing a portion of the blood ejected from the ventricle.

Diastole is the relaxation phase of the cardiac cycle, accounting for two-thirds of the cardiac cycle. During diastole, blood from the lungs and systemic circulation enters the heart. Relaxation results in negative pressure that passively draws blood into the chambers of the heart. The mitral and tricuspid valves open, and the aortic and pulmonic valves close, which produces the second heart sound, S2. Blood enters the coronary arteries during this phase. The aorta recoils to propel blood into systemic circulation.
PATHOPHYSIOLOGY

Aneurysms are classified by location and can affect any segment of the thoracic or abdominal aorta, singly or in combination. The terms aneurysm and dissection often are used interchangeably. Although both conditions may exist in the same patient, the terms describe two very different types of pathology.

AORTIC ANEURYSM. The term aortic aneurysm refers to a localized dilation of the wall of the aorta and generally is defined by an aortic diameter greater than 3 cm. Aortic aneurysms are caused by degeneration of the tunica media, causing dilation of all three layers of the artery. The wall of the aorta becomes progressively weaker as the aneurysm enlarges. If the aneurysm is left untreated, it may rupture and cause death from cardiac tamponade.

There is a strong link between aortic aneurysms and atherosclerosis, although the relationship is not understood. It is theorized that the atherosclerotic process reduces the aortic wall’s elasticity in addition to thinning the wall of the vessel. One study found an autosomal dominant genetic connection in patients with thoracic aortic aneurysms. Twenty-one percent of the study population (ie, patients who had a thoracic aneurysm or aortic dissection) had a close relative who had an aneurysm, either diag-

nosed or suspected due to sudden death with cardiac-like symptoms (eg, chest pain, shortness of breath, diaphoresis, nausea).

The term annuloaortic ectasia refers to an aneurysm of the aortic root accompanied by dilation of the annulus of the aortic valve and aortic valve incompetence as the result of cystic medial degeneration (ie, the tunica media of the aorta becomes less elastic as fibers break down). This may be a result of the aging process; hypertension; connective tissue disorders, such as Marfan’s syndrome; or other unknown factors. Annulaortic ectasia frequently is the indication for surgical aortic root replacement.

The pathologic changes in the ascending aorta can cause aneurysmal dilation of the aortic root (Figure 3), which can affect the ability of the aortic valve cusps to close, leading to valve incompetence and aortic regurgitation. When the aortic valve is incompetent, the valve fails to close completely, causing a backflow of blood into the heart from the aorta and increasing the workload of the left ventricle. Left ventricular hypertrophy may result from the increased workload and progress to left heart failure if the aortic regurgitation is not treated.

AORTIC DISSECTION. The term aortic dissection refers to a tear in the intimal wall of the vessel, creating a false lumen that allows blood to accumulate between the tunica intima and the tunica media. Systemic blood pressure forces more blood into this false lumen with each heartbeat, enlarging the area of dissection. Untreated, the dissection will continue to enlarge, creating possible complications, such as:

- aortic thrombus formation,
- compromised systemic circulation,
- rupture of the weakened aortic wall, or
- cardiac tamponade.

Patients may present with signs of shock because of decreased circulating blood flow.

Figure 3 • An aneurysm of the aortic root is caused by degeneration of the tunica media.
volume or sudden onset of stroke or paralysis as a result of disruption of blood flow to the brain or spinal cord. Dissections of the ascending aorta may alter the normal anatomical structure of the aortic root, resulting in dysfunction of the aortic valve and disruption of the flow of blood to the coronary arteries.15-17

**INCIDENCE.** The incidence of all thoracic aneurysms is estimated to be 10.4 cases per 100,000 people annually.18 Thoracic aortic aneurysms occur most frequently in the ascending aorta (ie, 50%), whereas only 40% occur in the descending aorta, and the remaining 10% occur in the aortic arch.13 Aortic dissection affects two in 100,000 people in the United States annually, most commonly men who are 40 to 70 years of age.19 Factors associated with developing an aortic aneurysm or aortic dissection are presented in Table 1.

**Symptoms.** Often thoracic aortic aneurysms are asymptomatic and are discovered only by testing for other conditions. Symptoms may not occur until the aneurysm grows large enough to compress adjacent structures in the chest, at which point patients may complain of chest or back pain.18 Symptoms specific to aortic root aneurysm caused by aortic regurgitation include

- cough
- diastolic murmur
- dysphasia
- dyspnea on exertion
- fatigue
- orthopnea
- palpitations
- paroxysmal nocturnal dyspnea, and
- widened pulse pressures.5,20

Symptoms of aortic dissection include sudden onset of severe chest pain, which may radiate to the back and often is described as a “ripping” or “tearing-like” pain. Clinical signs of acute aortic insufficiency or aortic regurgitation resulting from an aortic root dissection are the same as those caused by aortic root aneurysm.16

**Diagnosis**

Chest radiography may reveal an aortic aneurysm, usually by the presence of a widened mediastinum; however, it is not always possible to distinguish an aortic
aneurysm from a mass. In some patients, an aortic root aneurysm might be obscured by the cardiac silhouette and therefore not be visible on a chest x-ray. Patients with aortic incompetence may have an enlarged cardiac silhouette. Transthoracic or transesophageal echocardiography can be used to diagnose pathology of the aortic valve and aorta. Contrast-enhanced computed tomography can be used to diagnose the presence, location, and size of an aortic aneurysm. Cardiac catheterization with aortography provides accurate diagnosis of the presence and severity of an aortic root aneurysm. If coronary artery disease is demonstrated during the cardiac catheterization, the surgeon probably will elect to perform a coronary artery bypass at the time of the aneurysm repair.

If an aneurysm is asymptomatic, the patient’s health care provider may recommend regular follow-up to monitor the aneurysm’s growth before proceeding with surgical repair.

Aortic aneurysms also may be detected during diagnostic testing for another condition. If the aneurysm is asymptomatic, the patient’s health care provider may recommend regular follow-up to monitor the aneurysm’s growth before proceeding with surgical repair. The consensus of many cardiothoracic surgeons is that elective surgery to repair the aneurysm is indicated for:
- an aortic diameter greater than 4.5 cm in patients with Marfan’s syndrome,
- an aortic diameter greater than 5.5 cm to 6 cm,
- any symptomatic aneurysm, or
- patients who have a family history of a ruptured aortic aneurysm.

Elective surgery also is indicated if the patient has symptomatic aortic valve regurgitation related to the aneurysm. Rupture of the aneurysm requires emergency surgery to prevent death from cardiac tamponade or exsanguination.

**Preoperative Patient Preparation**

At University Hospital, Birmingham, Ala, the patient is admitted to the hospital on the day before the scheduled procedure. Patients with a symptomatic aortic root aneurysm accompanied by a low ejection fraction (ie, less than 35%) may be admitted to the cardiac intensive care unit (CICU) for preoperative placement of an intra-aortic balloon pump (IABP). The IABP provides counterpulsation that reduces the workload of the heart during the night before surgery. The decision to use the IABP depends on the aneurysm’s location and structural involvement; however, this device must be used with caution in the presence of an aortic aneurysm.

Patient teaching and discharge planning begin on admission. The preoperative nurse gives the patient and his or her family members a hospital-prepared patient teaching booklet that outlines what to expect during the hospital stay, both preoperatively and postoperatively, and includes postdischarge instructions. This booklet contains a simplified description of basic cardiac anatomy and physiology. The different roles of hospital staff members who will care for the patient (eg, nurse practitioner, chaplain, dietitian, case manager, physical therapist) also are described. Equipment that will be used during the patient’s CICU stay is described in detail (Figure 4). This booklet also contains information that family members may need, such as parking, dining, and lodging options.

The preoperative nurse instructs the patient that nurses will be using a one-to-10 rating scale to frequently assess postoperative pain. The nurse also explains that the patient will be NPO...
Figure 4
Excerpt from the Cardiovascular Surgery Patient Teaching Booklet

The Cardiac Intensive Care Unit (CICU)

The CICU is a 20-bed unit where nurses are always watching and taking care of you. The CICU is a busy place. You will stay in CICU for one to two days until you are ready to be transferred to your room. When you get to the CICU, you will have several small tubes attached to machines, monitors, or containers. You will not notice this until you start to wake from your anesthesia. Do not worry if you cannot move your arms or legs when you first wake up from surgery. This is because the medicine used during the surgery may result in your mind and body waking up at different times. In a short while, your entire body will be awake and you will be able to move your arms and legs. You will hear the sounds of equipment and may be aware of activity around you. If you overhear someone talking, do not think that they are necessarily talking about you. If someone wants to talk with you, he or she will call you by name and speak directly to you. Following are descriptions of some CICU equipment you will have while in the CICU.

Chest tubes
Several clear tubes will come out of the lower part of your chest to drain blood from your chest. Some bleeding after surgery is normal. Your doctor will decide when it is time to remove the chest tubes.

IV line
An IV line is a small, soft-plastic tube in a vein in your arm or hand through which fluid, medicine, or blood can be administered. The IV line may be connected to a pump to help the fluid go into your vein. You will have a least one IV line until you can take your medicine by mouth. You also will have a larger IV line in a vein on the side of your neck after surgery. This will remain in until the day you go home. Let your nurse know if you have any redness, swelling, or tenderness near the IV line.

Monitors
There will be a monitor screen on the shelf at the head of your bed. Small round pads will be placed on your chest to monitor your electrocardiogram (ie, heart rhythm). While you are in the CICU, your nurse will measure your blood pressure and temperature all the time. You also may have several small wires (ie, pacemaker wires) taped on your lower chest to increase your heart rate or keep track of your heart’s rhythm.

Nasogastric (NG) tube
An NG tube was put through your nose into your stomach during surgery. The NG tube keeps air from building up in your stomach. This helps keep you from getting sick to your stomach and vomiting. Your nurse will give you ice chips after he or she removes the NG and breathing tubes.

Oxygen mask or nasal cannula
After you are taken off the ventilator, your nurse will give you oxygen by using a small plastic mask or a thin, clear plastic tube called a cannula. The mask sits lightly on your face covering your mouth and nose. The cannula has two small, short prongs that fit just inside your nose.

Pulse oximeter
This small device estimates how much oxygen is in your blood. It is taped to your finger, toe, or ear.

Urinary catheter
A tube, called a catheter or Foley, will be put into your bladder during surgery. It drains urine from your bladder so you can rest instead of having to use a bedpan or urinal. This makes it easier for the nurse to keep an accurate record of your urine output. It is normal to feel like you need to urinate. Just relax, and let the catheter take care of it. The catheter will be removed a few days after surgery.

Ventilator
You will have a breathing tube in your mouth or nose when you wake up. You may have a full or tight feeling in your throat because the tube goes down your throat into your windpipe. You will not be able to talk with the tube in. Do not pull the tube or move your head too much.

The tube will be connected to a ventilator (ie, breathing machine) that breathes slowly and deeply for you until you are fully awake. You and your heart will rest better while the machine helps your breathing. The machine also gives more oxygen to your brain. Just lie quietly and rest. Your nurse will use various methods to find out if you are having much pain and you can respond by gently nodding or shaking your head.

You will have the breathing tube until you no longer need help breathing. Since you cannot cough up mucus, your nurse will use a tube to suction the mucus. It may hurt a little, but it is needed to prevent problems like pneumonia. Right after the tube is removed, your nurse will help you sit up in bed and will clap your back to help clear your lungs. You will be able to talk after the tube is removed, but your voice may be a little hoarse.

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TABLE 2
Equipment and Supplies Needed for the Modified Bentall Procedure

**Equipment**
- Autologous blood recovery system
- Cardiopulmonary bypass machine
- Headlights and headlight boxes
- Supplies for femoral arterial and venous cannulation
- Transesophageal echocardiography unit

**Instruments**
- Appropriate aortic valve sizers
- Basic cardiac instruments
- Electric reciprocating sternal saw
- Internal defibrillator paddles

**Medications**
- Bone paste made with 10,000 units thrombin, 500 mg vancomycin, and absorbable gelatin powder
- Epinephrine 1:10,000

**Positioning aids**
- Foam headrest
- Foam padding
- Full length gel pad on OR bed
- Small gel pads

**Supplies**
- Chest tubes
- Closed chest-drainage system
- Indwelling urinary catheter with temperature probe
- Pacemaker cable
- Temporary pacing wires

after midnight the night before surgery. On the morning of surgery, the patient’s body hair will be removed with clippers, if needed, and the patient will be instructed to shower using antibacterial soap.

**Preparation of the OR**

The circulating nurse and scrub person gather all equipment, supplies, instruments, and medications for the procedure (Table 2). The OR team prepares for femoral arterial and venous cannulation for cardiopulmonary bypass (CPB) to avoid the risk associated with cannulation of the aneurysm-weakened aorta. The circulating nurse checks the inventory of aortic root implants (Table 3) to ensure that all sizes of each implant that might be used are available.

The circulating nurse goes to the preoperative holding area to greet the patient and perform the preoperative nursing assessment. The circulating nurse introduces himself or herself to the patient and verifies the patient’s identity verbally and with the patient’s hospital identification bracelet. The nurse then verifies the surgical procedure with the patient and the consent form, ensuring that the written consent is in agreement with the patient’s statement of the planned procedure and the surgeon’s preoperative progress note. The circulating nurse questions the patient regarding allergies and NPO status and verifies that any dentures; partial dentures; contact lenses; and jewelry, including body jewelry, are removed before the patient’s transfer to the holding area. The nursing assessment also includes gathering all data relevant to the patient’s care, including
- the presence of any metal implants (eg, pacemakers, implanted defibrillators, total joint implants);
- sensory impairments;
- preexisting skin conditions; and
- any special positioning needs that the patient might have (eg, accommodating for the presence of joint contractures).

The nurse reviews the patient’s chart for relevant laboratory test results and the presence of a consent form for administration of blood products. Using information obtained during the preoperative assessment, the nurse formulates the appropriate nursing diagnoses and develops an intraoperative plan of care for the patient (Table 4). The anesthesia care provider administers preoperative IV antibiotics to the patient as ordered by the surgeon while the patient is in the holding area. To comply with infection control recommendations, antibiotic prophylaxis is administered within 60 minutes of the surgical skin incision.
### Table 3
Types of Grafts Used in Aortic Root Replacement

<table>
<thead>
<tr>
<th>Composite grafts</th>
<th>Advantages</th>
<th>Disadvantages</th>
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</thead>
<tbody>
<tr>
<td>Mechanical valve with attached woven tube vascular graft</td>
<td>• More durable than biologic valves—Expected to function for the life of the patient</td>
<td>• Thrombogenic (ie, promotes the formation of clots)—Patient will require lifelong anticoagulation therapy</td>
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<tr>
<td>Tissue valve (ie, porcine aortic valve, bovine pericardium) with attached woven tube vascular graft</td>
<td>• Nonthrombogenic—Patients will not require lifelong anticoagulation therapy</td>
<td>• Less durable than mechanical valves—Patient may require re-operation for valve replacement in the future</td>
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<table>
<thead>
<tr>
<th>Tissue grafts</th>
<th>Advantages</th>
<th>Disadvantages</th>
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<tbody>
<tr>
<td>Homograft or allograft (ie, tissue from cadaver donor) ascending aorta with aortic valve that is stored frozen until ready to implant</td>
<td>• Nonthrombogenic—Patient will not require lifelong anticoagulation therapy</td>
<td>• Storage and thawing of cryopreserved human tissue requires strict adherence to tissue center guidelines</td>
</tr>
<tr>
<td>Xenograft or heterograft (ie, porcine aortic root with valve)</td>
<td>• Nonthrombogenic—Patient will not require lifelong anticoagulation therapy</td>
<td>• Less durable than mechanical woven tube composite graft</td>
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### Intraoperative Patient Care

The circulating nurse and anesthesia care provider transfer the patient into the OR on either a stretcher or the CICU bed and help the patient move onto the OR bed. The circulating nurse offers the patient warm blankets for comfort and remains close to the patient during induction of anesthesia to offer emotional support to the patient and assistance to the anesthesia care provider. After anesthesia induction, the circulating nurse or the RN first assistant (RNFA) places an indwelling urinary catheter with a temperature probe. The surgeon and anesthesia care provider place pressure monitoring lines (ie, radial arterial line, central line, pulmonary artery catheter) for hemodynamic monitoring during the intraoperative and immediate postoperative periods. The circulating nurse places the patient’s wrist with the arterial line on a padded disposable arm board to help maintain the correct position of the arterial catheter.

The circulating nurse, surgeon, anesthesia care provider, and RNFA place the patient in the supine position for the procedure, ensuring that correct body alignment is maintained. The anesthesia care provider places the patient’s head on a padded headrest. The circulating nurse places an electrosurgical unit (ESU) dispersive pad under the patient’s upper back. If the patient has an implanted pacemaker or internal defibrillator, the ESU dispersive pad is placed at an alternate well-muscled site. The circulating nurse pads both of the patient’s arms at the elbows, and then tucks the patient’s arms at his or her sides using the draw sheet, with the palmar surface of the patient’s hands against the patient’s body. Padded sleds are used, if necessary, depending on the size of the patient.

### Surgical Procedure

The circulating nurse cleans the patient’s skin with an iodine/alcohol solution from chin to toes, prepping
<table>
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<tr>
<th>Diagnosis</th>
<th>Nursing interventions</th>
<th>Interim outcome criteria</th>
<th>Outcome statement</th>
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<tbody>
<tr>
<td>Risk for alteration in tissue perfusion</td>
<td>• Assesses for preexisting conditions that predispose to inadequate tissue perfusion.</td>
<td>The patient maintains adequate tissue perfusion throughout the procedure as demonstrated by peripheral pulses equal to or greater than baseline, adequate urinary output, and blood pressure and filling pressures within normal limits.</td>
<td>The patient demonstrates wound and tissue perfusion consistent with or improved from baseline levels established preoperatively.</td>
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<td></td>
<td>• Identifies baseline tissue perfusion.</td>
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<td>• Collaborates in fluid management.</td>
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<td></td>
<td>• Monitors physiological parameters (e.g., peripheral pulses, urinary output, blood pressure, filling pressures).</td>
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<td></td>
<td>• Evaluates postoperative cardiac and peripheral tissue perfusion.</td>
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<td>Risk for anxiety related to knowledge deficit and stress of surgery</td>
<td>• Determines knowledge level, assesses readiness to learn, and identifies barriers to communication.</td>
<td>The patient verbalizes decreased anxiety and an ability to cope, understanding of individualized procedure and sequence of events, that questions have been answered, and expected outcomes.</td>
<td>The patient demonstrates knowledge of the expected response to the procedure and discharge care.</td>
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<td></td>
<td>• Acts as a patient advocate by identifying individual values and wishes concerning care; maintaining the dignity, modesty, and privacy of the patient; protecting the patient from unsafe care; and ensuring confidentiality of patient information.</td>
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<td>The patient and appropriate family members participate in decisions affecting the patient’s plan of care.</td>
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<td></td>
<td>• Explains sequence of events; reinforces teaching about treatment options; provides instruction (i.e., verbal, written) for surgical procedure and discharge based on age and identified need; and ensures availability of support group interaction.</td>
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<td>• Verifies consent for planned procedure.</td>
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<td>• Communicates patient concerns to appropriate surgical team members.</td>
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<td>• Evaluates psychosocial effect of plan of care and response to instruction.</td>
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<td></td>
<td>• Provides status reports to family or support group.</td>
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<td>Risk for acute or chronic pain related to surgical procedure</td>
<td>• Assesses patient’s pain preoperatively.</td>
<td>The patient demonstrates adequate pain management.</td>
<td>The patient demonstrates and reports adequate pain control throughout the perioperative period.</td>
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<td></td>
<td>• Identifies patient’s accepted postoperative pain threshold.</td>
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<td></td>
<td>• Provides pain management instruction and pain scale to assess pain control.</td>
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<td></td>
<td>• Evaluates patient’s response to pain management interventions.</td>
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<tr>
<td>Risk for injury related to perioperative experience</td>
<td>• Verifies patient’s identity, allergies, NPO status, and informed consent.</td>
<td>The patient’s skin remains intact, and neuromuscular functions are maintained or improved from baseline.</td>
<td>The patient is free from positioning injury from extraneous objects.</td>
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<tr>
<td></td>
<td>• Assesses skin integrity, sensory impairments, and musculoskeletal status.</td>
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<td></td>
<td>• Transfers patient, implementing protective measures to prevent positioning injury and maintain correct body alignment.</td>
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both legs and feet circumferentially, taking care to avoid pooling of the prep solution. After the prep solution dries completely, the scrub person, RNFA, and surgeon drape the patient, and the scrub person passes the CPB pump lines off the field before the skin incision is made. The circulating nurse initiates a surgical “time out” in which all members of the surgical team participate, verifying the patient’s identity and scheduled surgical procedure before the skin incision.

The surgeon uses a #10-knife blade to make a midline incision extending from the supraventricular notch to just beyond the xiphoid process. The surgeon places a rake retractor in the upper end of the incision to expose the sternal notch. He or she uses curved Mayo scissors to separate the tissue above the transverse ligament and then places a Shallcross clamp under the ligament, using the monopolous ESU pencil to transect the ligament.

The surgeon uses the ESU pencil to cut through the subcutaneous tissue and pectoralis muscle to the sternum. He or she uses the ESU pencil to mark the sternum down the midline to prepare for sawing.

Using an electrically powered sternal saw, the surgeon performs a median sternotomy. He or she then uses electrosurgery to obtain hemostasis of the sternal edges and soft tissue. The surgeon and RNFA place a four-bladed self-retaining sternal retractor between the sternal edges.

The surgeon uses a #10-knife blade to open the pericardial sac, then uses electrosurgery to complete the dissection. If necessary, the surgeon places a 2-0 silk pericardial stay stitch on the surgeon’s side of the chest to expose the aorta and secure the patient’s subcutaneous tissue.

At the same time the surgeon is making the midline skin incision, the RNFA uses a #10-knife blade to make an incision in the groin to expose the femoral artery for cannulation. Cannulating the femoral artery makes the entire ascending aorta available for replacement if necessary. After exposing the femoral artery, the RNFA uses electrosurgery to dissect through the subcutaneous tissue and places a self-retaining Weitlaner retractor to expose the femoral artery.

The RNFA uses dissecting scissors to separate and expose the vessel and uses a single-armed 4-0 monofilament polypropylene suture with an RB-1 needle as a purse-string stitch. The RNFA cuts off the needle and threads the suture through a disposable tourniquet and secures it with a hemostat with shods.

The surgeon places a purse-string stitch of 3-0 polypropylene suture with a polytetrafluoroethylene (ie, Teflon) pledget in the inferior vena cava for venous cannulation. He or she threads the purse-string stitch through a disposable tourniquet and uses a hemostat with shods to secure the tourniquet.

The surgeon then places a second purse-string stitch in the superior vena cava using a 3-0 single-armed polypropylene suture. He or she secures the purse-string suture with a tourniquet and hemostat with shods.

Before cannulation, the scrub person measures the bypass tubing, cuts it into appropriate lengths, and places a 1/2-inch by 3-inch by 8-inch Y-shaped connector on the venous side of the tubing. There is no need for an arterial connector.

After using the electrosurgical pencil to cut through the subcutaneous tissue and pectoralis muscle, the surgeon marks the sternum down the midline in preparation for sawing.
because the percutaneous arterial cannula has a built-in arterial connector.

The surgeon inserts an 18-gauge, hollow needle into the femoral artery until blood is returned. He or she then inserts a guide wire into the needle and advances it up the aorta. The surgeon removes the needle and threads a series of dilators over the wire and into the artery to dilate the artery for insertion of the cannula. He or she then threads the femoral artery cannula over the wire and inserts it into the femoral artery. When arterial blood enters the cannula, the surgeon places a pump clamp across the cannula, removes the wire, and connects the cannula to the arterial pump tubing. If air is present, the surgeon attaches a 60-mL syringe to the connector and removes the air via the syringe. The RNFA then secures the cannula to the patient’s leg using a threaded 0-silk suture.

Using a #11-knife blade, the surgeon performs venous cannulation by making a stab wound in the inferior vena cava. If necessary, the surgeon uses a Kelly clamp to dilate the opening in the inferior vena cava and inserts a metal-tipped, right-angled femoral venous cannula. The surgeon tightens the tourniquet and secures it with a hemostat with shods. The surgeon ties a #2-silk suture around the cannula and the tourniquet to maintain proper cannula placement. The surgeon then cannulates the superior vena cava in the same manner. He or she connects these venous cannulas to the Y-shaped connector on the venous tubing and initiates CPB. After CPB has been established, the surgeon dissects around the aorta with dissecting scissors to separate it from the pulmonary artery.

The surgeon places a 3-0 polypropylene suture with a Teflon pledget in the proximal myocardial fat to allow the proximal aorta to be exposed and to establish the location of the coronary ostia. The surgeon cross-clamps the ascending aorta as close to the distal end as possible using an 35-degree-angled DeBakey peripheral vascular clamp.

The surgeon then inserts a cardioplegia needle into the ascending aorta and infuses cold sanguineous cardioplegia solution into the aortic root. Cold saline slush is applied topically to the heart to assist in myocardial protection.

When asystole is achieved, the surgeon incises the aorta transversely, proximal to the innominate artery. He or she then removes the excess tissue.

The surgeon inspects the aortic valve and the openings of the coronary ostia in regard to their position to the annulus and then detaches the coronary ostia from the aorta with rims of aortic tissue.

The surgeon excises the aortic valve leaflets and uses metal sizers to measure the annulus. When the appropriate annulus implant size is established, the circulating nurse delivers an appropriately sized composite graft to the sterile field.

The surgeon inserts the proximal (ie, valved) end of the composite graft into the annulus. He or she then places a continuous 3-0 polypropylene suture over externally placed Teflon-felt
Figure 4
The surgeon implants each coronary ostia with rings of aortic tissue into the graft and then anastomoses the distal portion of the tube graft to the distal aorta.

straps to secure the valve portion of the composite graft into the aorta.

The surgeon measures the graft for length and cuts it to the appropriate length. He or she manipulates the coronary ostia using the 3-0 polypropylene stay stitches for placement into the graft.

The surgeon uses a #11-knife blade to make a stab hole into the graft. He or she makes a circular opening with the #11-knife blade and tenotomy scissors and removes excess graft. The surgeon then repeats the process for the other ostia. Using a continuous double-armed 6-0 polypropylene suture, the surgeon implants each coronary ostia into the graft at the transfer sites (Figure 4).

When coronary circulation has been reestablished, the surgeon cuts the distal portion of the tube graft or tailors it and anastomoses it to the distal aorta using a continuous 3-0 polypropylene suture over externally placed Teflon-felt strips.

Before making the final stitches, the surgeon infuses carbon dioxide into the left ventricle and the aortic tube graft to displace any air that is present in the heart. The surgeon releases the aortic cross clamp and, using echocardiogram guidance, removes air from the heart by gently squeezing and massaging the heart.

When the air is eliminated, the surgeon removes the cardioplegia needle and closes the hole with a 3-0 polypropylene suture with Teflon pledgets. For extra security, the surgeon then wraps the distal anastomosis with polyethylene terephthalate that was prepared from the residual tube graft.

The CPB is discontinued gradually, and the surgeon removes the femoral artery cannula. The anesthesia care provider administers a heparin antagonist to reverse the anticoagulant effect of the heparin administered for the CPB phase of the procedure.

The surgeon removes the superior vena cava cannula and ties down the purse-string suture. The surgeon connects the aortic tubing to the inferior vena cava cannula for infusion of the residual volume in the CPB machine.

The surgeon places three temporary pacing wires on the heart—two on the right atrium and one on the right ventricle. He or she places a straight, 28-Fr chest tube and an angled, 24-Fr chest tube into the patient’s mediastinum, and the scrub person connects them to a closed, chest-drainage system for postoperative monitoring.

The surgeon inspects the surgical
sites for bleeding and makes any needed repairs. To ensure that the sternum is not bleeding, the surgeon removes the retractor and visually inspects the bone. The surgeon uses electrosurgery to stop any bleeding and then applies a paste to the bone, which aids in hemostasis. The surgeon places two surgical towels over the bone edges and replaces the sternal retractor in the chest.

When the volume in the CPB machine is infused, the surgeon removes the inferior vena cava cannula and ties down the purse-string suture. The surgeon examines all the cannulation sites as well as the anastomoses sites for bleeding. If no repairs are needed, he or she closes the patient's chest using #7 steel sternal wires.

The surgeon closes the fascia and subcutaneous tissue with 0 polypropylene and 2-0 polypropylene sutures respectively. He or she then closes the skin with 4-0 polydioxanone suture. The RNFA applies a sterile dressing over the incision.

The anesthesia care provider and circulating nurse transfer the patient to the CICU accompanied by the surgeon and RNFA. During transfer, the anesthesia care provider continues to monitor the patient's electrocardiogram (ECG), arterial pressure, and oxygen saturation with a portable monitoring unit and ventilates the patient using a bag/mask device and a portable oxygen tank.

**Postoperative Care**

On arrival in CICU, the circulating nurse and anesthesia care provider report to the postanesthesia care unit (PACU) nurse who will be caring for the patient. A respiratory therapist connects the patient to the ventilator. The PACU nurse continuously monitors the patient's physiologic parameters, such as ECG, oxygen saturation, arterial pressure, and pulmonary artery pressure. He or she also monitors the patient's arterial blood gases, chest tube drainage, and urinary output. Initially, all patients are ventilated mechanically, with weaning performed as tolerated. After extubation, the PACU nurse helps the patient with using an incentive spirometer and deep breathing and coughing every one to two hours to help prevent postoperative respiratory complications.

After 24 hours in the CICU, if the patient’s respiratory and hemodynamic status are stable, he or she may be transferred to the telemetry unit for the remainder of the hospitalization. If the patient had a mechanical valve implanted, the telemetry nurse starts the patient on prophylactic anticoagulation therapy when the patient is able to tolerate oral fluids and nutrition well. The telemetry nurse or a physical therapist assists the patient with progressive ambulation.

Before discharge from the hospital, the patient and his or her family members watch a videotape that explains the discharge instructions and are given the opportunity to ask any questions they may have about postdischarge care. Discharge instructions include

- progressively increasing activity as tolerated,
- avoiding vigorous activity for 12 weeks after surgery, and
- not lifting more than 5 lbs in the first two weeks and no more than 20 lbs for three months after discharge.

If the patient received a mechanical valve, he or she will require lifelong anticoagulation therapy. The goal is to maintain the international normalized ratio (INR) for anticoagulant monitoring between 2.5 and 3.5. Normal INR...
in an uncoagulated patient is 1.0.20

The telemetry nurse instructs the patient and his or her family members in the care of the incision, which includes cleansing the incision site daily with an antibacterial soap. The nurse also instructs the patient to report to the surgeon's office immediately if he or she has any signs or symptoms of infection, including

- chills;
- drainage from the incision;
- fever (ie, temperature higher than 101° F [38.3° C]);
- incisional redness; or
- increased incisinal tenderness.

The nurse instructs the patient to follow up with the cardiologist as well as the cardiothoracic surgeon who performed the procedure.

**Possible Complications Associated with the Bentall Procedure**

Patients undergoing the Bentall procedure may experience the complications associated with any cardiac surgery that involves CPB, including

- air embolus,
- arrhythmias,
- atelectasis,
- bleeding,
- pneumonia,
- transient confusion, or
- wound infections.

Potential complications specific to the Bentall procedure include

- graft infection,
- stroke caused by embolization of atherosclerotic plaques during surgery, or
- coronary insufficiency secondary to a coronary artery implanted into the graft becoming kinked.4

**Results**

Research studies have demonstrated good overall patient outcomes after surgery for aortic root replacement, with an average 86% long-term survival after the procedure.23 The postoperative outcome for these patients depends largely on their preoperative condition. Furthermore, patients undergoing elective aortic root replacement have demonstrated better outcomes than patients who underwent the procedure on an emergent basis.13

Patients who had a poor overall state of health before the procedure are referred to a cardiac rehabilitation program. The objective of the cardiac rehabilitation program is to help patients improve activity tolerance by building muscle strength and stamina and provide patient and family education in stress reduction skills and nutrition for heart health. This program also offers education and support for smoking cessation to patients who smoke.

Patients who had a good overall state of health before the procedure tend to recover more quickly than do patients who were debilitated as a result of advanced age or preexisting comorbid conditions.22 Typically, younger patients have better outcomes after aortic root replacement surgery than do older adult patients.13 Most patients who are in good overall health before the surgical procedure are able to fully resume their normal preoperative level of activity within six to eight weeks after the procedure.22

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Editor’s note: Teflon is a registered trademark of DuPont, Wilmington, Del.

NOTES


Examination
The modified Bentall procedure for aortic root replacement

1. The terms *aneurysm* and *dissection* define similar pathology and can be used interchangeably.
   a. true
   b. false

2. Aortic aneurysms are caused by degeneration of the tunica
   a. adventitia.
   b. intima.
   c. media.

3. Annuloaortic ectasia may be a result of
   1. atherosclerosis.
   2. hypertension.
   3. connective tissue disorders, such as Marfan’s syndrome.
   4. the aging process.
   a. 1 and 3
   b. 2 and 4
   c. 1, 2, and 3
   d. 2, 3, and 4

4. Failure of the aortic valve to close completely, causing a backflow of blood into the heart from the aorta and increasing the workload of the left ventricle is called aortic
   a. dissection.
   b. thrombus formation.
   c. valve annulus dilation.
   d. valve incompetence.

5. Symptoms specific to aortic root aneurysms caused by aortic regurgitation include
   1. “ripping” or “tearing-like” chest pain.
   2. diastolic murmur.
   3. dysphasia.
   4. orthopnea.
   5. paroxysmal nocturnal dyspnea.

6. sudden severe chest pain.
   a. 1, 3, and 5
   b. 2, 4, and 6
   c. 2, 3, 4, and 5
   d. 1, 2, 3, 4, 5, and 6

6. A diagnosis of aortic aneurysm may be made by
   1. cardiac catheterization with aortography.
   2. chest radiography.
   3. contrast-enhanced computed tomography.
   4. transthoracic or transesophageal echocardiography.
   a. 1 and 3
   b. 2 and 4
   c. 2, 3, and 4
   d. 1, 2, 3, and 4

7. A composite graft may be a
   a. homograft of the ascending aorta with tissue aortic valve.
   b. mechanical valve with an attached woven tube vascular graft.
   c. xenograft aortic root with valve.

8. The following nursing interventions are appropriate for the nursing diagnosis “Risk for alteration in tissue perfusion.”
   1. Collaborates in fluid management.
   2. Monitors physiological parameters.
   3. Evaluates postoperative cardiac and peripheral tissue perfusion.
   4. Identifies patient’s accepted postoperative pain threshold.
   5. Identifies nominal hazard zone.
   6. Assesses skin integrity, sensory impairments, and musculoskeletal status.
9. Cold saline slush is applied topically to the heart to
   a. assist in myocardial protection.
   b. improve visibility of the surgical site.
   c. provide hemostasis.

10. To displace air that may be present in the heart, before making the final stitches, the surgeon
   1. infuses carbon dioxide into the left ventricle and the aortic tube graft.
   2. installs saline through the coronary bypass machine.
   3. releases the aortic cross clamp and gently massages the heart.

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Soccer Shoes Linked to Toxic Shock Syndrome

Two cases of toxic shock syndrome (TSS) have been reported in children who played soccer while wearing new shoes, according to a June 8, 2006, news release from News-Medical.Net. Both instances of TSS arose after the patients developed friction blisters over their Achilles tendons. These blisters were shown to contain *Staphylococcus aureus*, and one tested positive for the TSS gene. The children developed symptoms of fever, rash, hypotension, vomiting, and diarrhea. Although the syndrome is uncommon, a diagnosis of TSS should be considered for children who exhibit a rash, fever, and hypotension.


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Antibiotic Effective Against Leading Cause of Blindness

A single oral dose of azithromycin administered after surgery is more effective for reducing recurrence of trichiasis than a six-week application of tetracycline ointment directly to the eye (ie, the usual preventive treatment), according to a March 13, 2006, news release from the National Institutes of Health. Researchers in Wolayta Zone, Ethiopia, administered a single dose of azithromycin to patients after surgical repair of the eyelid and found that the recurrence of trichiasis was reduced by one-third.

Trichiasis is condition in which the eyelid turns inward and eyelashes rub against the eye, often resulting in corneal scarring and loss of vision. It is a result of trachoma, an eye infection that is the leading preventable cause of blindness in the world. The condition occurs in poor, overcrowded communities that have little access to clean water, waste treatment facilities, or health care and is spread through contact with infected people, flies or other insects, and clothing or household items that carry the bacterium. An estimated 11 million people develop trichiasis every year worldwide.

Researchers suggest that the findings of this study may have major implications for preventing future vision loss in populations at risk for recurrence of trichiasis. In addition, researchers believe that the findings are transferable to other settings because there is now a free azithromycin distribution program available in most countries with widespread trichiasis.

Learner Evaluation

The modified Bentall procedure for aortic root replacement

Objectives
To what extent were the following objectives of this Home Study Program achieved?
1. Discuss the pathophysiology of aortic abnormalities.
2. List diagnostic tools used to identify aortic abnormalities.
4. Describe the aortic root replacement surgical procedure.

Content
To what extent
5. did this article increase your knowledge of the subject matter?
6. was the content clear and organized?
7. did this article facilitate learning?
8. were your individual objectives met?
9. did the objectives relate to the overall purpose/goal?

Test Questions/Answers
To what extent
10. were they reflective of the content?
11. were they easy to understand?
12. did they address important points?

Learner Input
13. Will you be able to use the information from this Home Study in your work setting?
   a. yes  b. no
14. I learned of this Home Study via
   a. the Journal I receive as an AORN member.
   b. a Journal I obtained elsewhere.
   c. the AORN web site.
   d. the AORN Manager Resources web page.

15. What factor most affects whether you take an AORN Journal Home Study?
   a. need for contact hours
   b. price
   c. subject matter relevant to current position
   d. number of contact hours offered

What other topics would you like to see addressed in a future Home Study Program? Would you be interested or do you know someone who would be interested in writing an article on this topic?
Topic(s): _________________________________________________________________________

Author names and addresses: __________________________________________________________