In the 1970s, transesophageal echocardiography, a method of cardiac imaging, was introduced in the United States. The method was a major advance in the ability to visualize cardiac structures, but it did not produce high-quality images until about the 1980s. In the 1990s, multiplanar imaging (allowing multiple views) with transesophageal echocardiography became available and provided clearer, more precise resolution. Today transesophageal imaging is being used with increased frequency as an adjunct to transthoracic echocardiography and nonexercise stress testing. The procedure provides a new kind of “window” through which to view cardiac structures and assess cardiac function. Variations of the procedure are performed in cardiac catheterization laboratories and critical care units and during surgical procedures. In addition to imaging of cardiac and vascular structures, transesophageal techniques for pacing and hemodynamic measurement are also being used.

Transesophageal imaging is a minimally invasive procedure in which a monitoring probe or transducer attached to the end of a flexible catheter (Figure 1) is inserted orally by way of an endoscope and advanced to the esophagus. The monitoring probe allows M-mode or Doppler echocardiographic display of images from the heart and aorta on a monitor screen. Because the esophagus lies directly behind the left atrium and ventricle, the transesophageal
A probe has only to send a beam across the esophageal wall to reach the intended heart structures (Figure 2). Because of the position of the heart, anterior cardiac structures (right atrium and ventricle) are not as clearly visible from the esophageal location as are posterior structures. The atria, atrial appendages, and aorta are the structures most often studied with transesophageal imaging.\(^\text{1,2,6,7}\)

### Uses of Transesophageal Technology

Transesophageal procedures are used in children and adults for both diagnostic and therapeutic purposes (Table 1). The most common uses of transesophageal imaging are to rule out or evaluate infective endocarditis, identify sources of ischemic emboli, and determine risk of stroke associated with cardioversion.\(^\text{1,6,8}\)

#### Table 1 Uses of transesophageal interventions\(^\text{1,4,6,8-10}\)

<table>
<thead>
<tr>
<th>Purpose</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>Detect trauma of the aorta (tears, dissection, stricture)</td>
<td></td>
</tr>
<tr>
<td>Assess valve structure and function (natural and prosthetic valves)</td>
<td></td>
</tr>
<tr>
<td>Monitor hemodynamic parameters during cardiac surgery and noncardiac surgery in patients with known cardiac disease.</td>
<td></td>
</tr>
<tr>
<td>Examine cardiac structures in patients for whom thoracic echocardiography is not accurate (patients with chronic lung disease, obese persons, patients receiving mechanically ventilation)</td>
<td></td>
</tr>
<tr>
<td>Treat or evaluate supraventricular arrhythmias (pacing, ablation)</td>
<td></td>
</tr>
<tr>
<td>Assess for thrombi (embolic risk) before cardioversion</td>
<td></td>
</tr>
<tr>
<td>Determine source of emboli with ischemic stroke</td>
<td></td>
</tr>
</tbody>
</table>

Additional uses are detailed in the following sections.

### Structural Assessment

Transesophageal echocardiography is widely used to evaluate heart valves. Valve mobility, thickening, and calcification can be evaluated, and blood flow across valves can be measured to determine the degree of regurgitation. Patients who have defective or prosthetic cardiac valves may undergo transesophageal imaging for detection of procedural complications or of vegetations on valve leaflets. In infective endocarditis, transesophageal echocardiography is used to detect complications of the infectious process and to plan management.\(^\text{1,8}\)

Transesophageal imaging has also been used to assess positioning of devices implanted in the atrial appendage to seal the appendage and prevent release of emboli and possible stroke.\(^\text{11}\) Transesophageal echocardiography is also used to assess aneurysms, right-to-left cardiac shunts, and cardiomyopathy.\(^\text{1,2,6,9}\)

### Management of Dysrhythmia

Traditionally, patients with atrial fibrillation who were scheduled for cardioversion would be given heparin for anticoagulation for at least 3 weeks before the procedure in case thrombi were present in the atrium. Presence of thrombi puts patients at risk for release of an embolus during cardioversion, resulting in stroke. Transesophageal echocardiography allows physicians to assess atrial function and determine whether thrombi are present in the atrium or atrial appendage. If a transesophageal image shows no clots in a patient with new-onset atrial fibrillation, the patient does not need long-term anticoagulation before cardioversion. Thus, the time to treatment is shorter and the...
chances for conversion to sinus rhythm are higher.1,10,12
Transesophageal images can be used to make a differential diagnosis of atrial dysrhythmias because P waves are amplified with this procedure. Supraventricular tachycardia can sometimes be corrected by performing ablation of the electrically overactive site. Also, supraventricular tachycardia can be induced when transesophageal echocardiography is used to evaluate the efficacy of antidysrhythmic therapies.10,12

The most common uses of transesophageal imaging are to rule out or evaluate infective endocarditis, identify sources of ischemic emboli, and determine risk of stroke associated with cardioversion.

Cardiac Pacing
Transesophageal atrial or ventricular pacing has been used to treat intraoperative bradycardias. Sinus bradycardia is common in patients receiving high doses of anesthetics such as those required for coronary artery bypass grafting and can result in decreased cardiac output.13 Transesophageal pacing is better than drugs (atropine, glycopyrrolate) for reversing these hemodynamic changes because it produces more reliable and precise control of heart rate and can be discontinued immediately when it is no longer needed. Anticholinergic drugs, on the other hand, have a variable duration of action after discontinuation.4 Other uses of this technology are “burst” pacing for interruption of reentry arrhythmias such as atrial flutter or supraventricular tachycardia and overdrive pacing to induce angina for diagnostic purposes. Transesophageal pacing has also been used for temporary pacing of the atrium for nonsurgical patients with significant bradycardias, hypotension, and/or sick sinus syndrome.4

Transesophageal pacing is achieved by using an esophageal pacing catheter with electrodes at the distal end. Anode and cathode metal electrode rings on the end of the catheter sense heart rhythm and provide pacing capability (Figure 3). The bipolar pacemaker is inserted through an introducer or endotracheal tube. The electrodes are advanced into the lower part of the esophagus or the stomach, positioned behind the atrium or ventricle, and connected to a cardiac monitoring device. The position of the pacing catheter is then adjusted in slight increments until the desired cardiac waveform is seen prominently on the monitor (ie, P wave for atrial pacing). Once the catheter is correctly positioned, minimum current strength is used to pace the selected heart chamber.14 Components of an esophageal pacing system are pictured in Figure 4.

Coronary Artery Disease/Ischemia Detection
Transesophageal atrial pacing (TAP) is a substitute for exercise or pharmacological stress testing. TAP is used to assess for the presence of coronary artery disease in patients with new onset of chest pain or unstable angina pectoris and for evaluation of early myocardial infarction. The atrium is paced at a rate rapid enough to simulate the stress of exercise-induced tachycardia. New ECG changes (ST-segment depression) as well as chest pain and other changes associated with ischemia are evaluated after peak heart rate is achieved. TAP is less time consuming than dobutamine stress testing and does not have the frequent adverse effects (hypotension, dysrhythmias, nausea) associated with use of dobutamine. In addition, TAP is safer than exercise or pharmacological stress testing because pacing and stress-induced ischemia can be discontinued immediately. TAP is also useful in patients who cannot respond to standard exercise or dobutamine-induced “stress” because rate-limiting medications have been used (ie, β-blockers). An additional advantage...
is that the test can be safely performed at the bedside.\textsuperscript{5}

Gastric positioning of the transesophageal probe allows visualization of ventricular walls for ischemia-induced abnormalities.\textsuperscript{1,5} In this procedure, the transesophageal probe is advanced from the esophagus into the stomach, where views of the posterior, anterior, lateral, and inferior ventricular walls, as well as the ventricular septum, can reveal abnormalities in wall motion associated with myocardial infarction.\textsuperscript{1}

**Hemodynamic Measurements**

During cardiac surgical procedures or in the initial postoperative period, transesophageal technology can be used to assess early hypotension and low cardiac output. Ejection fraction, size of the cardiac chamber, and systolic function are easily measured to differentiate between hypovolemia and left ventricular dysfunction in these cases.\textsuperscript{1,3,10} In hypovolemia, transesophageal images reveal a decrease in the size of the ventricular cavity and hyperdynamic systolic function. Left ventricular dysfunction is assessed through measurement of ejection fraction by using contrast-enhanced transesophageal imaging.\textsuperscript{2} Flow velocity across cardiac valves is assessed by using multiplane imaging and pulsed Doppler techniques.\textsuperscript{1}

Hemodynamic assessment via the transesophageal route is also used for patients undergoing noncardiac procedures who have a history of cardiac disease or hemodynamic instability.\textsuperscript{1} Transesophageal technology for evaluation and management of hypovolemia in critically ill surgical patients has been advocated as a less invasive and more reliable method than monitoring with a pulmonary artery catheter.\textsuperscript{1,3}

**Special Populations**

Traditional transthoracic echocardiography requires sound waves to penetrate chest wall structures such as bone, muscle, and fat, which can decrease clarity of underlying cardiac structures. For example, patients who are obese, have chronic lung disease, or are receiving mechanical ventilation often do not benefit from traditional echocardiography because of image interference by fat or the increased diameter of the chest wall.\textsuperscript{1,2,9} Transesophageal imaging is ideal for cardiac assessment in these patients.

**Advantages and Disadvantages**

Disadvantages of transesophageal procedures are few. The requirements for procedural sedation and analgesia and for an experienced practitioner are probably the primary disadvantages,\textsuperscript{2,10} but those are outweighed by the many advantages of the procedure (Table 2). Advantages include clearer, more precise images compared with transthoracic echocardiography and shorter periods of anticoagulation in preparation for cardioversion. Transesophageal hemodynamic monitoring for surgical patients may result in fewer complications (bleeding, lung trauma) than traditional monitoring with a pulmonary artery catheter.\textsuperscript{3} Speed, portability, and relatively low cost have also been cited as advantages.\textsuperscript{1,3,10} Transesophageal procedures do have some contraindications, as listed in Table 3.

**Preparation of Patients**

Any patient about to have a transesophageal procedure should receive a careful explanation of the procedure so that informed consent and an accurate medical history can be obtained. Although a physician will provide the initial explanation, critical care nurses must be prepared...
to reinforce and clarify the information as needed. Many facilities also have online instructions available for outpatients.14,15

Any patient scheduled for transesophageal procedures must fast for at least 4 to 6 hours before the procedure. Passage of the transesophageal probe can cause gagging and lead to vomiting with aspiration of stomach contents. Also, any dentures or oral prostheses should be removed and, because the procedure is invasive, the patient must sign a consent form.1,9

Documentation of drug allergies and any esophageal disorders is essential to protect the patient from allergic reactions or esophageal trauma. Critical care nurses should also assess the medications the patient is using, especially anticoagulants and antiplatelet drugs. The dosage of anticoagulant must be adjusted before transesophageal imaging or interventions. Any patient scheduled for transesophageal imaging most likely will have orders for hematocrit, hemoglobin, international normalized ratio, and other clotting studies if the patient has a history of bleeding or is taking anticoagulants.4

A critical care nurse will describe to the patient what to expect before, during, and after the transesophageal imaging procedure. The patient should know that he or she will be undressed from the waist up in the procedure room, will have ECG electrodes applied to the chest, and will have an intravenous catheter inserted if one is not already in place. A spray or mist of numbing medication will be administered orally to numb the back of the throat and make passage of the probe more comfortable. The patient will be in a side-lying position for the procedure. A small, flexible tube will be placed into the patient’s mouth and advanced to the back of the throat. At this point, the patient will be asked to swallow to facilitate passage of the pea-sized probe into the correct position. The patient should be warned that advancing the probe may cause brief gagging. Once in place, the probe sends sound waves across the esophagus to the heart or aorta, and images are recorded. If cardiac pacing is to be performed, the patient should know that a burning feeling similar to heartburn will be experienced when pacing is initiated.14 The patient can be told that the procedure will last about 1 to 2 hours, depending on the purpose.1,9,14

During the Procedure

In the catheterization laboratory (or at the bedside), intravenous access is verified or initiated for administration of sedatives. Low-flow oxygen by nasal cannula is used, and oxygen saturation is monitored throughout the procedure. A critical care nurse is often responsible for these interventions. Before the transesophageal catheter is inserted, a physician or a nurse will examine the patient’s mouth for presence of injuries, loose teeth, and appliances.

### Table 2  Advantages and disadvantages of transesophageal procedures

<table>
<thead>
<tr>
<th>Disadvantages2,10</th>
<th>Advantages1-3,10</th>
</tr>
</thead>
<tbody>
<tr>
<td>Requires an experienced practitioner</td>
<td>Is associated with less distortion than thoracic echocardiography is and provides clearer, more precise images</td>
</tr>
<tr>
<td>Is associated with slight discomfort/gagging when the probe is inserted</td>
<td>Is more accurate than thoracic echocardiography for detecting atrial and aortic thrombi</td>
</tr>
<tr>
<td>May not show very small thrombi</td>
<td>Is accurate in obese patients and patients receiving mechanical ventilation</td>
</tr>
<tr>
<td>Requires intravenous access and conscious sedation</td>
<td>Requires a short anticoagulation period before cardioversion and thus is associated with less risk of bleeding than thoracic echocardiography is</td>
</tr>
<tr>
<td>May not be appropriate in patients who are pregnant or who have unstable hemodynamic status or severe chronic lung disease</td>
<td>Is associated with a shorter delay to cardioversion than thoracic echocardiography is and thus a greater chance of achieving and maintaining sinus rhythm</td>
</tr>
<tr>
<td>May be associated with difficult or traumatic intubation in patients whose posterior part of the pharynx is small or who have an endotracheal tube in place</td>
<td>Is a relatively quick procedure</td>
</tr>
<tr>
<td>Can be used for stress tests without the side effects or risks of pharmacological or exercise-induced stress tests</td>
<td></td>
</tr>
</tbody>
</table>

### Table 3  Possible contraindications to transesophageal procedures*1,2

- Esophageal stricture
- Gastrointestinal bleeding
- Patient unable to follow directions
- Difficulty swallowing
- Unregulated anticoagulation
- General bleeding disorder
- Facial or esophageal trauma
- Previous esophageal irradiation or surgery
- Esophageal diverticular disease
- Pregnancy (patient cannot be sedated)
- Advanced pulmonary disease

* Patients with 1 or more of these conditions will require further evaluation before transesophageal imaging.
The patient is then placed in a left lateral position, and topical oropharyngeal anesthesia in the form of benzocaine, lidocaine, or Cetacaine (Cetylite Industries, Inc, Pennsauken, NJ) gargle or spray is administered. Typically, a sedative such as midazolam (Versed) and an analgesic such as meperidine (Demerol) are given intravenously just before the examination to maintain a level of sedation sufficient to ensure the patient’s comfort, while allowing the patient to alert staff if chest pain or other cardiac symptoms occur. The patient’s neck is flexed before the catheter is introduced through an endoscope. Once the physician positions the probe at the back of the throat, the patient is asked to swallow. After correct positioning of the probe within the esophagus is verified, the procedure begins.

Throughout the procedure, continuous 3-lead ECG monitoring is used to detect dysrhythmias. The nurse or an assistant measures blood pressure and heart rate at least every 3 minutes with an automated blood pressure cuff. Suctioning may be required if secretions are excessive. Views obtained during the procedure are displayed on a screen and recorded.

### Monitoring After the Procedure

When the examination is completed, the intravenous catheter is discontinued if the procedure was done on an outpatient basis. The patient must have someone to drive him or her home because sedation will not be completely reversed. In order to prevent choking and aspiration, a period of 30 minutes to an hour should pass before the patient attempts to eat or drink. For patients, a nurse routinely checks the gag reflex, and once a patient’s gag reflex is intact, the patient’s diet is progressed slowly. The patient is also questioned about any discomfort after the procedure (there should be none) and informed that results of the procedure will be sent to the physician, who will discuss the findings with the patient.

Table 4 provides an overview of the responsibilities of critical care nurses before, during, and after transesophageal procedures.

### Complications

Transesophageal procedures are well tolerated and are associated with minimal risks. In a study of transesophageal imaging in both obese and nonobese patients, researchers reported the following minor complications: transient hypotension (in 9% of nonobese

<table>
<thead>
<tr>
<th>Time</th>
<th>Interventions</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Before the procedure</strong></td>
<td>Obtain and document the patient's history of drug allergies, any esophageal disorders or surgeries, bleeding disorders, and medication use. Address any anxiety or fears the patient may have about the procedure. Verify the patient’s understanding of the procedure and obtain informed consent. Review laboratory values as ordered and report variances from normal to the physician (complete blood cell count, coagulation studies). Ensure that the patient fasts for 4 to 6 hours before the procedure, as specified by the physician. Establish or assess adequate intravenous access. Apply electrocardiographic electrodes if they are not already in place. Help the patient remove and store any dental appliances.</td>
</tr>
<tr>
<td><strong>During the procedure</strong></td>
<td>Examine the patient’s mouth for injuries, loose teeth, and appliances. Establish a low flow of oxygen by nasal cannula. Initiate continuous oxygen saturation monitoring. Assist the patient into a recumbent left lateral position. Administer prescribed drug dosages for procedural sedation as directed by the physician. Assist with positioning the patient’s head in flexed position for insertion of transesophageal probe. Assess cardiac rhythm, vital signs, and oxygen saturation at 1- to 3-minute intervals. Assess the patient for discomfort.</td>
</tr>
<tr>
<td><strong>After the procedure</strong></td>
<td>Assess vital signs, cardiac rhythm, level of consciousness, gag reflex, and oxygen saturation at least every 15 minutes until the patient is awake and his or her condition is stable. Discontinue intravenous catheter once the patient’s condition is stable, unless needed for other purposes. Once a gag reflex can be elicited and the patient is alert, progress diet slowly as tolerated. Assess patient for discomfort and complications (respiratory, cardiac, esophageal) and report the findings to the physician.</td>
</tr>
</tbody>
</table>
To decrease discomfort associated with passage of the transesophageal probe, researchers have evaluated use of smaller, child-sized probes (8-10 mm) in adult patients. Apparently the smaller probes can be used without loss of image quality. An added advantage of smaller probes is the ability to use the intranasal route for intubation and possibly less sedation during the procedure.2

**Case Study**

Mr James was a 67-year-old man admitted to a telemetry unit with a diagnosis of “increasing shortness of breath” and recent onset of atrial fibrillation. He had been treated earlier in the month for pneumonia. Mr James was married with no children and earned his living as a truck driver. He reported that he used alcohol only occasionally and smoked 1 pack of cigarettes daily.

Mr James said that he had been experiencing dyspnea at night when lying flat. He had attributed the shortness of breath to pneumonia, but it did not resolve with antibiotics and prednisone therapy. He had increased swelling in both legs and reported he had gained weight but it did not resolve with antibiotics or chest discomfort. He had no history of cardiac problems, but he did have diabetes mellitus type 2, asthma, and hyperlipidemia. Vital signs on admission to the hospital were as follows: body temperature 36.2°C, heart rate 75-100/min and irregular, blood pressure 110/70 mm Hg, and oxygen saturation 94%. On physical assessment, he had jugular venous distention to the jaw, decreased breath sounds with crackles in the bases bilaterally, and 3+ edema in both feet.

Laboratory studies revealed low hematocrit and hemoglobin, and platelet count, cardiac isoenzyme levels, and serum electrolyte levels were within the reference range. The level of brain natriuretic peptide was 1202 pg/mL in the emergency department, and a chest radiograph showed signs of congestive heart failure.

An ECG indicated atrial fibrillation with rapid ventricular response (heart rate 151/min) and nonspecific changes in the ST segment and the T wave. After administration of diltiazem, his heart rate slowed to between 80/min and 100/min. A heparin infusion and oral administration of metoprolol, furosemide, and digitalis were started. A follow-up ECG was ordered, as were analysis of arterial blood gases and thyroid function studies.

In the telemetry unit, oxygen saturation was monitored every 4 hours, samples to determine serum electrolyte levels were obtained, and fluid intake and output and body weight were monitored. A potassium supplement protocol was started when the serum level of potassium was 3.3 mmol/L. In addition, blood glucose level was to be assessed and elevations treated by using sliding-scale insulin. The results of arterial blood gas analysis were as follows: pH 7.47; PO₂ 68 mm Hg; PCO₂ 34 mm Hg. The level of thyroid-stimulating hormone was 3.3 mIU/L, chloride level was 107 mmol/L, serum urea nitrogen was 7.5 mmol/L (21 mg/dL), and creatinine level was 88 umol/L (1.0 mg/dL), all of which were within the reference ranges.

The physician stated that Mr James’ heart failure was most likely due to the rapid ventricular response, but left ventricular dysfunction...
could not be ruled out. Therefore, once his condition was stabilized with medications, Mr James was scheduled for transesophageal echocardiography to evaluate ventricular wall motion and function. Mr James tolerated the examination well, without complications. Findings of the procedure were an ejection fraction of 0.20 to 0.25 and severe left ventricular dysfunction. In addition, he had a large thrombus in the left atrium that precluded use of cardioversion for treatment of the arrhythmia. The heparin infusion was continued, and warfarin was added to medications that had been ordered. Mr James was scheduled for an adenosine thallium stress test to determine if he had myocardial ischemia. He stated that he remembered little of the transesophageal procedure (because of the sedation) and had no discomfort afterward.

Summary

Transesophageal imaging is a safe and cost-effective procedure for the evaluation and treatment of various cardiac and noncardiac disorders. Its use is likely to continue to increase as instrumentation and imaging become more sophisticated. Critical care nurses will most likely care for patients in and outside acute care settings who are undergoing transesophageal imaging. Therefore, it is important that the nurses know how to educate patients and patients’ families about the procedure and how to assess patients during and after transesophageal imaging.

Financial Disclosures

None reported.

References

Learning objectives:

1. Identify the most common uses of transesophageal imaging.
2. Describe the patient concerns and assessment needs during transesophageal imaging.
3. Identify how transesophageal imaging is a valuable tool for detecting aortic and thoracic injury after chest trauma and for pacing procedures.

1. Which of the following does the transesophageal imaging monitoring probe allow?
   a. M-mode or Doppler echocardiographic display of images of the heart and aorta
   b. M-mode and fiber-optic displays of images of the cardiovascular circulation
   c. Doppler echocardiographic display of images of only the heart
   d. M-mode or Doppler echocardiographic displays of images of only the aorta

2. What structures are most often studied with transesophageal imaging?
   a. Ventricular appendages, aorta, and valves
   b. Atria, cardiovascular circulation, and valves
   c. Atria, atrial appendages, and aorta
   d. Ventricular and atrial appendages, and aorta

3. What are the most common uses of transesophageal imaging?
   a. To rule out or evaluate ineffective endocarditis, to identify sources of ischemic emboli, and to determine risk of stroke associated with cardiovascular disease
   b. To identify sources of ischemic and pulmonary emboli and to determine stroke risk from atrial fibrillation
   c. To rule out or evaluate ineffective endocarditis and to determine stroke risk from atrial fibrillation
   d. To identify sources of ischemic emboli and to determine stroke risk associated with cardiovascular disease

4. Transesophageal imaging is more accurate than electrocardiography or measurement of levels of cardiac enzymes in detecting which of the following?
   a. Endocarditis and injury after chest trauma
   b. Aortic and thoracic injury after chest trauma
   c. Endocarditis and thoracic injury after chest trauma
   d. Endocarditis and aortic injury after trauma

5. What appears as an undulating linear density within the aortic lumen with differing Doppler color flow parameters during transesophageal imaging?
   a. Thoracic injury
   b. Aortic injury
   c. Aortic dissection
   d. Aortic aneurysms

6. Why can transesophageal images be used to make a differential diagnosis of atrial dysrhythmias?
   a. Because sinus node function can be assessed
   b. Because atrial function can be assessed
   c. Because blood flow across valves can be measured
   d. Because P waves are amplified with the procedure

7. Which of the following describes when the atrium is paced at a rate rapid enough to stimulate the stress of exercise-induced tachycardia?
   a. Transesophageal atrial pacing
   b. Burst pacing
   c. Esophageal pacing
   d. Stress pacing

8. Transesophageal technology for evaluation and management of hypotension in critically ill patients has been advocated as less invasive and more reliable method than monitoring with which of the following?
   a. Central venous pressure catheter
   b. Arterial catheter
   c. Pulmonary artery catheter
   d. Continuous cardiac outputs

9. Why do patients who are obese, have chronic lung disease, or are receiving mechanical ventilation often not benefit from traditional echocardiography?
   a. Due to the increased diameter of the chest wall and/or the work of breathing
   b. Due to the image interference by fat or the increased diameter of the chest wall
   c. Due to the image interference by fat
   d. Due to the image interference caused by the increased diameter of the chest wall

10. During which transesophageal imaging procedure does a patient experience a burning feeling similar to heartburn?
    a. Cardiac pacing
    b. Ejection fraction assessment
    c. Echocardiography
    d. Cardiac imaging

11. With real-time imaging, the 3-dimensional modality improves which of the following?
    a. Ability to accurately measure cardiac volume and ejection fraction, and evaluation of valvular disease and cardiac tumors
    b. Ability to measure cardiac output and evaluation of valvular disease and cardiac tumors
    c. Ability to accurately measure ejection fraction and evaluation of valvular disease
    d. Ability to accurately measure cardiac volume and ejection fraction

12. What are the advantages of using a smaller, child-sized probe in transesophageal imaging in adult patients?
    a. Decreased discomfort and less sedation during the procedure
    b. Decreased discomfort and no loss of image quality
    c. Increased comfort and no loss of image quality use of the intranasal route for intubation
    d. Decreased discomfort, no loss of image quality, use of the intranasal route for intubation, and less sedation during the procedure

Test answers: Mark only one box for your answer to each question. You may photocopy this form.

1. □a □b □c □d
2. □a □b □c □d
3. □a □b □c □d
4. □a □b □c □d
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10. □a □b □c □d
11. □a □b □c □d
12. □a □b □c □d

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Transesophageal Imaging and Interventions: Nursing Implications
Kathleen Marchiondo

Crit Care Nurse 2007;27 25-35
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