Intraoperative Transesophageal Echocardiography Examination
Probe Placement and Manipulation

Gregg S. Hartman, M.D.
Professor of Anesthesiology
Dartmouth Medical School
Director of Cardiac Anesthesia
Dartmouth Hitchcock Medical Center
Lebanon, NH 03756
gregg.s.hartman@hitchcock.org

Conflicts and Disclosures:
I have no conflicts of interest and I have no disclosures

Objectives:
- to understand the relevant anatomical relationships involved in TEE
- to understand TEE probe manipulations and their impact on scan planes
- to gain an understanding of the contraindications of TEE

Anatomical Relationships of the Heart, Esophagus, and Surrounding Structures
Because of the proximity of the esophagus to the heart, it is an excellent “window” for obtaining detailed echocardiographic images of the heart. The esophagus extends from the posterior pharynx through the mediastinum and finally to the level of the diaphragm where it joins the stomach. Within the mediastinum it courses behind the trachea and left mainstem bronchus and continues caudally to become immediately adjacent to the anteriorly positioned LA and LV. It also runs next to the thoracic aorta and both lung cavities. The narrowest portion of the esophagus is at its origin at the level of the pharynx.

ASE Guidelines for Performing Multiplane TEE poster
www.asecho.org
TEE Probe Insertion:

Prior to insertion, the TEE probe should be carefully examined for structural defects. Correct mechanical functioning should be confirmed by manipulation of the controls and finally the TEE probe should be attached to the TEE console and the proper electrical performance established. In addition to these pre-insertion checks, the probes should have frequent testing by biomedical personnel.

The probe is then thoroughly lubricated and carefully placed in the posterior pharynx. A bite block may be used to prevent any damage to or from the teeth. The probe is then carefully advanced into the esophagus. At some centers, routine direct visualization of the probe passage is aided by direct laryngoscopy. Passage of the TEE probe beyond the laryngeal structures may be facilitated by anterior lift/thrust of the mandible, flexion of the head and or manual – digital guidance. Slight anteflexion of the probe tip is often helpful. There should be little or no resistance to probe passage. Marked resistance to TEE advancement should alert the operator to the possibility of unappreciated esophageal stricture. Typically there is a noticeable loss of resistance as the probe passes the glottic structures and constrictor muscles. In a small subset of patients (usually < 2%) significant difficulty to probe passage is encountered. It is usually best to terminate further attempts at placement and utilize alternative imaging modalities, (e.g. epicardial echocardiography).

<table>
<thead>
<tr>
<th>Complications</th>
<th>No. of Patients</th>
<th>% of All Cases (N = 7,200)</th>
<th>% of All Complications (N = 14)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Odynophagia</td>
<td>7</td>
<td>0.10%</td>
<td>50%</td>
</tr>
<tr>
<td>Swallowing abnormality</td>
<td>1</td>
<td>0.01%</td>
<td>7%</td>
</tr>
<tr>
<td>Esophageal abrasions</td>
<td>4</td>
<td>0.06%</td>
<td>29%</td>
</tr>
<tr>
<td>No associated pathology</td>
<td>2</td>
<td>0.03%</td>
<td>14%</td>
</tr>
<tr>
<td>Upper gastrointestinal</td>
<td>2</td>
<td>0.03%</td>
<td>14%</td>
</tr>
<tr>
<td>Hemorrhage</td>
<td>1</td>
<td>0.01%</td>
<td>8%</td>
</tr>
<tr>
<td>Esophageal perforation</td>
<td>2</td>
<td>0.03%</td>
<td>14%</td>
</tr>
<tr>
<td>Dental injury</td>
<td>2</td>
<td>0.03%</td>
<td>14%</td>
</tr>
<tr>
<td>Endotracheal tube malposition</td>
<td>2</td>
<td>0.03%</td>
<td>14%</td>
</tr>
<tr>
<td>Total</td>
<td>14</td>
<td>0.20%</td>
<td>100%</td>
</tr>
</tbody>
</table>


TEE Probe Manipulation:

There are five possible manipulations of the TEE probe and corresponding terminology for such maneuvers. These include moving the probe up and down within the esophagus to obtain different levels of imaging. This is called advancement or withdrawal. The probe may be turned or rotated to the patient’s right (clockwise from the anesthesiologist’s prospective at the head) or to the patient’s left (counterclockwise). The control knobs permit further movement of the probe’s tip. It may be flexed anteriorly (anteflexion), or posteriorly (retroflexion) and to the left or right (probe flexion). Finally there is
the capacity to rotate the transducer within the probe from 0 degrees or the horizontal plane “forward” to 180 degrees or from 180 to 0 degrees (backward transducer rotation).

The SCA and ASE have produced guidelines for performing and intraoperative TEE examination and have standardized the nomenclature for such a study. This helps to ensure common language and completeness of examinations. They have also defined 20 cross sectional views which are fundamental in the performance of a complete TEE exam.
TEE Probe manipulation and anatomical scan planes. GS Hartman

Anesth Analg 1999;89:870-84
0 degrees – 90 degrees  Short axis – long axis: right side of screen changes from left lateral to superior and left side of screen changes from right lateral to caudal

0 degrees – 90 degrees  ME long axis – long axis: right side of screen changes from left lateral to anterior and left side of screen changes from right lateral to inferior
Transesophageal Echocardiographic Windows

There are four main positions within the esophagus from which the standard TEE scan planes can be obtained. These four "windows" are 1) the upper esophageal (UE), 2) the mid esophageal (ME), 3) the transgastric (TG) and 4) the deep transgastric (dTG). From these four positions in combination with appropriate scan plane angulations, all of the aforementioned "SCA-20" cross sectional views can be imaged. An alternative way to organize the scan plane images is by structure of interest. For example, the mitral valve can be imaged from the ME level from multiple scan angles, (sections a,b,c), from the TG level (sections e,f,g), and from the dTG level (section k).

Virtual TEE: Computer simulation of scan planes vs. heart

In order to fully utilize transesophageal echocardiography (TEE), the echocardiographer is required to have a 3-dimensional understanding of the heart and the surrounding structures. Integrated into this concept, is a mental image of the ultrasound scan plane. Unlike surface echocardiography, TEE requires placement of the probe in the esophagus and thus while quite safe, it is somewhat "invasive." The student of TEE must learn from such hands-on situations, limited typically to the operative setting with anesthetized patients. In addition, teachers of TEE are limited to static illustrations of the image scan planes and their orientation to the heart. Lastly, the vantage point for these illustrations is fixed, whereas the vantage-point for anesthesiologist is from the top of the patient, and for cardiologists it is typically from the side, facing the patient. These differences complicate an already difficult concept.

Computer technology has evolved the world of visual reality. In the virtual TEE simulator, students have the ability to manipulate the flexible TEE probe, see the resulting movement of the corresponding scan planes on a 3-dimensional heart model, and view the ultrasound image obtained from that scanning location (acoustic "window"). The student is able to perform repetitive examinations and probe manipulations without the added morbidity associated with similar probe movements as required for an actual TEE examination.

Computer and video technology have evolved dramatically allowing virtual reality simulators to be developed in many settings. Aviation for example has
demonstrated the utility of realistic simulators for safely and efficiently teaching complex and dangerous skills like flying an airplane. Simulators have numerous medical applications as well including fiberoptic intubation, pharmacokinetics and pharmacodynamics, epidural and other regional anesthetic techniques, and recently complete simulators for operating rooms and anesthetic delivery have been brought to the public domain. The utility of these various systems has been demonstrated in improved trainee success and patient safety.

Several self-tutorial programs have been developed for TEE utilizing numerous media including video-tapes, computer-based tutorials and web-based interactive sites. However, all suffer from the limitation of having a predetermined set of scan planes and images. The presenter or student is not able to independently manipulate the TEE probe and thus perform a "virtual" scan. Not infrequently, students can understand the images when shown them, but are unable to gain facility with obtaining the images themselves. These students often related their difficulties to the lack of a clear grasp of the three dimensional relationships of the heart and ultrasound scan planes.

As part of the workshop, examples of the probe and scan plane position necessary to obtain the "SCA standard 20 views" will be demonstrated. The pages to follow are copies of these TEE positions and resulting TEE scan window for the SCA standard set of 20 views for a comprehensive intraoperative TEE exam.

Performing a comprehensive TEE examination.

There are two basic schemes for performing a comprehensive examination. The underlying principle is to assure a complete and comprehensive study. This can be achieved by either obtaining images from a given level within the esophagus (e.g. upper, middle, transgastric or deep-transgastric) or by organizing the study based upon structure of interest, (e.g. left ventricle, mitral valve, aortic valve etc.). Both systems work- each with their advantages and limitations. “Esophageal level” focused examinations have the advantage of limiting movement of the probe, can permit a global or 3D sequential imaging strategy and may be best tolerated in the sedated but not completely anesthetized patient. The structure focused examination can facilitate a more comprehensive study of valves/chambers in question and permits the interrogation of a specific structure from varying levels or vantage points.

Whatever system is used, most important is to document and communicate your findings. This is essential to a complete examination.

Useful Websites:
http://pie.med.utoronto.ca/TEE/index.htm
http://www.e-echocardiography.com/

References: