Chapter 3
Normal Cardiac Anatomy and TEE Imaging Planes

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INTRODUCTION

In order to improve efficiency, the sonographer should determine the approximate sequence of ultrasound images that will be acquired during the transesophageal echocardiography (TEE) study prior to inserting the probe. In effect, this decision can be simplified by establishing whether this will be a comprehensive or goal-directed study. This chapter will review the recommended TEE views to complete a basic TEE study, as well as describe options for TEE probe manipulation.

IMAGE SEQUENCE

During a comprehensive study, the entire recommended set of ultrasound images is acquired in a convenient anatomic sequence that minimizes back-and-forth probe movements. This is analogous to the approach used for transthoracic echocardiography (TTE) imaging in stable patients, where image acquisition typically follows a standard sequence for all patients regardless of underlying pathology. A goal-directed study, on the other hand, requires that the image sequence be tailored to answer a specific question or set of questions relevant to the care of the individual patient undergoing the examination. A goal-directed TEE study for a severely hypotensive patient would differ from one performed for a patient who was very hypoxemic, for example.

In the critical care environment, a goal-directed approach to TEE is generally recommended as this more expeditiously yields the information required to answer the question at hand. In most cases, this will also shorten the overall length of the study, an important factor if the patient is unstable or poorly tolerant of sedative medications. A comprehensive approach may be appropriate in a very stable patient, particularly when the study is being compared to a previous study (or will be compared to a future study), or when a trainee is performing the study under supervision. Sometimes, a hybrid approach is best: a goal-directed study can be initiated, and once the clinical question has been answered the remaining views can be obtained to finish the comprehensive examination provided the patient is stable enough to proceed.

NUMBER OF VIEWS

The American Society of Echocardiography (ASE) and the Society of Cardiovascular Anesthesiologists (SCA) endorse two main protocols when performing a comprehensive examination. The basic protocol recommends an 11-view sequence (**Figure 3.1**),[1] while the advanced protocol involves acquisition of a 28-view sequence.[2] In the critical care setting and emergency settings, the 11-view study is sufficient to provide the required information in the majority of patients, and is thus recommended (**Table 3.1**). In unusual circumstances where additional specific information is required (for example, related to pulmonary vein anatomy), it would be reasonable for the TEE provider with a basic skill set to seek help from a more experienced colleague who regularly performs 28-view studies.

TEE PROBE MOVEMENTS

Once the TEE probe has been inserted into the esophagus, it can be manipulated to acquire images as follows (**Figure 3.2**):

- Advancement/withdrawal involves pushing the probe in or pulling it out to view structures that are more caudal or cranial, respectively.
- Rotating or turning is moving the entire probe shaft clockwise to view rightward structures and counterclockwise to view leftward structures.
- Anteflexion and retroflexion involves turning the larger wheel on the probe handle, moving the probe tip forwards or backwards to view structures at the heart base or towards the apex, respectively.
- Leftward and rightward flexion involves turning the smaller wheel on the probe handle to move the probe tip to the left or right.
- Image plane rotation (**Figure 3.3**) changes the transducer angle to rotate the imaging plane from 0° to 180°, where 0° represents the transverse plane and 90° the longitudinal plane.

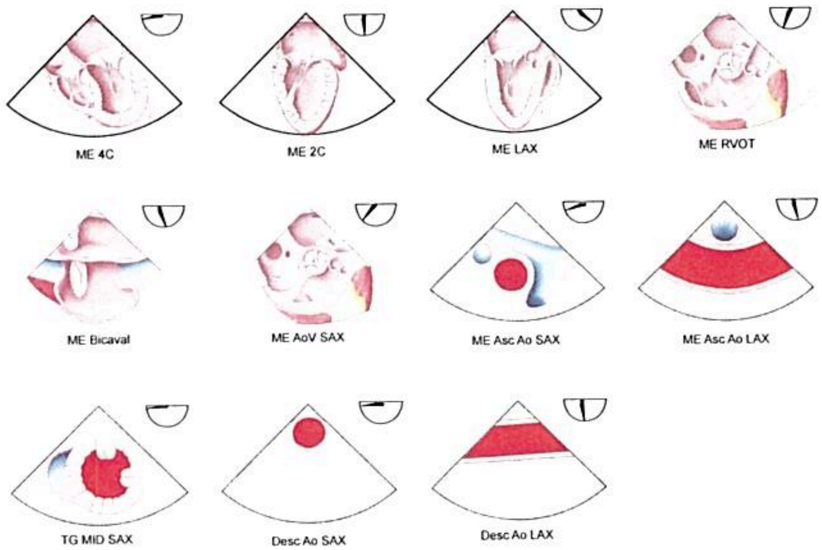

Fig. 3.1 Transesophageal echocardiography (TEE) views. Diagrams of the 11 basic TEE views are shown. Ao, aorta; AoV, aortic valve; Asc, ascending; Desc, descending; LAX, long-axis; ME, mid-esophageal; RVOT, right ventricular outflow tract; SAX, short-axis; TG, transgastric; 2C, two-chamber; 4C, four-chamber. (Adapted with permission from Denault *et al.*[3])

Table 3.1 Outline of the 11-View TEE Study

	Angle	Structures	Diagnosis
ME 4C	0°	RA, RV, LA, LV, TV, MV	Chamber dilatation, systolic dysfunction, pericardial effusion
ME 2C	90°	LA, LV, LAA	LV function, LAA thrombus
ME LAX	120°	LA, LV, AoV, Ao	LV function, AoV disease, LVOT obstruction
ME RVOT	60°	LA, RA, AoV, TV, PV, PA	TV, RVOT obstruction
ME Bicaval	90°	LA, RA, IVC, SVC	PFO
ME AoV SAX	30°	LA, RA, AoV, TV, PV, PA	AoV pathology
ME Asc Ao LAX	100°	RPA, Ao	Ao pathology
ME Asc Ao SAX	10°	PA, Ao	Pulmonary embolism
TG MID SAX	0°	LV, RV	LV function
Desc Ao SAX	0°	Ao	Dissection, aneurysm
Desc Ao LAX	90°	Ao	Dissection, aneurysm

2C, two-chamber; 4C, four-chamber; Ao, aorta; AoV, aortic valve; Asc, ascending; Desc, descending; IVC, inferior vena cava; LA, left atrium; LAA; left atrial appendage; LAX, long-axis; LV, left ventricle; LVOT, left ventricular outflow tract; ME, mid-esophageal; MV, mitral valve; PA, pulmonary artery; PFO, patent foramen ovale; PV, pulmonary vein; RA, right atrium; RPA, right pulmonary artery; RV, right ventricle; RVOT, right ventricular outflow tract; SAX, short-axis; SVC, superior vena cava; TG, transgastric; TV, tricuspid valve.

PROBE DEPTH

Selection of an appropriate probe depth is essential both to orient the sonographer and to enable the acquisition of the required views. Three main depths are measured from the incisors to the tip of the probe:

- Upper-esophageal (UE) Level ~20–30 cm probe depth
- Mid-esophageal (ME) Level ~30–40 cm probe depth
- Transgastric (TG) Level ~40–45 cm probe depth.

Most TEE studies begin at the ME level where the majority of views are obtained. The probe is advanced to obtain at least one image at the TG level, and then withdrawn to the UE level to image the aorta at the end of the study. This approach has the advantage of minimizing movement as the probe is advanced and withdrawn to change levels, avoiding irritation of the esophagus and potential patient discomfort. In urgent situations starting at the TG level is sometimes preferred, as discussed below.

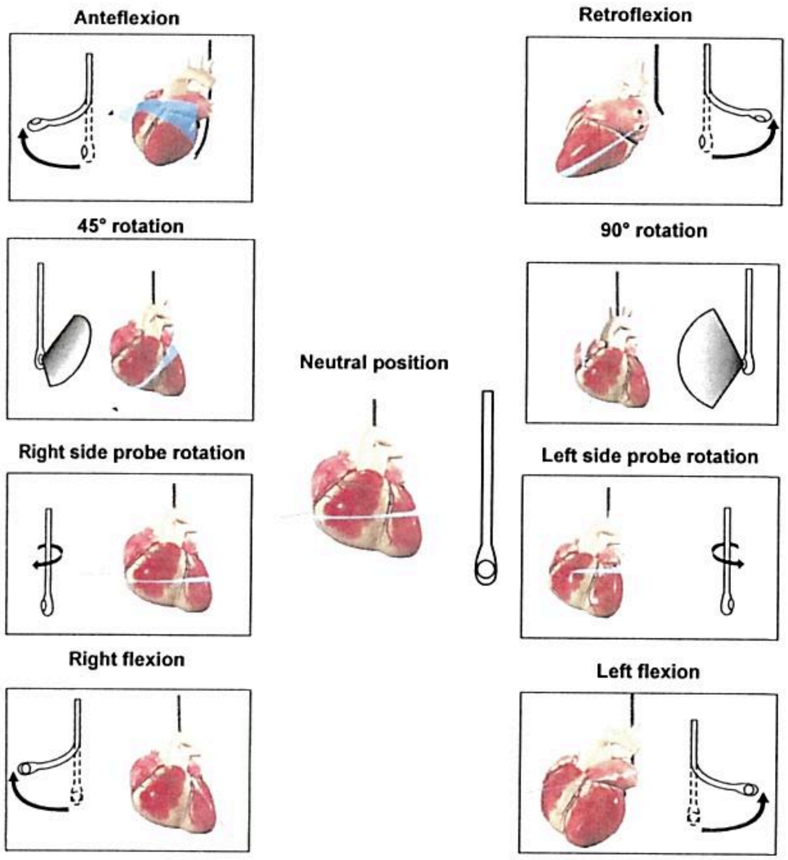

Fig. 3.2 Transesophageal echocardiography (TEE) probe manipulation. Graphic display of TEE probe manipulation and plane orientation is shown. (Adapted with permission from Denault *et al.*[3]; video courtesy of Philips.)

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RECOMMENDED VIEWS FOR A COMPREHENSIVE BASIC EXAMINATION

Mid-esophageal Level

There are eight distinct views to be captured at the ME level:[1]

1. ME Four-Chamber (ME 4C) View. This is often the initial view obtained as the probe is inserted into the patient's esophagus. It functions as a "home base" for novices who can reacquire this familiar view should they become disorientated during the study. The required steps to achieve most other views begin from this view, further emphasizing its importance.

   To acquire the ME 4C view, the probe is gently advanced from the oropharynx in a neutral position with the transducer angle at 0° to the ME level behind the left atrium (LA). As long as the ultrasound beam is pointed anteriorly, the heart appears at approximately 30 cm probe depth for average-sized patients. Several small probe adjustments are usually required to optimize the image (**Figure 3.4**). The probe may be rotated left or right as needed to center the heart in the display. Slight retroflexion may be required to align the imaging plane so that both atria and both ventricles are visible. Finally, if the left ventricular outflow tract (LVOT) is visible, slightly advancing the probe or rotating the transducer angle to 10° or 20° eliminates this structure from view. Display depth should be adjusted such that the apex of the left ventricle (LV) is seen in the lower portion of the screen, without wasted space below. However, sufficient depth should be obtained in order to exclude conditions such as a pericardial effusion.

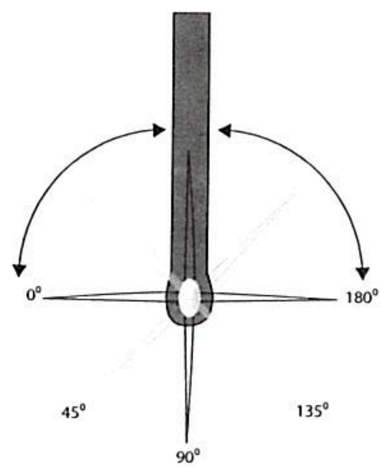

Fig. 3.3 Transesophageal echocardiography (TEE) imaging planes. Diagram of TEE probe image plane rotation from 0° to 180° and 180° to 0°, where 0° represents a transverse plane, perpendicular to the length of the probe.

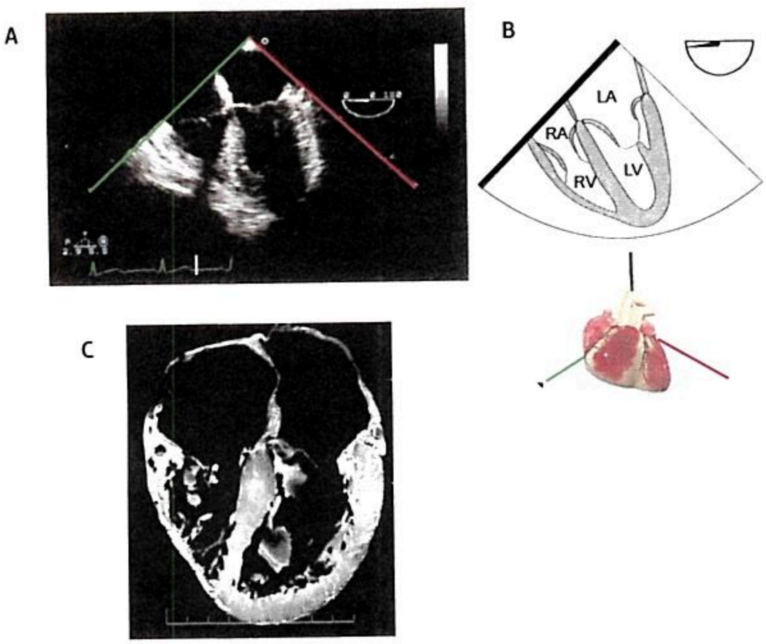

Fig. 3.4 Mid-esophageal four-chamber view. (A,B) This transesophageal echocardiography view at 0° shows all four cardiac chambers compared with (C) a magnetic resonance image. LA, left atrium; LV, left ventricle; RA, right atrium; RV, right ventricle. (Reproduced with permission from Denault *et al.*[3])

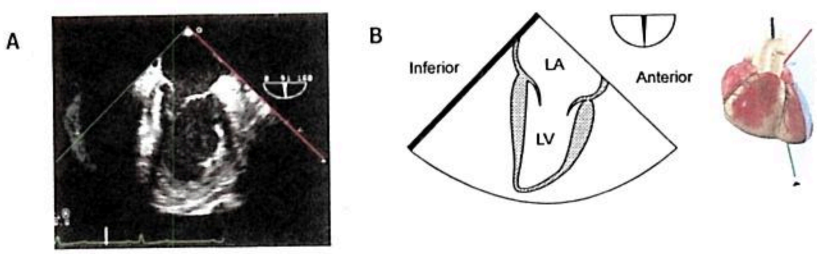

Fig. 3.5 Mid-esophageal two-chamber view. (A,B) This transesophageal echocardiography view obtained at 90° shows only two chambers, the left atrium (LA) and left ventricle (LV). The probe should be manipulated to elongate the LV cavity and avoid foreshortening the LV apex. (Reproduced with permission from Denault *et al.*[3])

Structures identified in the ME 4C view include the LA, right atrium (RA), LV, right ventricle (RV), inter-atrial and inter-ventricular septa, mitral valve (MV), and tricuspid valve (TV); a considerable amount of clinical information is available. Importantly, the size of the four cardiac chambers can be evaluated and directly compared. An assessment of LV systolic function can be made, although only the lateral and septal LV walls are visible. Similarly, while an estimate of RV systolic function can be arrived at, it is important to note that the entire RV free wall cannot be seen. The ME 4C view is an ideal starting point for evaluation of both mitral and tricuspid valves using two-dimensional (2D) imaging, and has good alignment for spectral and color Doppler interrogation. Finally, the presence of a pericardial effusion can be detected when present (see **Figure 5.18**).

2. ME Two-Chamber (ME 2C) View. From the ME 4C view, the transducer angle is rotated to approximately 90°, at which point the right-sided chambers disappear completely leaving only the LA, LV, and MV (**Figure 3.5**). The useful clinical information obtained from this view mainly involves assessment of LV function; here the anterior and inferior walls are easily visualized, with a good opportunity to estimate global LV function.

The LA is well seen and assessment of the left atrial appendage (LAA) can be attempted when clinically indicated. The LAA can usually be found with the transducer angle at 90°–110°, with clockwise rotation of the probe and anteflexion of the probe tip (**Figure 3.6**). The anatomy of the LAA is complex, and a thorough evaluation requires viewing it from multiple imaging planes. In the ME 2C view, the structure and function of the MV can be assessed by both 2D and Doppler imaging. A small pericardial effusion under the LAA can be detected, when present.

3. ME Long-Axis (ME LAX) View. Rotating the transducer angle a further 30°–50° from the ME 2C view will bring the LVOT, aortic valve (AoV), and proximal ascending aorta into view at the 2 o'clock position (**Figure 3.7**). Again, this view is most useful for LV assessment; here

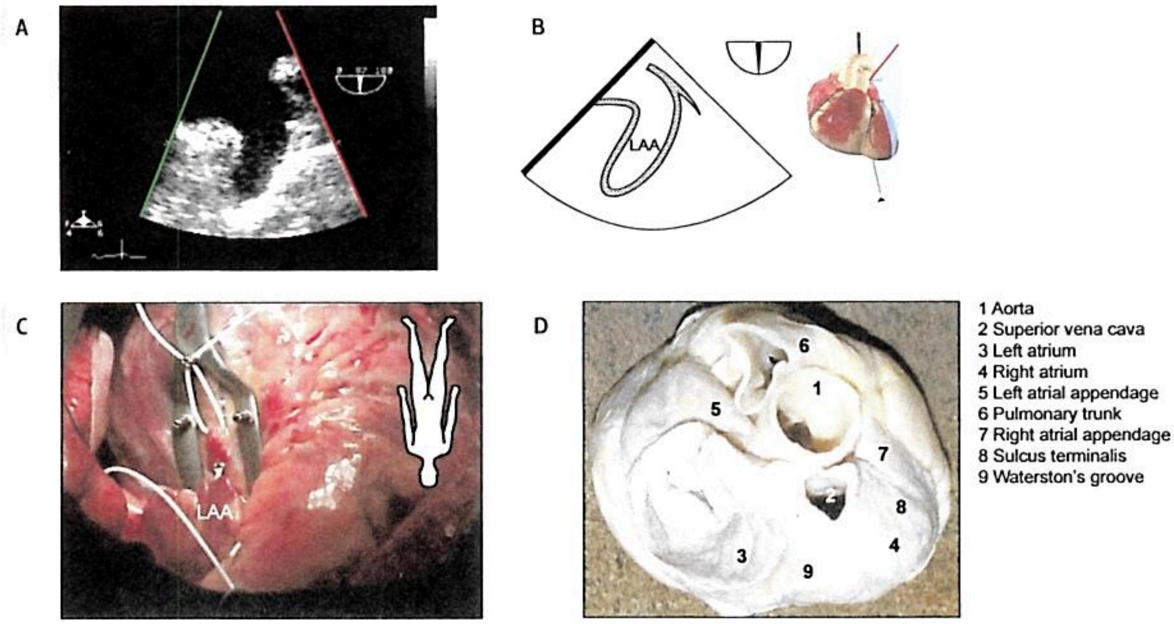

Fig. 3.6 Mid-esophageal (ME) left atrial appendage (LAA) view. (A,B) ME view of the LAA as obtained at 90° is shown. (C) Intraoperative view of the LAA during off-pump bypass surgery. (D) The LAA is anterolateral to the left atrium and close to the left upper pulmonary vein as shown in this anatomic specimen. Source: Panel (C) courtesy of Dr Raymond Cartier. (Reproduced with permission from Denault *et al.*[3])

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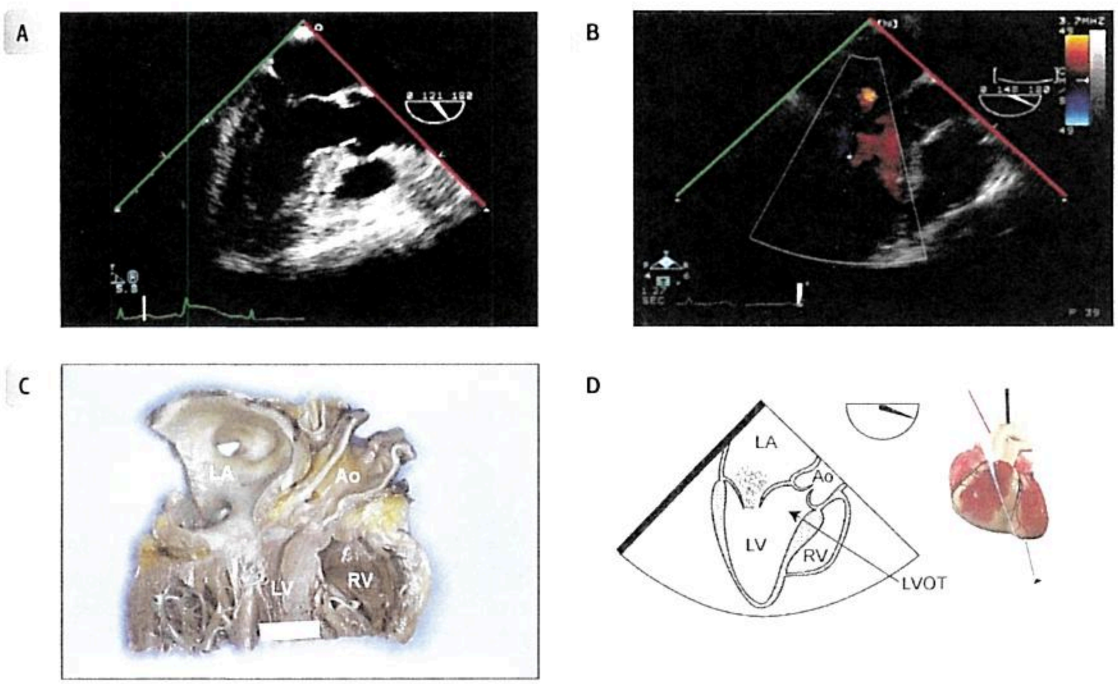

Fig. 3.7 Mid-esophageal long-axis view. Views obtained at 121° and 146° of the LV (A) without and (B, D) with color Doppler in the LVOT compared with (C) an anatomic specimen. Ao, aorta; LA, left atrium; LV, left ventricle; LVOT, left ventricular outflow tract; RV, right ventricle. (Reproduced with permission from Denault *et al.*[3])

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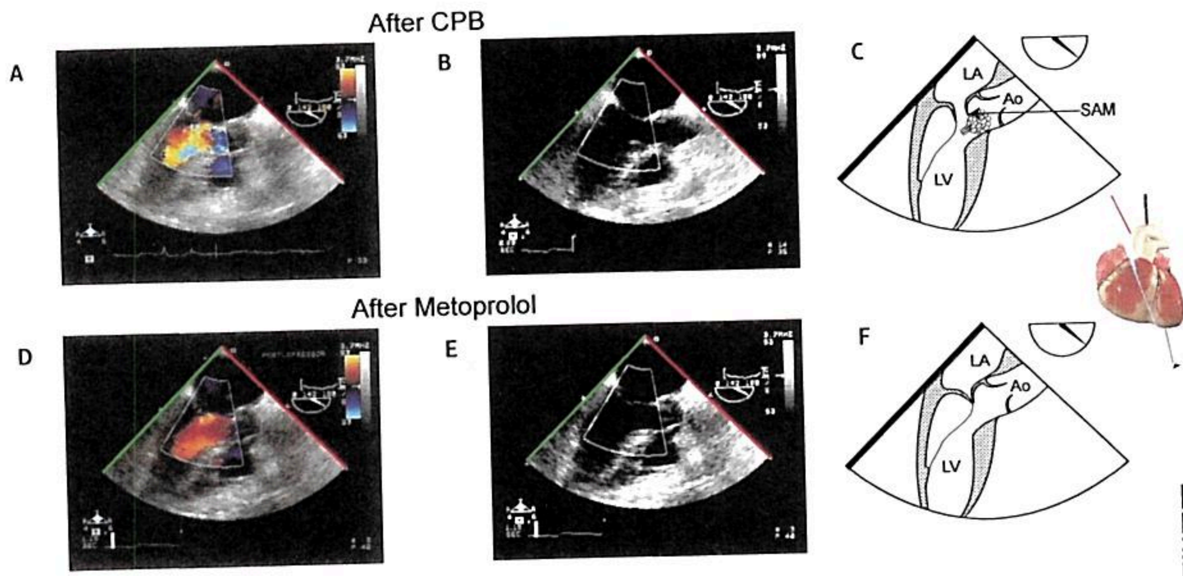

A & D:

B & E:

Fig. 3.8 Left ventricular outflow tract (LVOT) obstruction. A 63-year-old female becomes hemodynamically unstable following separation from cardiopulmonary bypass (CPB) after coronary revascularization. (A–C) Mid-esophageal long axis views with and without color Doppler show systolic anterior motion (SAM) of the anterior mitral valve leaflet with flow acceleration in the left ventricular outflow tract (LVOT). (D–F) Following administration of an intravenous bolus of metoprolol, the SAM improves and the patient is clinically more stable. Ao, aorta; LA, left atrium; LV, left ventricle. (Reproduced with permission from Denault *et al.*[3])

the anteroseptal and inferolateral walls can be seen. In this view, the structure and function of the AoV can be examined using 2D imaging and color Doppler. However, the AoV/LVOT axis is often horizontal and thus nearly perpendicular to the plane of Doppler interrogation, making spectral Doppler evaluation suboptimal in this view. Additional TG views or a TTE examination are required to obtain proper spectral Doppler alignment. The presence of turbulent systolic flow in the region of the AoV with color Doppler suggests elevated flow velocities and aortic stenosis should be suspected. This can be confirmed by 2D assessment of the valve combined with continuous wave (CW) spectral Doppler measurements of transvalvular velocity. Color Doppler can be used to screen for diastolic regurgitant flow, identifying the presence of aortic regurgitation (see **Figure 7.13**). Though large regurgitant jets are suggestive of severe regurgitation, accurate quantification depends on complex 2D and Doppler assessment from multiple angles of interrogation.

The ME LAX view is ideal for observing the path of the anterior leaflet of the MV. Of particular interest to point-of-care providers is identifying dynamic obstruction of the LVOT by systolic anterior motion (SAM) of the anterior leaflet; color Doppler can show turbulent flow in the LVOT and associated mitral regurgitation (**Figure 3.8**).

4. ME Ascending Aorta Long-Axis (ME Asc Ao LAX) View. From the ME LAX view the probe is slowly withdrawn until the ascending aorta comes into view in long axis, oriented horizontally on the display (**Figure 3.9**). Frequently, the transducer angle must be reduced towards 90° to achieve an optimal LAX view. The right pulmonary artery (PA) will be visible in SAX at the top of the screen. The key clinical application of this view in urgent situations is to screen for a type A aortic dissection or other proximal acute aortic syndrome. It should be remembered that there is a blind spot created by the air-filled trachea, which may cause a localized aortic dissection to be overlooked.

5. ME Ascending Aorta Short-Axis (ME Asc Ao SAX) View. A SAX view of the ascending aorta is attained by reducing the transducer angle by exactly 90°, usually to an angle of 0°–20°, from the point where an optimal LAX view was obtained. Centering the PA at the top of the display in the ME Asc Ao LAX view before changing the transducer angle will facilitate the right PA appearing in LAX in the center of the display (**Figure 3.10**).

If a proximal aortic dissection is suspected, the dissection flap is sometimes better appreciated in SAX where it is frequently easier to distinguish a true flap from an

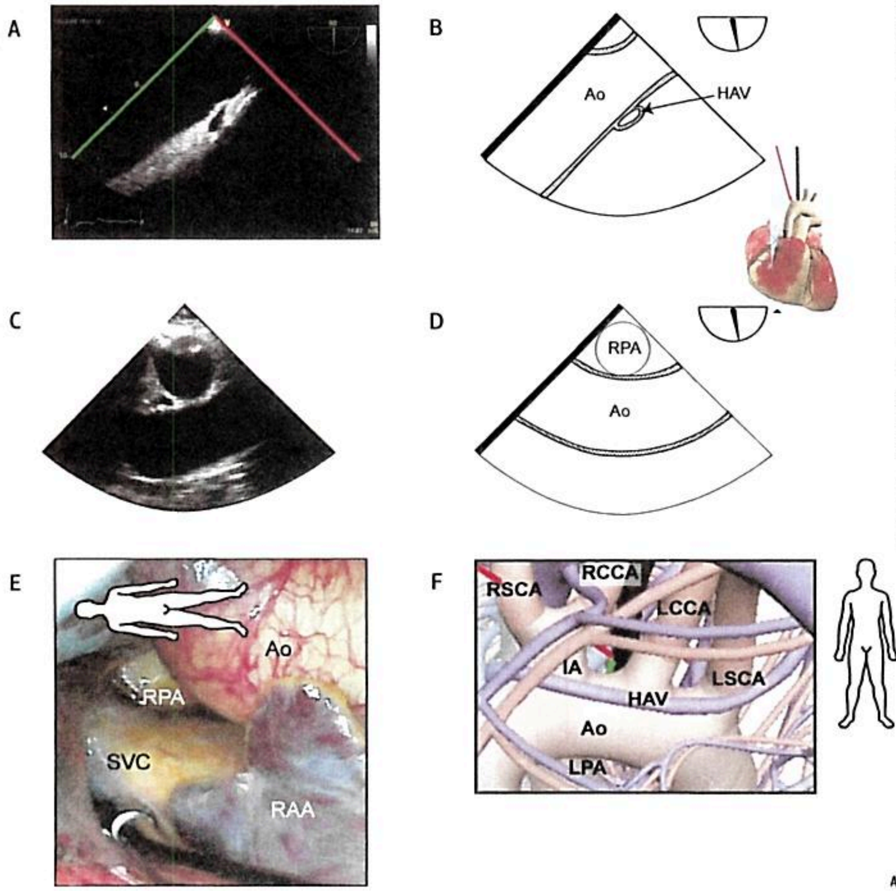

Fig. 3.9 Ascending aorta (Ao) views. (A,B) An upper esophageal view of the proximal ascending Ao and hemiazygos vein (HAV) at 90° is shown. (C,D) Mid-esophageal ascending Ao long-axis view at 100° compared with (E) an intraoperative view of the Ao. (F) Diagram of the relationship of the HAV to the Ao is shown. IA, innominate artery, LCCA, left common carotid artery; LPA, left pulmonary artery; LSCA, left subclavian artery; RAA, right atrial appendage; RCCA, right common carotid artery; RPA, right pulmonary artery; RSCA, right subclavian artery; SVC, superior vena cava. Source: Photo (E) courtesy of Dr Michel Pellerin (Reproduced with permission from Denault *et al.*[3])

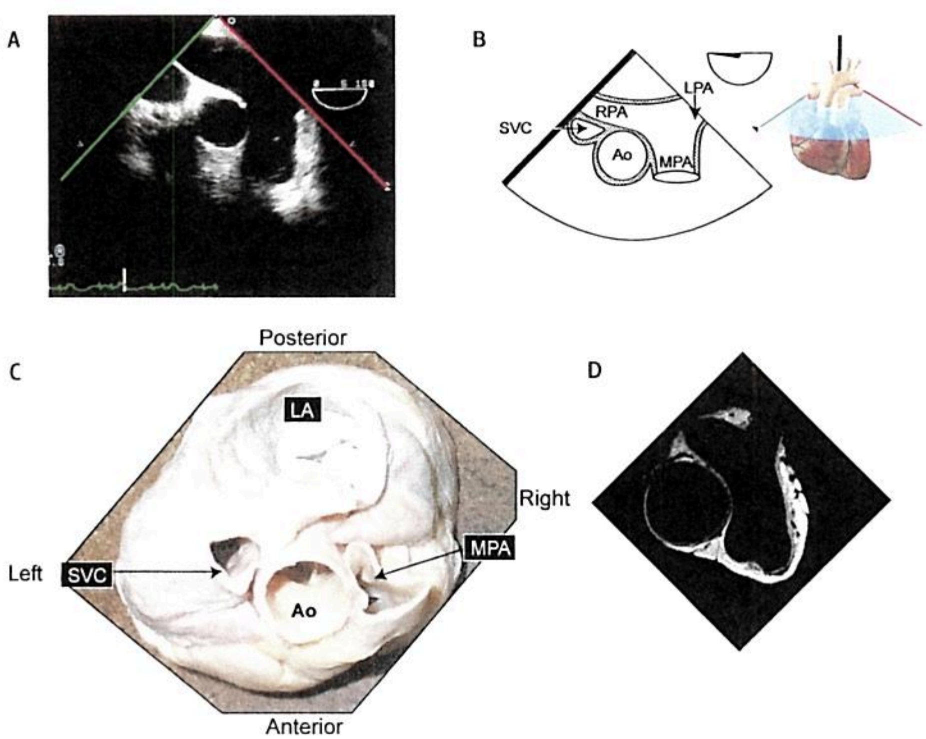

Fig. 3.10 Mid-esophageal (ME) ascending aorta short-axis view. (A,B) ME view at 0° of the great vessels compared with (C) anatomic correlation and (D) magnetic resonance imaging. LA, left atrium; LPA, left pulmonary artery; MPA, main pulmonary artery; RPA, right pulmonary artery; SVC, superior vena cava. (Reproduced with permission from Denault *et al.*[3])

artifact (see **Figure 12.23**). This view is often used to look for a very proximal pulmonary embolism (PE) located in the main PA (see **Figure 12.6**), the saddle position, or the very proximal right or left PA (see **Figure 10.14**). As such, TEE is much more specific than sensitive; whereas visualising an embolus is very rare but obviously very helpful, the absence of a visualized embolus does not exclude a PE. Furthermore, hyperechoic structures in the PA are often artifactual, and great care must be exercised to confirm that a suspected PE is in fact real before establishing this diagnosis and exposing the patient to the risks of anticoagulation, thrombolysis, or embolectomy.

6. ME Aortic Valve Short-Axis (ME AoV SAX) View. To move from a SAX view of the ascending aorta to a SAX view of the AoV usually requires only that the probe be advanced a few centimeters. Once the AoV is seen, it is necessary to slightly adjust the image plane (usually to between 20° and 50°) to acquire an optimal SAX view where all valvular cusps appear symmetric (**Figure 3.11**).

   This view can assess the AoV in detail, although this is not necessary for most point-of-care examinations. In aortic stenosis, a heavily calcified valve will be seen, with greatly diminished cusp motion and reduced effective orifice area (see **Figure 7.4**). A bicuspid (or unicuspid) valve may, on rare occasions, be an incidental finding.

7. ME Right Ventricular Inflow-Outflow (ME RV In-Out) View. The RV inflow-outflow view (alternately called the ME right ventricular outflow tract (RVOT) view in some publications) lies very close to the previously described ME AoV SAX view. The transducer angle is rotated to approximately 60°, and it may be necessary to advance the probe slightly until both the TV and pulmonic valve (PV) appear (**Figure 3.12**).

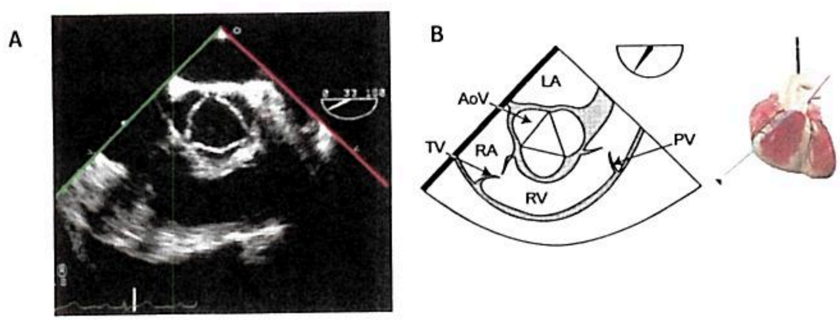

Fig. 3.11 Mid-esophageal aortic valve (AoV) short-axis view. (A,B) This view at 33° of the aortic valve shows all three cusps open during systole. LA, left atrium; PV, pulmonic valve; RA, right atrium; RV, right ventricle; TV, tricuspid valve. (Reproduced with permission from Denault *et al.*[3])

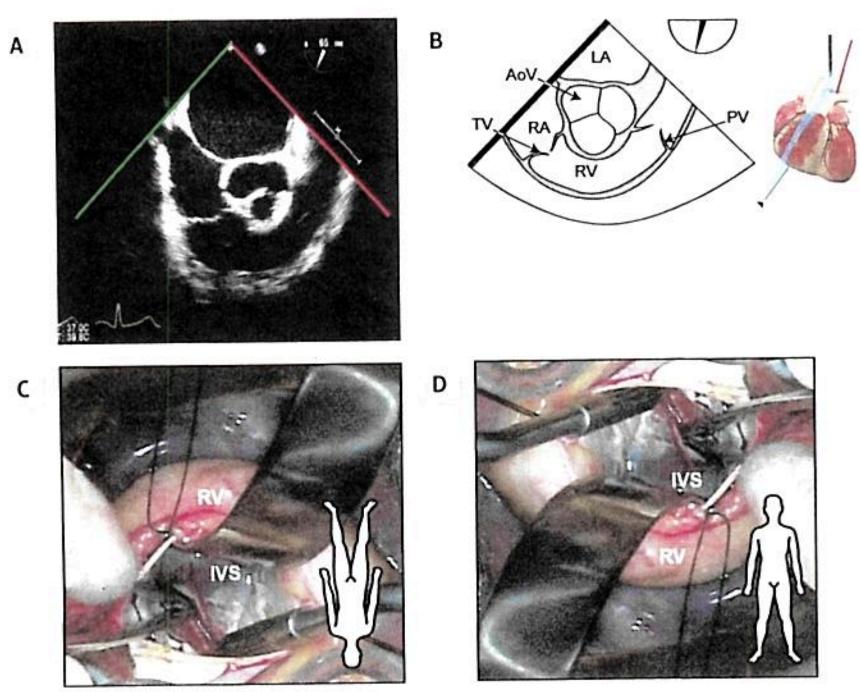

Fig. 3.12 Mid-esophageal right ventricular inflow/outflow view. (A,B) This view obtained at 65° shows the aortic valve (AoV) in the center, the tricuspid valve (TV) on the left, and the pulmonic valve (PV) on the right. (C) The surgical view is repositioned to correlate better with (D) the echocardiographic window. IVS, interventricular septum; LA, left atrium; RA, right atrium; RV, right ventricle. Source: Photo (C) courtesy of Dr Nancy Poirier. (Reproduced with permission from Denault *et al.*[3])

This view provides valuable information about the RV, as the outflow tract is usually clearly seen in the lower portion of the display. When a pericardial effusion or any mechanical or dynamic obstruction of the RVOT is identified, this view can assess its impact on the RV in terms of impediment of flow from collapse (see **Figure 9.14**). The TV can be assessed for the presence of regurgitation, and the systolic PA pressure can be estimated in cases where the regurgitant jet is well aligned. In very rare clinical situations where PV pathology is suspected, an assessment of this structure is possible (see **Figure 7.33**).

8. ME Bicaval View. With clockwise rotation of the probe shaft and the transducer angle at approximately 90°, the ME bicaval view can be found. This view shows the LA and the RA with both the inferior vena cava (IVC) and superior vena cava (SVC) draining into the RA (**Figure 3.13**).

This view is primarily useful in urgent cases to measure the diameter and degree of respiratory variation of both vena cava to help determine intravascular volume status and volume responsiveness (see **Figure 15.14**). It may be used in the context of procedural guidance. When placing a central venous catheter, detecting the guidewire in the RA confirms venous position prior to vessel dilatation (see **Figure 18.12**). Transvenous pacemakers can likewise be guided into the RA and away from the IVC.

Transgastric Level

There are many potential views that can be obtained from the TG position, with nine distinct views listed in the ASE comprehensive guidelines.[2] From the perspective of a basic TEE examination performed on an acutely ill patient, most of the information required can be achieved by adding a single TG view to the ME views described earlier in this chapter:

Transgastric Mid-Papillary Short-Axis (TG mid SAX) View. This view is usually straightforward to obtain. From the ME 4C view, the unflexed probe is advanced with the transducer angle at 0° into the stomach. As the gastro-esophageal junction is crossed, sufficient anteflexion is added to keep the transducer in contact with the gastric mucosa to prevent air from degrading the image quality. Subtle transducer tip movements may be required to achieve an optimal SAX view at the mid-papillary level where the LV appears round and the papillary muscles are symmetric (**Figure 3.14**).

The TG mid SAX view is primarily useful for assessing LV function. At the ME level, there is no single view where all LV walls can be seen together; instead they must be viewed in pairs from three different views as described earlier. The TG SAX view offers a good representation of global LV function albeit only at the mid-papillary muscle level as the base and apex are not seen in this view. It is also a helpful view to look for regional wall motion abnormalities by direct comparison of the different LV wall segments (see **Figure 6.3**).

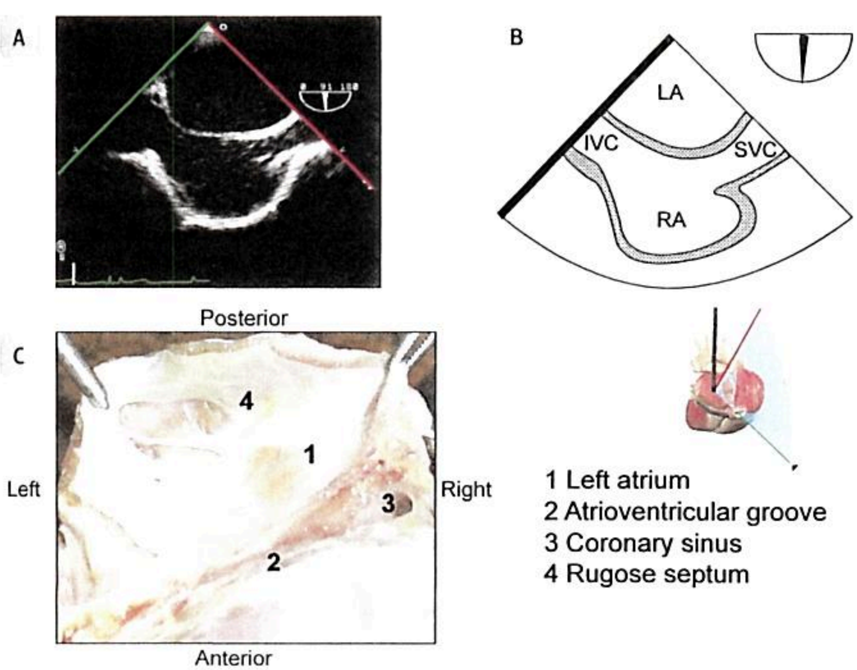

Fig. 3.13 Mid-esophageal bicaval view. (A,B) This view obtained at 91° shows the inferior vena cava (IVC) and superior vena cava (SVC) entering the right atrium (RA). (C) Anatomic features of the interatrial septum are shown for comparison as viewed from the left atrium (LA). (Reproduced with permission from Denault *et al.*[3])

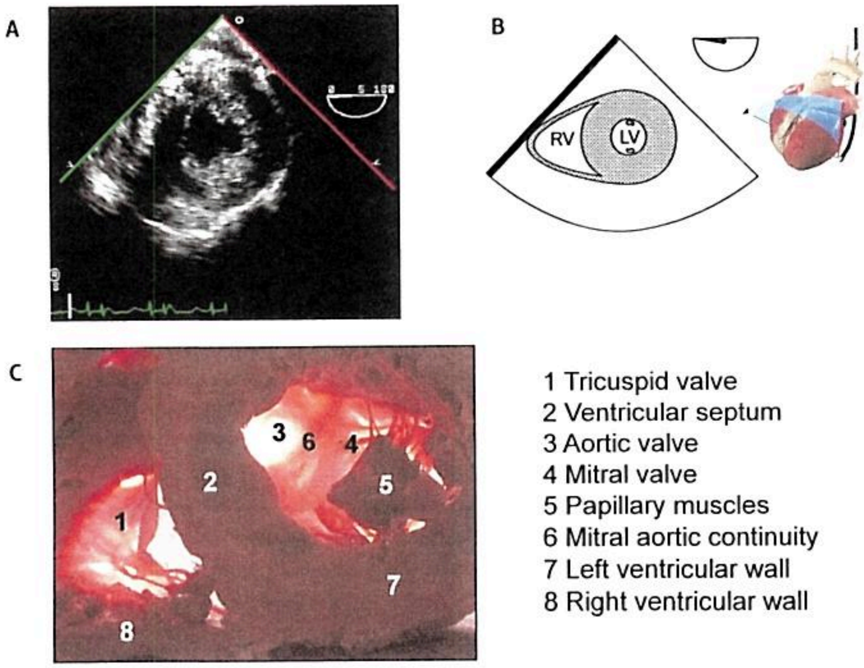

Fig. 3.14 Transgastric mid short-axis view. (A,B) This view obtained at 0° of the left ventricle (LV) at the mid-papillary level with anatomic correlation (C) is shown. RV, right ventricle. (Reproduced with permission from Denault *et al.*[3])

Although the RV free wall may not be seen clearly, important information related to RV size and function can be obtained by examining the interventricular septum (IVS), which is visible in this view. A pressure overloaded RV will cause the IVS to be displaced to the left, resulting in a "D"-shaped LV cavity (see **Figure 5.12**). This can be of great value when acute cor pulmonale is suspected as a cause of shock (perhaps due to a PE), or where the effect of positive pressure ventilation on the RV may be deleterious.

Upper Esophageal Level

Imaging of the descending aorta is less useful in the care of acutely ill patients. However, in some cases where a more distal acute aortic syndrome is suspected or where the source of a thromboembolism is sought, it can be helpful.

1. Descending Aortic SAX View. To find this view, begin at the ME 4C view and turn the entire probe until the ultrasound transducer is pointed towards the patient's back, and the aorta, in SAX, comes into view at the top of the screen. At this point, the display depth should be decreased until the aorta takes up the majority of the screen. It can be interrogated along its length by advancing the probe towards the stomach and withdrawing it to the upper esophagus (**Figure 3.15A**).

2. Descending Aortic LAX View. From the position described above, simply increasing the transducer angle to 90° changes the SAX view of the aorta into a LAX view (**Figure 3.15C**). The same information is available, specifically with respect to aortic diameter, presence of atherosclerotic disease, and presence of an acute aortic syndrome, such as a more distal aortic dissection (see **Figure 12.10**).

RECOMMENDED VIEWS FOR A GOAL-DIRECTED EXAMINATION

As described above, a goal-directed exam is usually more appropriate when imaging patients in urgent situations whether in the intensive care unit, emergency department, or operating room. Pathological states that can cause severe acute illness and can be identified using a goal-directed TEE study have been agreed upon by international consensus.[4] These include pathologies that are common, such as:

1. LV dysfunction
2. RV dysfunction
3. Intravascular hypovolemia or reduced mean systemic venous pressure (see Chapter 9, Basic Hemodynamic Assessment).

Also, pathologies that are less common, but which require a specific change in management should be considered:

1. Pericardial tamponade
2. Acute pulmonary embolism
3. Major valvulopathy (including dynamic obstruction of the LVOT and RVOT)
4. Extra-cardiac conditions resulting in resistance to venous return (pneumothorax, abdominal compartment syndrome, IVC occlusion, etc.) (see Chapters 4 and 9).

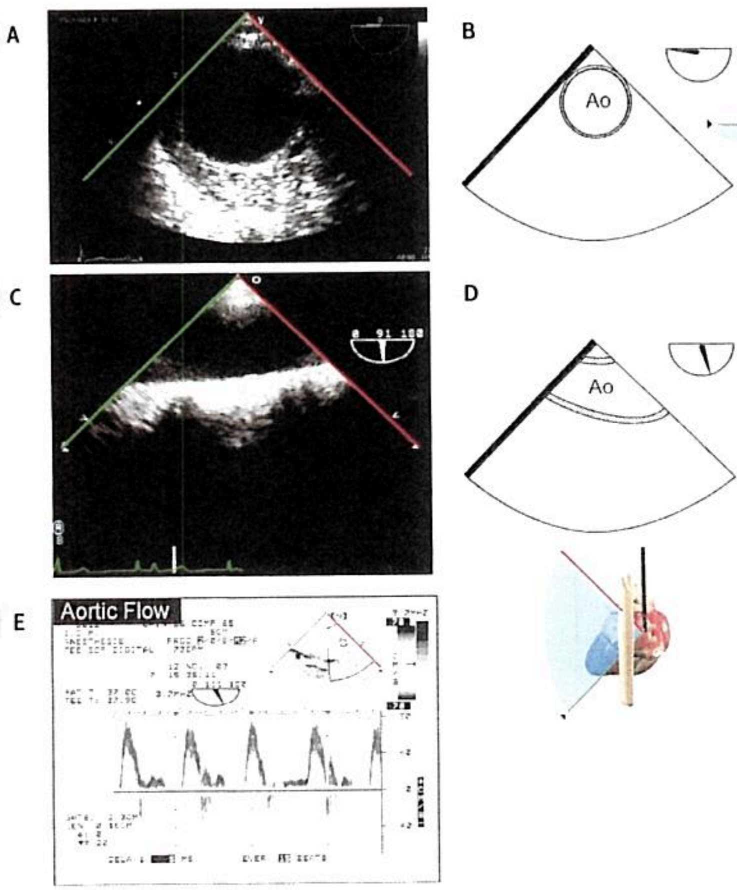

Fig. 3.15 Descending thoracic aorta (Ao) views. The descending Ao is imaged in (A,B) short-axis at 0° and (C,D) long-axis at 90°. (E) A pulsed wave Doppler signal of aortic flow is obtained by placing the sample volume in the proximal portion of the descending Ao. (Reproduced with permission from Denault *et al.*[3])

Standard Goal-directed Exam: Patients with Shock/ Hypotension

A patient presenting with shock or unexplained severe hypotension is the most common clinical scenario that prompts a goal-directed echocardiographic study, whether TTE or TEE. In this scenario, investigating the seven pathologies described above will identify the etiology of shock in the majority of cases.[5] A suggested approach involves the following TEE views:

1. TG Mid-Papillary Short-Axis (TG mid SAX) View. This is the best single view to investigate the etiology of shock, and fortunately it is easy to acquire in most cases. LV systolic function can be estimated and the position of the IVS interrogated. In cases where RV failure or acute PE are suspected, a dilated or pressure overloaded RV can be diagnosed by looking at the shape of the IVS. Pericardial effusions, especially when circumferential, can be detected. When severe hypovolemia is present, a hyperdynamic LV with a relatively empty cavity in both systole and diastole is expected.

2. ME Four-Chamber (ME 4C) View. Transitioning to this view is simple as the unflexed probe need only be withdrawn to the ME level. This view, as previously described, provides further information related to LV and RV size and function, as well as allowing investigation for pericardial effusion and valvular (MV, TV) dysfunction.

3. ME Long-Axis (ME LAX) View. Moving to this next view is again usually straightforward, requiring only a change in image plane from 0° to approximately 120°. This view reveals the AoV and LVOT, allowing aortic stenosis, aortic insufficiency, or dynamic obstruction of the LVOT to be suspected, if not confirmed (**Figure 3.8**). The MV can be interrogated from another plane, as can the LV. A proximal aortic dissection may be detected if the ascending aorta is seen to be dilated or if an overt dissection flap is visualized.

4. ME Bicaval View. This final recommended view can be slightly more difficult to obtain, but is nonetheless achievable in almost every patient. Evaluation of SVC diameter and respiratory variation provides useful information regarding volume responsiveness, particularly in patients who are mechanically ventilated and not making spontaneous respiratory efforts.[6]

5. ME Right Ventricular Inflow-Outflow (ME RV In-Out) View. This view will be useful in order to exclude RVOT obstruction[7], which can be associated with reduced preload or secondary to external compression such as a pneumothorax (see **Figure 9.17**).[8] In addition, evaluation for RV failure can be performed using that view and diagnosis such as PE can be obtained if, for instance, a clot is present.

Additional Goal-directed Views: Patients with Dyspnea/ Hypoxemia

In many cases where patients are dyspneic or hypoxemic, the possibility of an acute PE or intracardiac shunt is raised. Some of the views described above (particularly the TG mid-SAX view) will help with respect to the former, but it is recommended that the following views be analyzed carefully:

1. ME Ascending Aorta SAX (ME Asc Ao SAX) View. If there is a very proximal PE, it may be detected here.

2. Modified ME Right Ventricular Inflow-Outflow (ME RV In-Out) View. In addition to providing a look at the RV outflow tract, a slightly modified version of this view shows the inter-atrial septum (IAS) at the 11 o'clock position. Color Doppler can be used to screen the IAS for the presence of a patent foramen ovale, which may be contributing to hypoxemia in the patient.

SUMMARY

There is an unlimited assortment of potential TEE protocols, and indeed the exact image sequence can be modified for a specific patient, even in the context of a goal-directed exam. The image sequences described above can function as templates that will serve novice transesophageal echocardiographers well as they begin to accrue experience. The study can always be expanded to the comprehensive 11- or 28-view exams should time and patient stability permit. Finally, in the presence of hemodynamic instability or hypoxemia with a normal or abnormal cardiac examination, TEE can be used to detect isolated or associated extra-cardiac pathologies in the lung or in the abdominal cavity. This will be discussed in Chapter 4, Extra-Cardiac Transesophageal Ultrasonography.

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