Artifacts can be defined as any structure in an ultrasound image that does not have a corresponding anatomic tissue structure. Artifacts are a common occurrence in an ultrasound display since they are often the result of the physical properties of ultrasound itself. Recognizing artifacts is essential to proper ultrasound interpretation, as not identifying an artifact as such may lead to unwarranted clinical intervention or concern.

Artifacts may be classified into four main categories: **missing structures**, **degraded images**, **falsely perceived objects**, and **structures with a misregistered location**.

**Missing Structures**

Missing Structures occur for several reasons and can be related to the resolution of the ultrasound image. **Resolution** is defined as the ability to distinguish between two distinct structures that are in close proximity. Lateral resolution, or the ability to distinguish between two objects in a horizontal plane, is related to the width of band of the ultrasound beam. If two structures are closer together than the width of the lateral resolution, they will appear as a single image; in essence the display is missing images. The best lateral resolution occurs at the focal zone, where the near field meets the far field and where the beam width is the narrowest. (figures 1, 2). Determination of the size of a structure in the horizontal plane incorporating two beams is never as good as measurements made in the vertical plane or down a single beam (axial resolution).

**Acoustic shadowing** may also create missing images. It occurs when the ultrasound beam reaches a strong reflector. This reflector decreases the beam intensity to distal structures, essentially blocking the beam to that area. Therefore, any image that lies deep to the strongly reflecting item cannot be seen. (figure 3)

To improve resolution, increase the frequency, change your area of interest to the focal zone and decrease the overall gain.

When shadowing occurs, change your acoustic window.
Degraded Images
An image of imperfect or poor quality is referred to as degraded and is often due to artifact phenomena. **Reverberations** are a type of image degradation. They are secondary reflections that occur along the path of a sound pulse and are a result of the ultrasound “bouncing” in between the structure and another reflecting surface. Reverberations appear as parallel yet irregular lines extending from the object away from the transducer. They occur when either the near side of the object, a second object, or the transducer itself functions as another reflecting surface. The repeated journeys traveled by the same beam produce additional signals that are interpreted as the same object at twice the distance from the primary target. Therefore, a reverberation is two or more equally spaced echo signals at increasing depths, twice the distance as the original signal (figure 4). Reverberations generally occur with strong, superficial reflectors such as calcified structures and metallic objects. A common site for this to occur is in the descending thoracic aorta. More commonly reverberations are merged together and appear as a solid line directed away from the transducer. This is called comet tail or ring down (figure 5).

Enhancement is another type of image degradation and is the reciprocal of acoustic shadowing. If a structure is a weak reflector or the medium through which the ultrasound travels has a lower attenuation rate than soft tissue, the beam is attenuated less than normal. The echoes below the weak reflector are then enhanced and these structures appear to be brighter than normal, or hyperechoic. (figure 6)

**Enhancement** can be adjusted in the vertical plane by decreasing the time-gain compensation on the console.

Noise can also degrade the quality of an image. Noise has many etiologies, including excessive gain and other changes in settings, but in the operating room arena it is most commonly from electrical
interference such as electrocautery. Noise appears as very small amplitude echoes on the scan. It is most likely to affect low-level echolucent areas rather than bright echogenic areas. Some TEE machines are now coming equipped with filters designed to limit the amount of interference but the effectiveness of this technology is somewhat limited.

**Falsely Perceived Objects**

Falsely perceived objects may occur as a result of *refraction*. Refracted ultrasound waves are beams that have been deflected from their original uniform path and occur as a result of the waves passing through a medium with a different acoustic impedance. The transducer assumes the reflected signal originated from the initial scan line and the image is displayed as such. A mirror image can also be created as a result of the ultrasound wave bouncing in between the near and the far side of the structure before returning to the transducer, similar to a reverberation. This mirrored image is always located on a straight line between the transducer and the artifact as is always deeper than the true reflector. A common place of occurrence for this is the descending aorta and is often referred to as a double-barrel aorta. This artifact is believed to be caused by the aorta-lung interface.

Mirror images can be detected by noting the placement of an identical image distal to another at twice the distance from the transducer as the original image. They can sometimes be discerned by altering the imaging plane, the depth or the transducer frequency. Suspect a mirror image when viewing the aortic arch and descending thoracic aorta.

**False Dissections**

Falsely perceived images can also be a result of reverberations which were discussed earlier. Linear Artifacts are a type of reverberation artifact and like mirror images can be identified as being twice the distance from the transducer as the original image. They are commonly seen in the ascending aorta and may mimic intimal flaps. These false intimal flaps were seen in 44% of patients with monoplane TEE and 35% of patients with biplane in a series published by Appelbe et al. and have been shown in vitro to be multiple path artifacts caused by reflection of ultrasound within the left atrium. They are associated with dilation of the ascending aorta and are more frequent when the aortic diameter exceeds the left atrial diameter (figures 8 and 9). They can be detected as false flaps when they have indistinct borders, do not display rapid oscillatory motion, and are located at twice the distance from the LA wall. In addition, color Doppler should not show interruption of the flow pattern.

Artifacts are more likely to occur when the diameter of the aorta is > 5 cm and atrial-aortic ratio is <=0.6
Linear artifacts mimicking dissections can also occur in the ascending aorta near the right pulmonary artery (Figure 10).

![Image of linear artifact](image)

**Figure 10:** Upper esophageal view of the pulmonary artery and ascending aorta. The linear artifact flap is seen parallel to the posterior wall of the aorta. It is twice the distance from the posterior border of the right pulmonary artery which raises suspicion for an artifact.

**Figure 11:** Linear artifact appears thicker than the intimal flap seen in the images below. Blood flow velocities appear similar on both sides of the artifact.

High velocity and turbulent blood flow seen here and does not appear overimposed on the intimal flap of the aortic dissection.


The presence of a thick linear image (> 2.5 mm), laying nearly horizontal within the ascending aorta and similar blood flow velocities on both sides of the image are strong predictors of an underlying ultrasound reverberation artifact within the ascending aorta.

**Reverberation Artifacts in Left Atrial Appendage**

Reverberation artifacts have also been described in the left atrial appendage, and have been confused with atrial thrombi. In a series of patients undergoing TEE for cardioversion, Maltagliati found that 23% of patients had images in their LAA which were interpreted as artifacts. All artifacts were twice the distance from the transducer as from the membranous bend (or coumadin ridge) between the left upper pulmonary vein and the LAA. Their position and echogenicity were markedly different from those LAA thrombi. Unlike the artifacts, all thrombi found in the LAA were confined within the cavity with an attachment and had a uniform consistency and different texture to that of the LA wall (figure 12). None of the artifacts had an attachment to the LAA wall and their consistency was not uniform (figure 13).
Figure 12: LAA at 75 degrees shows no thrombus. Image at 135 degrees shows bilobed appendage with a clear thrombus marked by arrows.

Figure 13: Left atrial appendage artifact seen inside appendage without clear attachment to atrial wall. The measurements on the left image show that the artifact is twice the distance from the transducer as the coumadin ridge.

Images from Maltagliati, (Ital Heart J 2003; 4 (11): 797-802)

**Misregistered Locations**

**Range ambiguity** results in the display of the correct structures in the wrong location. It occurs with high pulse repetition frequency. With a high PRF a second pulse is sent out before the first Doppler signal along the same scan line is received. Therefore the machine is unable to recognize the returning signal as originating from the first or second or even a subsequent pulse. This results in deep structures appearing closer to the transducer than their true location. When an unexpected object is observed in a cardiac chamber, it is often due to range ambiguity.

When an unexpected object appears in a cardiac chamber, make sure it is not an artifact created by range ambiguity by changing the depth setting of the image (and therefore the pulse repetition frequency).
**Side Lobes**: Although the main ultrasound beam is central, multiple beams are projected out from the transducer in a diverging manner. (figure 15) These beams are referred to as *side lobes* and can result in images being placed in the wrong location on the displayed image. Side lobe artifacts usually become apparent when they do not conflict with real echoes. If the emitted echo beam is rapidly oscillating, then multiple side-lobe artifacts may be displayed as a curved line at the level of the true object with the brightest area corresponding to the original structure. In the ascending aorta, a side lobe artifact may also create the appearance of a false dissection (Fig 16) (false dissections in the ascending aorta can also be a reflection artifact related to the left atrium-see linear artifacts above).

Identification of sidelobes is accomplished by recognition of the fact that the side lobe artifacts cross anatomical walls and cavities without regard for natural borders, and always have a common radius from the transducer. They may disappear with adjustment of the depth or angle of the transducer.

References:
