# Artifact, Fact, or Artefact?



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"All I hear is noise.

Can't get away from the noise."

Noise; D. Davies; The Kinks; State of Confusion. Arista, 1983

It is expected that most readers of this editorial understand the immense value of ultrasound, especially as it is applied to the heart and vasculature. It is also likely that a general appreciation of the potential for noise and image *artifact* from the physical properties necessary to create an image is widely held. It is with this background that I attempt to compile some common themes on this topic while I also address the homophonic terms *artifact* and *artefact*.

Let me start by attempting to provide what I learned while reading about these commonly used and seemingly synonymous terms. The simplest concept is that these two variations represent the American (*artifact*) and British (*artefact*) English spelling for the same word and therefore, the same definitions. In fact, searching both spellings in the Oxford dictionary offers the exact same list of options. Some other dictionaries attempt to categorize *artefacts* as historical or archaeologic objects (usually man-made), whereas *artifacts* are false signals or artificial products (EIC note: should it be *arteficial*?). To continue, the root of these words may help us better understand their application. *Artifact* comes from the Latin phrase: *arte factus*. Arte means "by skill" and factus means "to make." When combined, it means "made by human agency."

I'm satisfied with this approach to understanding the historical adoption of our use of *artefact* as a man-made archaeologic object, but I had to search deeper into the meaning for our daily use of *artifact* as noise. One approach might be to apply *artificial* production of a natural object and assume that 'artificial' was the main driver to the word origin. In fact, although *artefact* was the initial spelling (obviously, the British version was first), the insertion of the 'i' in place of the 'e' was noted a century later and was supposedly influenced by the Latin stem *artifice*. So, with that in mind, I am satisfied that our growing practice of using the American *artifact* for ultrasound errors (image noise), and the British *artefact* for historical human art is in fact, based in fact.

There are a couple of very well-written reviews on the topic of *artifacts* in echocardiography. Bertand *et al.* have the best title ever: Fact or *Artifact* in 2D Echo: Avoiding Misdiagnosis and Missed Diagnosis.[1] Quien and Saric also have an outstanding review: Ultrasound Imaging *Artifacts*: How to Recognize Them and How to Avoid Them.[2] Both of these manuscripts should be kept readily available in your lab's required reading portfolio.

I teach novice echo courses with the understanding that ultrasound is relatively stupid: it is only fully knowledgeable of the direction it was transmitted and the time it takes for the reflection to return and then be processed. Everything else in the image production is assumed. Ultrasound can only obey the laws of physics and therefore, many assumptions are applied to the actual image creation. Ultrasound cannot account for errors that alter the actual direction, so even when it is refracted, or transmitted through a tissue boundary, the image produced will ignore those facts. Similarly, since ultrasound moves at a relatively consistent, medium-determined speed, the time-constant is able to place an image at a particular distance which is assumed to accurately represent the location of the acoustic mismatch. Once again, however, ultrasound cannot account for errors that alter this assumed time-distance product which results in the incorrect display of the artifactual images that ignore those facts.

For simplicity, I like to categorize *artifacts* into two groups: (1) those that are distant to the object of interest, but in the same ultrasound line as the central beam; or (2) those that are at the same distance as the object of interest (Table 1).

Understanding the common location of these *artifacts* and steps to eliminate them (when possible) is necessary for a high-quality echo lab to create meaningful reports that are not inundated with unclear messaging. Figure 1 is an excellent example of the near-field clutter due to high amplitude ultrasound signal oscillations from the transducer material itself. Can you imagine the downstream impact if you simply reported "possible" or "cannot rule out" apical thrombus every time you saw that characteristic *artifact*? Luckily, we all know that by applying harmonic instead of fundamental imaging, using color flow Doppler, administering ultrasound enhancing agents, making various changes to transducer frequency, depth, and/or focus, applying multiple imaging planes and/or sweeps, as well as considering the clinical setting (such as global and regional LV systolic function, pattern of *artifact* motion, and more), we can usually recognize these as *artifacts*. Near-field clutter *artifacts* are unaffected by the adjacent LV regional wall motion, and they often are seen to pass through the adjacent wall. The same rules do not apply to a real LV apical mass.

Near-field clutter *artifacts* were very common when fundamental frequency imaging was the default setting on the ultrasound system. With the development of multifrequency imaging transducers and our use of harmonic frequency imaging as the default, these *artifacts* are significantly less common. Although initially created as a means to digitally subtract the returning fundamental signals and selectively display the harmonic signals returning from oscillating microbubbles injected into the imaging field of view, there was an immediate recognition that the signal-to-noise ratio of the LV apex was also improved (as were the endocardial borders). This topic is reviewed in detail in a previous CASE by De Vos L *et al.*[3] These authors elegantly describe the various etiologies for near-field clutter, including the fact that step-ladder *artifacts* can be intentionally created in a normal LV apex by slightly altering the transducer angle and increasing the chest wall refractions and reverberations in the near-field resulting in this *artifact* (Figure 2). For other *artifacts*, there are many imaging characteristics that help distinguish between a real finding and noise or *artifact* (Table 2).

In this month's issue of CASE, we continue our Sonographer Challenge Part B with two *Reports That Highlight Sonographer*



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**Table 1** Types of Artifacts

| Common Artifact Name | Proximity to Object | Alignment to Object |
|---|---|---|
| Reverberation (parallel motion) | Distant | In line |
| Comet tail | Distant | In line |
| Mirror Image (opposite motion) | Distant | In line |
| Acoustic shadowing | Distant | In line |
| Beam Width | Same as object | Off line |
| Side Lobe (grating lobe) | Same as object | Off line |
| Refraction (lens) | Same as object | Off line |

*Authors.* The first report, Infective Endocarditis of the Autograft and the Neo-Aortic Root Following the Ross Operation, described the findings in a 10-year-old with infective endocarditis (IE) and periannular extension of infection in an autograft diagnosed 5 months after undergoing the Ross procedure for congenital aortic valve (AV) disease. The authors remind us that IE is not uncommon in congenital heart disease and a high index of suspicion should be maintained. In addition to their excellent echo images, these authors included outstanding computed tomographic (CT) images as well.

In our final Sonographer Challenge report, Isolated Occlusive Right Pulmonary Artery Thrombus Presenting as Respiratory Distress in a Premature Neonate, these authors described their findings on a premature neonate with acute respiratory distress found to have an occlusive pulmonary embolus with no identifiable risk factors. They included serial echo findings and corroborative CT imaging making this a phenomenal report with many excellent educational points.

Two reports come from outside the U.S. and demonstrate the global appeal of CASE. Nguyen HL *et al.* presented their findings to demonstrate the natural history of a young man with an untreated subarterial VSD and progression to a ruptured sinus of Valsalva aneurysm in Successful Treatment of Ruptured Sinus of Valsalva Aneurysm Associated With Subarterial Ventricular Septal Defect. They included excellent TTE images and correlative intraoperative findings to enhance your understanding of their findings.

In another international report within the category JUST ANOTHER DAY IN THE ECHO LAB, Kawabe *et al.* described how they used manipulation of the cardiopulmonary bypass circuit and emergent aortic cross-clamping when they discovered an LV thrombus that had dislodged and was freely mobile during intraoperative TEE. In Thrombus Migration Resulting From Cessation of Cardiopulmonary Bypass Flow in a Patient With Left Ventricular Thrombus, these authors provided readers with their clever approach to this clinical scenario. Although it was not a successful approach in this index patient who suffered an acute peripheral arterial occlusion, there was no neurologic event and an overall good clinical outcome. There are TTE, TEE, epicardial, CT, and peripheral angiographic images to inform readers.

As stated previously, CASE receives many submissions for CARDIAC TUMORS AND PSEUDOTUMORS. The editorial board must make their decision to accept or reject based upon not only the quality of the report, but also the incremental value compared to other publications, the correlative multimodal imaging, the associated surgical or pathologic findings, and the uniqueness of their mass relative to the current CASE archive log of images. This issue contains two reports that meet this standard and add significant value to Journal readers.

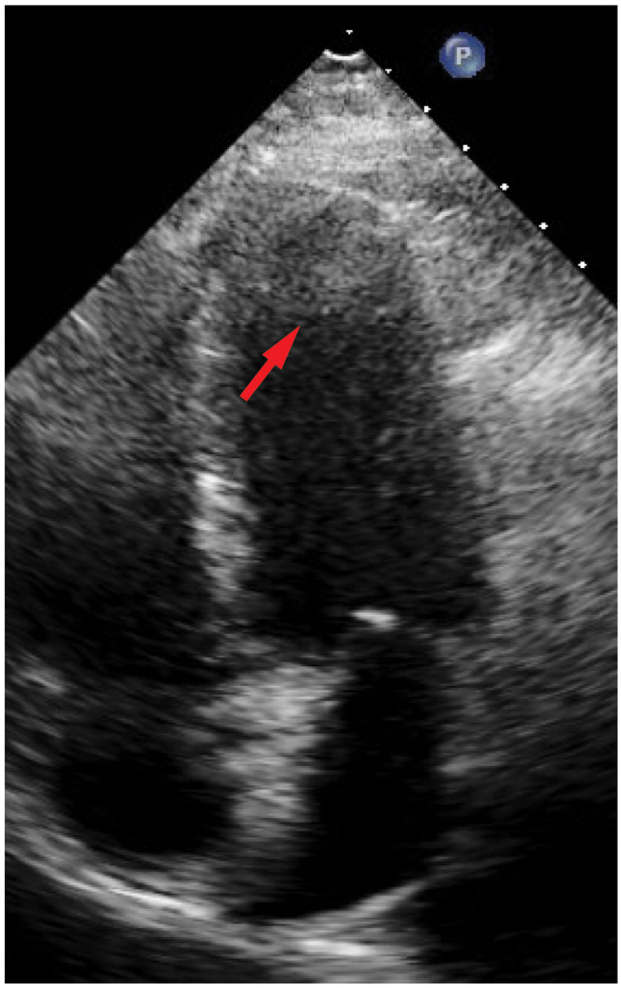


**Figure 1** 2D TTE, apical four-chamber view, demonstrates near-field noise (clutter *artifact*; arrow) which may be misinterpreted as an apical thrombus. Reprinted from Figure 7, J Am Soc Echocardiogr, 29(5):381-91, Bertrand PB, Levine RA, Isselbacher EM, Vandervoort PM, Fact or Artifact in Two-Dimensional Echocardiography: Avoiding Misdiagnosis and Missed Diagnosis, Copyright (2016), with permission from Elsevier.

In the first CASE, Vincent L *et al.* described a mass that would almost certainly not be accurately reported as a papillary fibroelastoma due to its location and size. In Ticking Time Bomb: Embolic Risks and Complex Management of an Exceptionally Large Papillary Fibroelastoma, these authors presented a middle-aged woman with heart failure and a mid-diastolic opening snap with a large, obstructing LA mass (nearly 6.0 cm). They included TTE with UEA, spectral and color flow Doppler, TEE, and gross histopathology. Given its phenotypical appearance of a myxoma, they included a table with their comparison of these two masses.

In the second CASE, Khaleel IM *et al.* nicely reported their findings on a patient with very rare, multiple tricuspid valve blood cysts using TTE, TEE, CT, and ICE. In Tricuspid Valve Blood Cysts on Intracardiac Echocardiography, these authors nicely demonstrated the potential limitations of TTE and even TEE, and the advantage of ICE and CT to more comprehensively visualize these cysts. In my many years of searching for blood cysts, be it in the CV images I interpret or the published reports I peruse, this report is now my favorite example. I'm

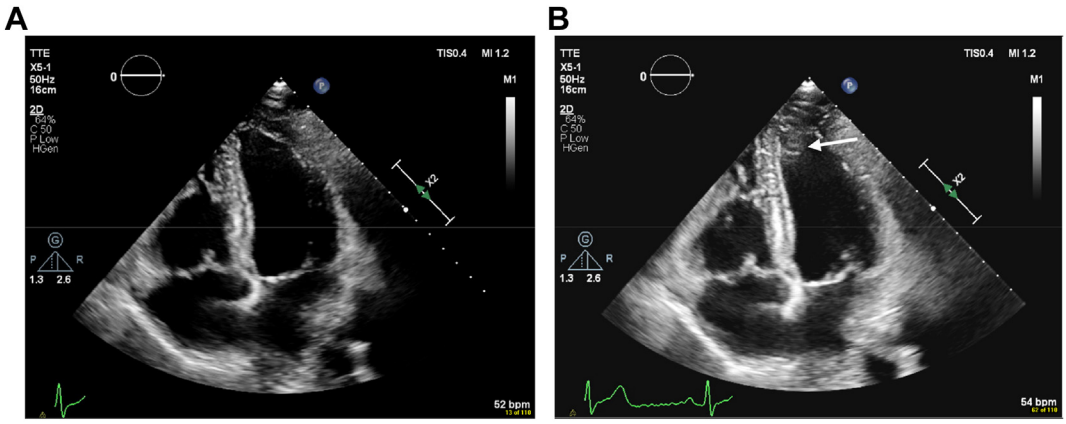


Figure 2 Example of how to create near-field clutter *artifact* by mild foreshortening angle transducer. 2D TTE, A4C systolic view in optimal probe alignment (**A**) and with slight tilting off-axis (**B**) demonstrates an excellent image without NFC and how the sonographer can create NFC with inattention and suboptimal probe alignment. Modified from Figure 3, De Vos L, De Herdt V, Timmermans F. Misdiagnosis or Missed Diagnosis: Digging Out the "Near-Field Clutter" Artifact in a Patient with Stroke. CASE (Phila). 2019 Dec 3;4(1):2-6. https://doi.org/10.1016/j.case.2019.10.007. Used under Creative Commons Attribution-NonCommercial-No Derivatives License (CC BY NC ND).

Table 2 Approach to Distinguishing a Real Finding from Noise

| Characteristics | Real | Noise |
|---|---|---|
| Appearance | Well-defined border or shape | Amorphous border or linear shape |
| Mobility | Restricted by anatomy | May cross anatomic borders |
| Mobility | Independently mobile | Parallel or mirror pattern |
| Imaging View | Seen in all projections | Disappears when projection changes |
| Ultrasound enhancing agent | Filling defect | No filling defect |
| Color flow Doppler | Flow altered by mass | Flow passes through mass |

proud that this will be available in our image archive for all CASE readers across the globe for the foreseeable future.

A humorous byproduct that I find whenever I focus my attention too much on *artifacts* is that I begin to see the noise on every echo, every view, every frame. It's a gentle reminder of just how gifted we are in our echo skills – we have the ability to overlook the noise and see the value beneath it. So, unlike the Kinks who "can't get away from the noise," we are conditioned to not hearing, nor seeing it.

Editor note: Here's an interesting fact. When you search *artifact* in the ASE Guidelines search engine, the following are the top 5 documents (in order): Thoracic Aorta Diseases in Adults; Ultrasound-Guided Vascular Cannulation; Multimodality Imaging of LVADs and TMCS; Comprehensive Pediatric TTE; and Evaluation of Prosthetic Valve Function.

However, when you search *artefact* in the ASE Guidelines search engine, the following are the top 5 documents (in order): Valvular Heart Disease: Echo in Transcatheter Interventions; Non-Invasive Imaging in Coronary Syndromes; Update of Aortic Valve Stenosis; Stress Echo in Non-Ischaemic Heart Disease; and 3D Echo in CHD.

Based upon that single-center experiment alone, I believe our ASE search engine algorithm must have some different value or meaning awarded for each word. I rest my CASE that these two words have become slightly different in their contemporary use despite an actual meaning that is the same. I, for one, am OK with that approach.

*And remember, every echo you see today has a teaching point; and every teaching point is a potential new CASE report!*

## REFERENCES

1. Bertrand PB, Levine RA, Isselbacher EM, Vandervoort PM. Fact or artifact in two-dimensional echocardiography: avoiding misdiagnosis and missed diagnosis. J Am Soc Echocardiogr 2016;29:381-91 (Note: this report includes numerous video examples of most types of echo artifacts).
2. Quien MM, Saric M. Ultrasound imaging artifacts: how to recognize them and how to avoid them. Echocardiography 2018;35:1388-401.
3. De Vos L, De Herdt V, Timmermans F. Misdiagnosis or missed diagnosis: digging out the "Near-Field Clutter" artifact in a patient with stroke. CASE (Phila) 2019;4:2-6.

## ADDITIONAL READING

1. Fatemi A, Berg EAR, Rodriguez-Molares A. Studying the origin of reverberation clutter in echocardiography: in vitro experiments and in vivo demonstrations. Ultrasound Med Biol 2019;45:1799-813 (Note: includes multiple video examples).
2. Sorrell VL. United States air defense system turns on tissue Doppler!. CASE (Phila) 2023;7:119-20 (Note: editorial provides readers with insights into publishing a CASE of a cardiac mass).