Misdiagnosis or Missed Diagnosis: Digging Out the ''Near-Field Clutter'' Artifact in a Patient with Stroke

Laurens De Vos, MD, Veerle De Herdt, MD, PhD, and Frank Timmermans, MD, PhD, *Gent, Belgium*

INTRODUCTION

Near-field clutter (NFC) or artifact is a frequently encountered ultrasound artifact, but scarce literature exists on the exact mechanism(s) governing this artifact. In particular, NFC can mimic a left ventricular (LV) thrombus, which may be a diagnostic challenge, especially when the clinical context of a thrombus is suggestive. Alternatively, NFC may also mask a true structure or even obscure a thrombus close to the echocardiographic transducer, such as may occur in the LV apex. We here present a patient with embolic stroke and NFC mimicking a thrombus in an akinetic LV apical aneurysm. In the Discussion section, we explain the potential mechanism(s) governing NFC and provide some strategies for differentiating NFC from a true LV thrombus or mass.

CASE PRESENTATION

A 85-year-old Caucasian man was hospitalized for ischemic stroke, and computed tomography of the brain revealed a zone of recent ischemia in the area of the left posterior cerebral artery. The cerebral infarct size and location were suggestive of an embolic source. Conservative medical treatment with antiplatelet therapy was initiated, as he did not meet the criteria for thrombolysis or thrombectomy. The patient had a history of myocardial infarction and coronary artery bypass graft surgery.

As part of the diagnostic workup for patients with stroke at our institution, the patient was referred for an echocardiographic examination to screen for potential cardiac embolic sources. Transthoracic echocardiography (Epiq 7 with X5-1 matrix probe; Philips Medical Systems, Andover, MA) in apical views revealed a remarkable but poorly defined mass in the akinetic apex of the left ventricle (Figures 1A and 1B, Videos 1 and 2). Further analysis showed no clear spontaneous contrast in the LV apex. Color Doppler imaging could not detect blood flow passing over or through the mass, even at low pulse repetition frequency (the lowest kilohertz scale possible; Figure 1C, Video 3). Given the context of an ischemic embolic stroke and apical akinesia, the LV apical mass was suggestive of an intraventricular thrombus.

However, when repositioning the transthoracic probe to a more apicolateral position, the apparent mass co-translocated along with the incident ultrasound beam towards the apicolateral region, whereas the apical "mass" could not be observed anymore (Figure 1D, Video 4). Ultrasound contrast (SonoVue; Bracco, Milan, Italy) transthoracic echocardiography clearly showed the absence of an apical mass or thrombus (Figure 1E, Video 5). Finally, transesophageal echocardiography confirmed the absence of a mass in the left ventricle (Figure 1F). Therefore, the apparent mass was identified as an ultrasound artifact. Eventually, the patient was treated with dual antiplatelet therapy, as no clear indication for anticoagulative therapy remained after complete workup.

DISCUSSION

The poorly defined LV apical mass in our patient was caused by an ultrasound artifact, which may create a diagnostic challenge in the context of an embolic stroke in a patient with apical akinesia. The most common image artifacts encountered in clinical practice are due to the physics of reflection and refraction of ultrasound waves when they interact with tissues, or to ultrasound beam properties and machine settings. Although tissue-harmonic imaging (THI)[1] and improved probe design over the past decades have significantly reduced ultrasound artifacts, they nevertheless remain an important issue in daily clinical practice and may lead to misdiagnosis or missed diagnosis.[2,3]

The near-field artifact in our patient has been designated in the past as NFC, and this may be particularly challenging, as it may mimic a thrombus.[4] Misdiagnosis may expose the patient to the unnecessary bleeding risk of anticoagulative therapy. Alternatively, NFC may even obscure a true thrombus or other structures present in the transducer near field, such as in the LV apex when transthoracic apical windows are used. From a clinical point of view, this was especially the case in our patient because he presented with embolic stroke and an akinetic LV apex region.

Mechanism of NFC

In the literature, the mechanism underlying NFC has been explained or attributed to "the high amplitude oscillations of the piezo-electrical elements of the transducer itself."[2,4,5] This in fact refers to the "ringing" phenomenon of the transducers' piezoelectric elements that are not well or timely dampened. This creates a longer pulse length and reduced axial resolution,[6] resulting in a cloudy or hazy artifact beneath the probe in the near field. However, this problem

From the Department of Cardiology, Heart Center (L.D.V., F.T.), and the Department of Neurology, Stroke Unit (V.D.H.), University Hospital Gent, Ghent, Belgium.

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VIDEO HIGHLIGHTS

Video 1: Apical four-chamber view shows a remarkable but poorly defined mass in the akinetic apex of the left ventricle.
Video 2: Apical two-chamber view shows a remarkable but poorly defined mass in the akinetic apex of the left ventricle.
Video 3: Apical four-chamber view with color Doppler imaging could not detect blood flow passing over or through the "mass," even at low pulse repetition frequency (Nyquist limit 19.3 cm/sec).
Video 4: Modified apical four-chamber view. When repositioning the transthoracic probe to a more apicolateral position, the apparent mass cotranslocates along with the incident ultrasound beam toward the apicolateral region.
Video 5: Apical four-chamber view with ultrasound contrast (SonoVue). There is complete opacification of the apex, thereby excluding an intra-apical thrombus.
Video 6: Modified apical four-chamber view of a healthy individual. When slightly tilting the probe in the intercostal space, a hazy NFC appears in the apex.
Video 7: Apical four-chamber view of a healthy individual.
Video 8: Short-axis view of the LV apex.
Video 9: Apical three-dimensional view. Three-dimensional imaging does not solve the NFC, because the ultrasound beam still interacts with the same reverberation-causing reflectors in the chest wall.

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is significantly resolved using modern ultrasound transducers because of improved dampening, and with current echocardiographic probes, this will create NFC only in the very first millimeters, which is therefore unapparent.

How then can we explain the NFC observed in our patient? On transthoracic echocardiography, such as occurred in our patient, NFC appears as a stationary (i.e., it does not move relative to the probe) haze with often indistinct borders, and it may cross the myocardial wall underneath the probe (i.e., it crosses the anatomic borders). Recently, ultrasound investigators from Trondheim proposed some scenarios that result in different types of clutter noise.[7] All scenarios were elegantly shown to result from reverberations because of reflective structures within the chest wall and/or the nearby thoracic cavity, such as (part) of the lung. Reverberations are created when ultrasound is reflected, causing a large number of reflections to build up and then decay as the ultrasound is absorbed by the surfaces of objects in the space[2] (Figure 2A). The NFC in our case may have been caused by reverberations that originated from the underlying chest wall structures, because the NFC remained stationary despite forced respiration. The mechanism of stationary NFC is schematically shown in Figure 2B. As can be appreciated, because of the random presence of multiple reflectors in the near field of the probe, including the scarred myocardial apex of our patient, multiple pathways between the reflectors and the probe generate a stepladder reverberation, which in fact is similar to the well-known comet-tail and ring-down ultrasound artifacts.[3] Finally, the clutter in our patient is not generated by reverberations caused by interfering lung tissue, as this type of reverberation artifact fluctuates or displaces upon (forced) respiration,[7] which was not the case in our patient.

Why Might NFC Appear Despite the Use of THI?

NFC is expected to be much less frequent during THI compared with fundamental ultrasound imaging. This is because tissue-harmonic frequencies are mostly created beyond the near field, and thus near-field interactions with the lower emitted frequencies will be filtered out and do not contribute to the two-dimensional image.[1] As proposed by Fatemi *et al.*,[7] the occurrence of NFC may be related or exaggerated by the interposition of much more random reflectors in the chest wall, as can be encountered in obese individuals with thicker chest walls. A thicker chest wall theoretically implicates a longer ultrasound beam path and thus a higher likelihood of generating reverberations and generating tissue harmonics.[1,7] Importantly, an alternative or additional explanation for the stationary NFC in our patient is also provided by Fatemi *et al.* They demonstrated that NFC can also be caused by reverberations that originate from subcutaneous fat or tissue distant from the expected incident beam (i.e., via refraction), where ultrasound waves are first deflected from their original path. These refractions occur where the ultrasound waves hit a rib at a certain angle (Figure 2C). Because of the longer beam path in this scenario, harmonics may be created and eventually appear in the image as NFC. However, in this scenario, the clutter may be stationary as long as the rib does not move excessively with respiration, as the correct angle to the rib is critical for reflection of the ultrasound beam.[7] Interestingly, we were able to generate such a mechanism of NFC in a healthy individual, as shown in Figure 3 and Video 6. Only when slightly tilting the probe in the intercostal space, a hazy NFC appeared in the apex, whereas it no longer appeared when keeping the probe more perpendicular and carefully between the ribs (Video 7).

How can We Assess the Likelihood or Exclude a NFC?

1. First, ascertain that the THI function is turned on; THI is usually a default setting in modern echocardiographic machines.
2. The typical NFC as presented here is stationary (i.e., it does not move during [forced] respiration or cardiac movement). In contrast, changing the probe position relative to the apex (i.e., changing the imaging window off axis, for example, to a short-axis view of the apex; Video 8) will lead to the disappearance of the clutter and the possible appearance of the NFC beneath the repositioned probe. However, ensure that the probe is repositioned within the same longitudinal or transverse plane to judge the original location of the probable artifact. This is important because the NFC may indeed obscure a true underlying thrombus (e.g., in the LV apex).
3. As explained above, gently tilting the probe without repositioning may avoid refraction due to rib interference and therefore make the NFC disappear.
4. Applying color Doppler may be helpful; however, as was the case in our patient, color Doppler mapping did not "cross" the artifactual structure, probably because of very low velocities in the akinetic apex, despite the lowest

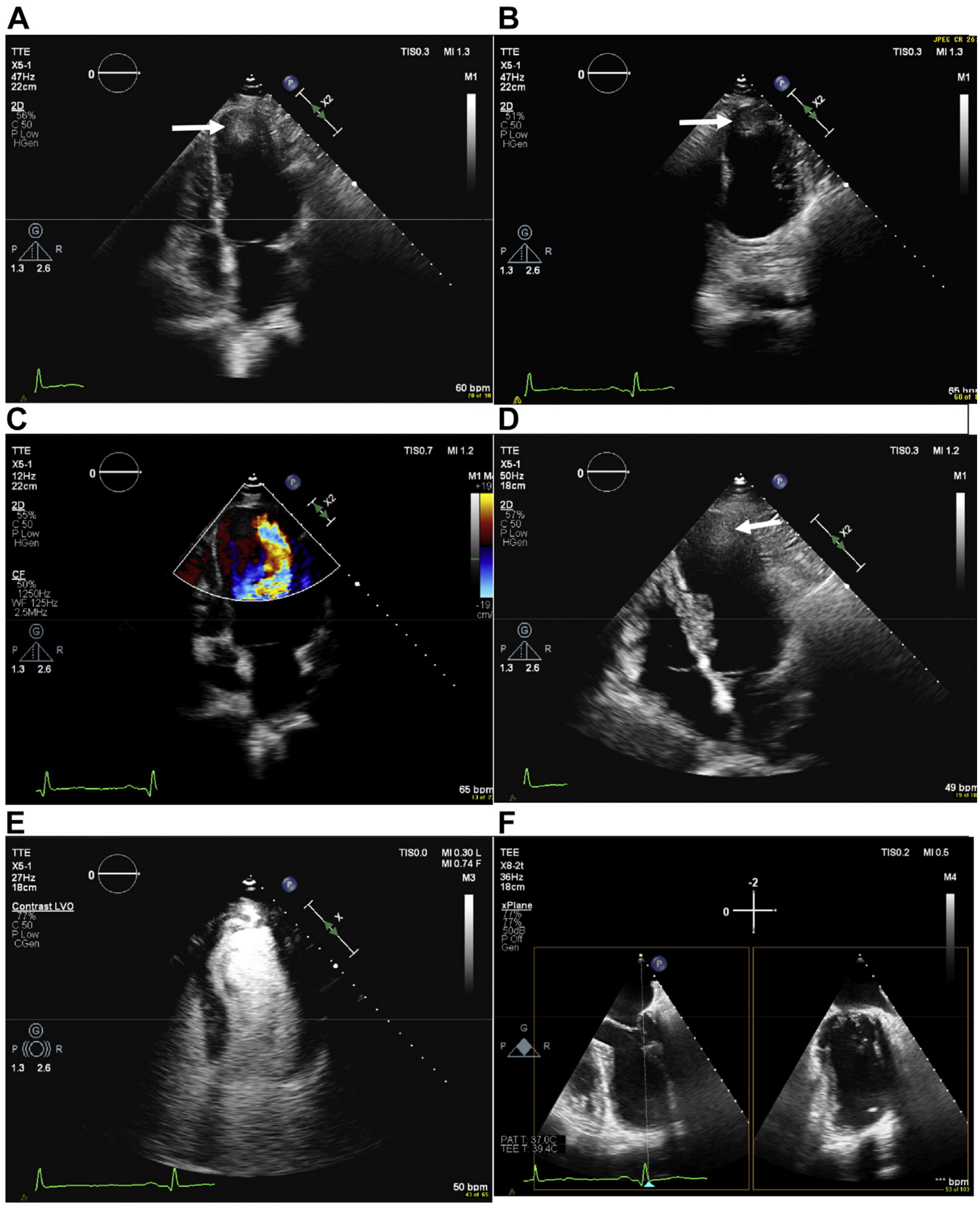

Figure 1 **(A, B)** Apical biplane four- and two-chamber views show a remarkable but poorly defined mass in the akinetic apex of the left ventricle (*arrow*). **(C)** Color Doppler imaging could not detect blood flow passing over or through the "mass," even at low pulse repetition frequency (Nyquist limit 19.3 cm/sec). **(D)** When repositioning the transthoracic probe to a more apicolateral position, the apparent mass co-translocates along with the incident ultrasound beam towards the apicolateral region (*arrow*). The original apical "mass" cannot be observed anymore. **(E)** Apical four-chamber view with ultrasound contrast (SonoVue). There is complete opacification of the apex, thereby excluding an intra-apical thrombus. **(F)** Biplane midesophageal four- and two-chamber views show absence of an apical mass.

pulse repetition frequency possible. Although vendors do not specify the minimal velocity that can be detected with color Doppler, this is typically about 10% of the full Nyquist velocity.[8]

5. Because the reverberation-causing reflectors are within the intervening chest wall, it can often be observed that the hazy NFC travels across the myocardial wall, and it therefore does not respect the anatomic borders, which is mostly consistent with an artifact.
6. Apical three-dimensional imaging does not solve NFC, as the ultrasound beam still interacts with the same reverberation-causing reflectors in the chest wall (Video 9); this also applies for biplane imaging.
7. As shown in our patient, an echocardiographic contrast agent (SonoVue) can be used to exclude a true thrombus, especially when NFC is suspected to obscure a true underlying thrombus.[9] Alternative imaging modalities such as cardiac magnetic resonance imaging or computed tomography can be considered if doubts remain.
8. Finally, reducing the transmission power may seem helpful, but this will only reduce the relative intensity of the overall pixels in the image, and it will

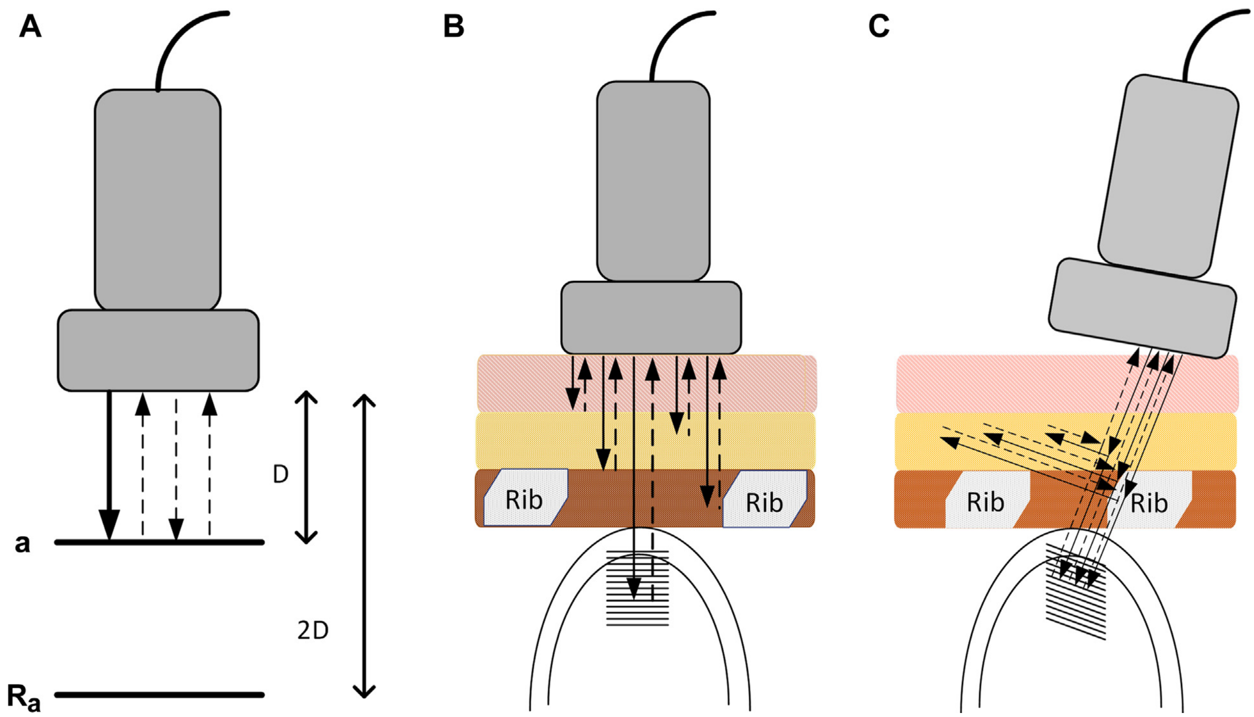

Figure 2 **(A)** Mechanism of reverberation artifact. Ultrasound waves are reflected multiple times between a single reflector (a) in the scan field and the probe, which results in its projection (Ra) more distant than its original position. This is because reverberation lengthens the travel time before the transducer is finally reached, which results in a more distant projection compared with the original position of the reflector in the scan field (a longer travel path, in the example two times the path length). **(B)** Stepladder reverberation artifact caused by chest wall structures resulting in NFC. The same principle as in **(A)** applies, but here a high burden of ultrasound reflection occurs on the abundant reflectors in the chest wall, creating the distant projection of closely packed stepladder reverberations (shown as multiple lines). This results in a projection of the reverberation thrombus-like artifact into the LV apex beneath the probe (near-field artifact), as occurred in our patient. **(C)** Combination of refraction and reverberation. An ultrasound wave refracts on a strong reflector (e.g., rib) and reverberates on the heterogeneous tissue interfaces as in **(B)**, creating multiple path lengths and thus echo travel times. The heterogeneous and longer travel times are then translated and projected as an oblique stepladder reverberation into the nearby LV apex similar to **(B)**, mimicking a thrombus or masking underlying structures. Obviously, for reverberation to occur with the chest reflectors, the angle between the incident ultrasound beam and the rib is important.

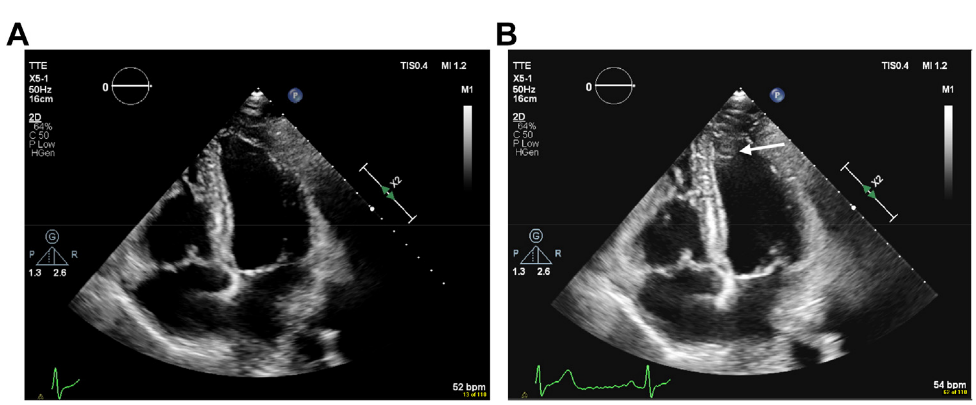

Figure 3 Generation of NFC in a healthy individual. In panel **A**, a standard apical four-chamber view is shown with clear visualization of the LV apical region without any artifact. When slightly tilting the probe in the intercostal space, a hazy NFC appears (*white arrow* in panel **B**).

therefore not selectively remove the NFC. On the contrary, this strategy may even obscure a true, low echogenic thrombus in the near field. Therefore this strategy is not recommend.

CONCLUSION

We present a case of near-field artifact mimicking an LV intraventricular thrombus in a patient with a high likelihood of an apical thrombus. We aim to provide some insights into the underlying mechanisms of NFC and conclude with some hints to differentiate between NFC and true thrombus.

SUPPLEMENTARY DATA

Supplementary data related to this article can be found at https://doi.org/10.1016/j.case.2019.10.007.

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