Trends in Emergency Aortic Imaging

Determining optimal imaging techniques for each patient.

BY PERRY CHOI, MD, AND HAMID MOJIBIAN, MD

Computed tomography (CT) and magnetic resonance imaging (MRI) play vital roles in both the diagnosis and management of patients with aortic emergencies. Due to its wide availability and limited contraindications, helical CT is considered the fastest and the standard method of imaging for acute aortic pathologies such as traumatic injuries, acute aortic syndromes, and aortic aneurysms. The imaging features of these conditions have been well described in the literature.[1-3] For patients who are unstable, such as those with traumatic injury or clinical concern for ruptured aneurysm, non–electrocardiography (ECG)-gated helical multidetector (MD) CT with contrast is often ordered. Given the accessibility, speed, and ease of patient monitoring, this is a favorable option. However, the one big disadvantage of non–ECG-gated CT study is the lack of dynamic evaluation of a very dynamic and mobile structure. The most obvious consequence of this problem is motion artifact, especially at the root and ascending aorta, which can lead to a misdiagnosis of aortic dissections or other pathologies in a significant number of patients (Figures 1 and 2).[4]

A less-recognized aspect of the dynamic nature of the aorta is the change in size and shape during the cardiac cycle and in different hemodynamic statuses. As shown in several recent publications, the aortic diameter can vary up to 15% during diastole and systole.[5] Aortic size also changes in patients with hemodynamic instability, as shown in both human and animal studies.[6,7] The aortic branches also move significantly during the cardiac cycle.[8] None of these variables can be evaluated with a non–ECG-gated CT

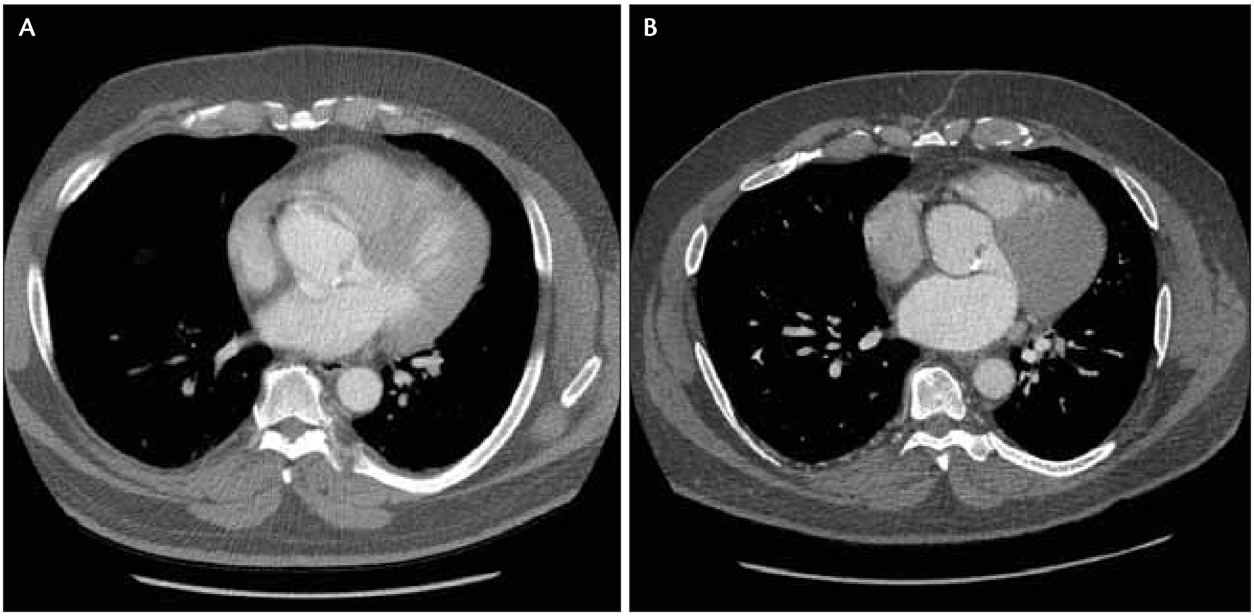

Figure 1. Non–ECG-gated MDCT in a trauma patient with chest pain. Given the motion around the aortic root and ascending aorta, a Stanford type A aortic dissection cannot be excluded (A). ECG-gated MDCT reveals no signs of aortic dissection. The aortic valve calcification is also better shown (B).

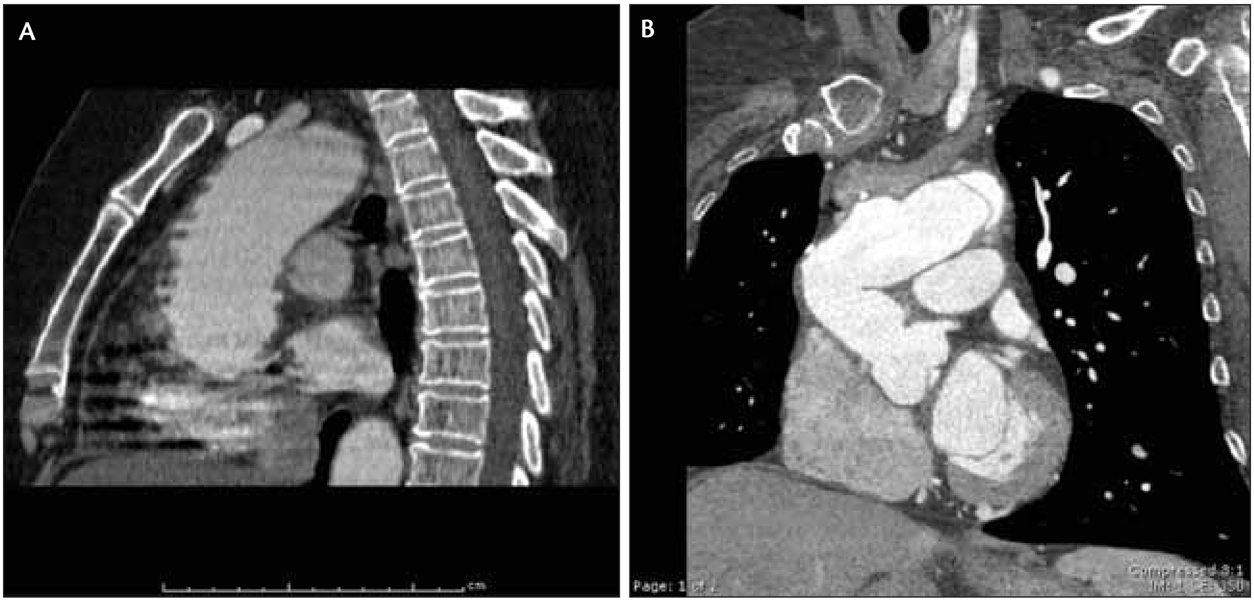

Figure 2. Non–ECG-gated MDCT shows irregularities of the ascending aorta that may simulate ulcerated atherosclerotic plaque or penetrating atherosclerotic ulcers (A). This patient had a follow-up examination due to her type B aortic dissection. At this point in time, an ECG-gated study was performed and shows normal contour to the ascending aorta (B).

Figure 3. This patient had an ECG-gated CT angiogram to specifically evaluate his aorta. With ECG triggering, the coronary arteries can be well evaluated despite receiving no special preparations such as beta-blockers or nitroglycerine. In this patient, there were several calcified plaques along the right coronary artery with up to 50% stenosis involving the proximal lesion. With gated techniques for the aorta, aortic and coronary artery disease can be evaluated at the same setting.

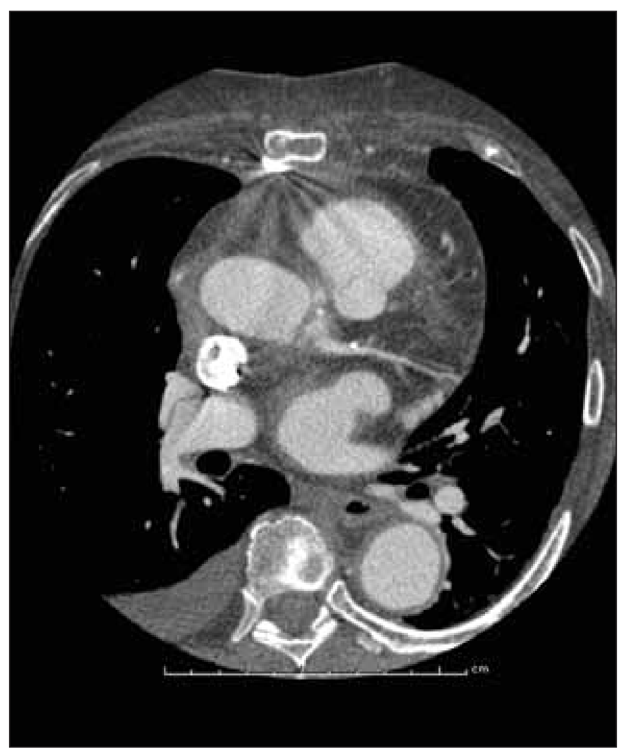

Figure 4. This patient had an ECG-gated examination to evaluate his aorta. There are relatively motion-free images of the left circumflex artery with a small focal calcified plaque causing approximately 50% stenosis in the proximal segment.

angiography (CTA) or magnetic resonance angiography (MRA) examination. During the past few years, the number, extent, and complexity of percutaneous aortic interventions have exponentially increased; not considering the variables of device designs and a lack of planning for many of these interventions may result in poor outcomes or complications.

To reduce motion artifact from cardiac pulsations, ECG gating was introduced. With retrospective ECG-gated studies of the aorta, the patient is scanned helically with a low pitch while continuous ECG recording is performed.[9] After the scan, the data can be reconstructed during a specific phase of the cardiac cycle, or the entire cardiac cycle can be used for a comprehensive dynamic evaluation. In many instances, the coronary arteries and cardiac function can also be evaluated at the same time, eliminating the need for further invasive cardiac studies.[10] In one study in which patients had a heart rate of < 75 bpm, 98% of the coronary artery segments were well visualized for assessment when imaging was performed for the aorta.[11] Coronary artery occlusion from dissection flaps, coronary artery disease, aberrant coronary artery origin, and other pathologies can be more accurately evaluated with ECG-gated studies dedicated to the aorta (Figures 3 through 5). The main disadvantage of retrospectively gated studies is the high radiation dose to the patient, because a low pitch value is used. The radiation dose is particularly high when the chest, abdomen, and pelvis are included in the scan. The radiation dose may reach 40 mSv, which is almost equivalent to 3,000 chest radiographs.

REDUCING EXPOSURE

One solution would be to image the chest portion with retrospective gating and the abdomen/pelvis portion with the nongated technique. This would help minimize the radiation dose (Figure 6). The recent introduction of prospectively ECG-triggered CT scanning provides a low-radiation method for aortic evaluation. With the prospective technique, the CT tube current is turned on for a short time during a defined range of the R-R interval, often centered in the mid-to-late diastolic phase, during which heart motion is minimized. Based on the average length of previous R-R intervals, the scan is triggered after an R wave. Studies have shown a significant reduction in radiation dose when prospective ECG triggering is used compared with retrospective gating. In one study, the average radiation from

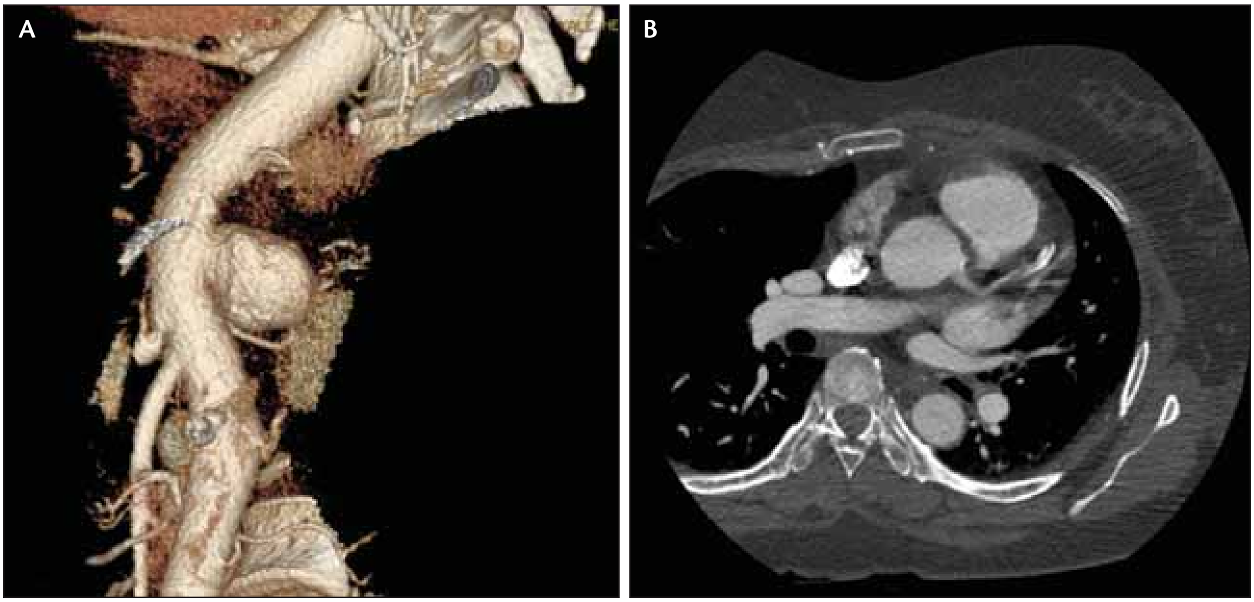

Figure 5. This patient had an ECG-gated examination of the aorta. She had a moderate-sized saccular pseudoaneurysm of the abdominal aorta due to tuberculosis (A). With ECG-gated techniques for the aorta, improved evaluation of the coronary arteries is possible with relatively motion-free images compared to nongated techniques. In this patient, we can see that there are nonobstructive calcified plaques in the left anterior descending artery (B).

prospective scanning was 14 mSv compared with 43 mSv with retrospective gating.[12] At Yale-New Haven Hospital, we have been able to optimize our studies to yield a high diagnostic accuracy with radiation dose in the range of 3 to 6 mSv in the average-sized patient. This method works best for patients with normal rhythms. The disadvantage of this prospective technique occurs in patients with irregular heart rates. This variability of the R-R interval makes prediction of the next R-R interval length difficult and can lead to scanning during systole when there is relatively more motion and a resultant decrease in image quality. Another disadvantage is that only a limited number of phases of the cardiac cycle can be reconstructed, and dynamic evaluation of the aorta during the entire cardiac cycle is not possible.

MR VERSUS CT

In stable patients, MRI offers several advantages over CT. The main advantage is the lack of ionizing radiation with similar accuracy to CT.[13] Also, for patients allergic to iodinated contrast, gadolinium-based contrast agents used for MRA are a viable alternative. Many protocols and techniques are also available for MRI.[14] ECG gating is recommended in all patients undergoing MRI, as this produces relatively motion-free images. Studies examining the optimal sequences for MRI of the aorta suggest that a combination of imaging techniques is required to most accurately characterize the range of aortic pathologies. For example, one study compared the diagnostic yield of cine steady-state free precession (SSFP), two-dimensional double inversion-recovery fast spin-echo (IR-FSE), and contrast-enhanced MRA in the diagnosis of aortic pathologies.[15] Emergent conditions were found to occur equally among the three indi-

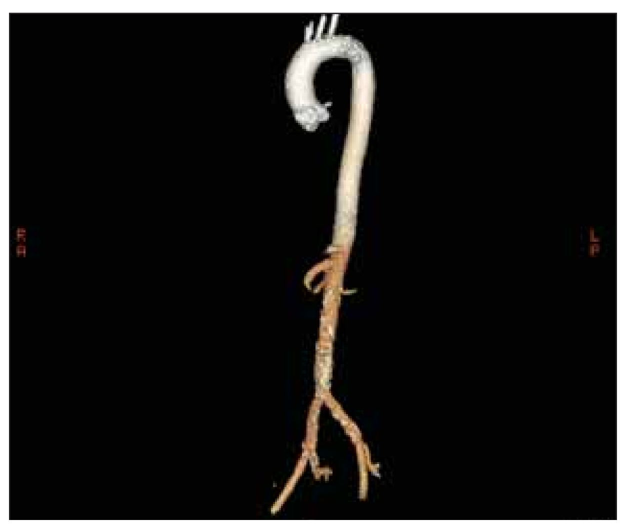

Figure 6. A hybrid technique was used to evaluate this patient's aorta. The thoracic portion of the examination was performed with retrospective ECG gating, and the abdomen portion was nongated. Because cardiac motion affects the diagnostic accuracy of the abdominal aorta, gating can be turned off to save radiation dose if a retrospective gating approach is required for dynamic evaluation of the thoracic aorta.

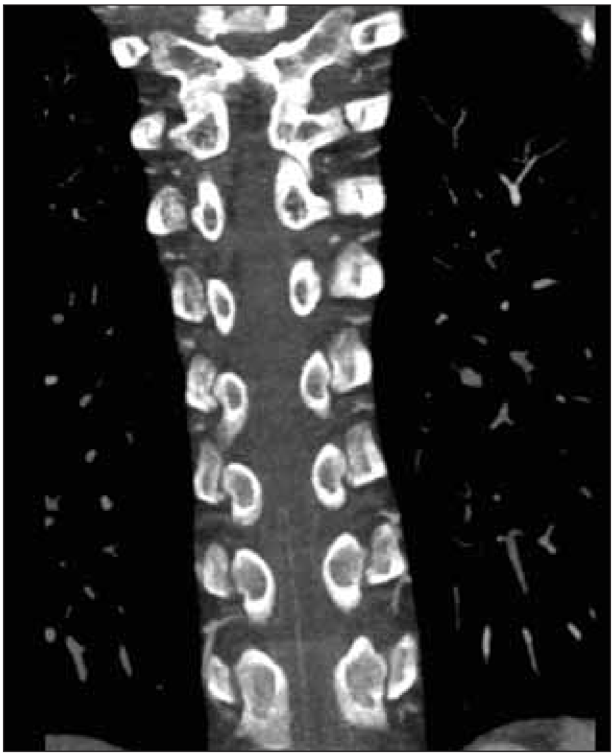

Figure 7. The artery of Adamkiewicz with the characteristic hairpin turn is being supplied from the right side. In patients with abdominal aneurysms, identification of this artery is very useful for preoperative planning for many surgeons.

vidual techniques, but the investigators concluded that a combination of the techniques provided the best overall diagnosis accuracy. There is some institutional variability in the MRI protocol, but most include both pre- and postcontrast images. At Yale, we routinely use both black-blood and white-blood imaging. Additionally, cine- balanced SSFP or gradient-recalled echo images are also important, along with gadolinium-enhanced MRA.

For patients with poor renal function, there is concern for iodinated contrast-induced nephrotoxicity with CT and gadolinium-associated nephrogenic systemic sclerosis with MRI. In these patients, noncontrast MR techniques such as cine SSFP and double IR-FSE can play an important role. Many noncontrast MRA techniques are also available. Studies have confirmed that noncontrast MRI demonstrates similar efficacy in diagnosis of most aortic emergencies including aortic dissection.[16]

Regardless of technique, CTA or MRA of the aorta can provide additional information that is invaluable for patient management. In patients with aortic aneurysms, identification of the artery of Adamkiewicz can be important for preoperative management. CTA and MRA can identify this artery in a majority of patients.[17]

CONCLUSION

The optimal imaging technique depends on the pathology in question and stability of the patient. In stable patients, ECG-gated MRI provides an accurate dynamic assessment of the aorta with no radiation. If CT is used, prospective ECG gating should be used in most instances given a reduction in radiation dose and improved diagnostic ability of adjacent structures, such as the coronary arteries. In the near future, ECG-gated techniques for the aorta will become the standard of care. ■

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