Position of Subcutaneous Implantable Cardioverter-Defibrillators

and Possible Interference on Myocardial Perfusion Imaging

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Implanted cardioverter-defibrillators can prevent sudden cardiac death in at-risk patients. In comparison with conventional transvenous systems, entirely subcutaneous implantable cardioverter-defibrillators have produced similar reductions in the rate of sudden cardiac death but with fewer sequelae. An infrequently reported drawback of subcutaneous devices, however, is the potential for generating attenuation artifact during nuclear myocardial perfusion imaging. We had concerns about potential attenuation artifact in a 65-year-old man with coronary artery disease but found that having positioned the pulse generator in the midaxillary zone avoided problems. ***(Tex Heart Inst J 2017;44(3):223-5)***

Key words: *Arrhythmias, cardiac/therapy; artifacts; coronary artery disease/diagnostic imaging; death, sudden, cardiac/prevention & control; defibrillators, implantable; equipment safety; myocardial perfusion imaging/methods*

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Patients at risk of sudden cardiac death can benefit greatly from implantable cardioverter-defibrillators (ICDs) as primary or secondary preventive measures. Sequelae of conventional transvenous ICDs include pneumothorax, hematoma, lead dislodgment, and infection.[1,2] These problems contribute to patient morbidity and have prompted the use of a safer preventive device: the entirely subcutaneous implantable cardioverter-defibrillator (S-ICD). Data from the Investigational Device Exemption trial and the EFFORTLESS registry indicate fewer sequelae from S-ICDs than from conventional ICDs.[3] Ideal candidates for the S-ICD are typically younger patients who have had a prior device infection and patients in whom venous access is limited.

The chief disadvantages of the S-ICD are its inabilities to provide bradycardia support, antitachycardia pacing, and resynchronization therapy. A more subtle shortcoming has become apparent in S-ICD recipients who have concomitant coronary artery disease (CAD) and periodically need evaluation of symptomatic ischemia. Artifact burden can produce false-positive results during nuclear myocardial perfusion stress imaging, which appeared to be a concern in one of our patients.

Case Report

Our patient was a 65-year-old man with a history of CAD, quadruple coronary artery bypass grafting, percutaneous coronary intervention to the left main coronary artery (LMCA), type 2 diabetes mellitus, atrial fibrillation, transient ischemic attack, congestive heart failure (left ventricular ejection fraction, 0.25–0.30), hypertension, end-stage renal disease, and ventricular fibrillation arrest. In May 2015, after his ventricular fibrillation arrest, he underwent planned S-ICD placement with no procedural sequelae. However, during recovery, he had ongoing exertional dyspnea and several days of orthopnea. Physical examination results, laboratory findings, and imaging data were consistent with acute decompensated heart failure. He was placed on an intravenous diuretic regimen.

The patient reported intermittent chest pain at rest. His cardiac troponin level was not elevated, and his electrocardiogram was unchanged from prior tracings; however, given his history of significant CAD and worsening heart failure, we ordered a nuclear myocardial perfusion stress test. The results—all new when compared with those of a test 2 years earlier—included a large fixed perfusion abnormality involving the apical, distal anterior, distal lateral, distal inferior, and distal septal walls; reversible ischemic areas included the midanterior wall and mid/basal inferior wall. The abnormality extended into the basal inferolateral wall. Of note, our patient's coronary artery bypass grafting had been completed years before either stress test. Procedures that had been performed between the 2 stress tests included percutaneous intervention to the LMCA, resuscitation from the ventricular fibrillation arrest, and, most recently, the S-ICD placement.

Revascularization and cardiogenic arrest can jeopardize myocardium and cause scarring that could appear to be a fixed perfusion defect. Any of the foregoing procedures could have caused the perfusion defect. Alternatively, placement of the S-ICD's pulse generator in a suboptimal position might have caused attenuation artifact that could be mistakenly interpreted as new ischemic burden.

To resolve these concerns, we scheduled the patient for left-sided heart catheterization. The angiogram revealed severe native 3-vessel disease, 2 patent venous grafts to the obtuse marginal branches, a patent graft from the left internal mammary artery to the left anterior descending coronary artery, and a patent stent in the LMCA. The patient had a known occluded venous graft to the right posterior descending coronary artery. During the catheterization procedure, we placed a drug-eluting stent in an 85% stenotic lesion in the mid left circumflex coronary artery. The distribution of CAD was consistent with what the nuclear myocardial perfusion stress test had revealed and was thus unlikely to have been attenuation artifact from the S-ICD. We concluded that the S-ICD was positioned optimally, as shown in the patient's computed tomographic (CT) fusion scan (Fig. 1).

Discussion

This case exemplifies an important technical aspect of implanting an S-ICD—not obscuring the heart-wall borders. In brief, an S-ICD's pulse generator is typically implanted in the left lateral position, between the anterior and midaxillary lines near the apex of the left ventricle.[4] Positioning the generator too anteriorly can result in a photopenic attenuation artifact during myocardial perfusion imaging, as described by Katz and colleagues.[5] Figure 2 shows a chest radiograph (lateral view) from a patient whose S-ICD was implanted too far anteriorly, so that it obscures the inferolateral wall. In contrast, Figure 3 shows a pulse generator positioned more centrally along the midaxillary line, which minimizes the

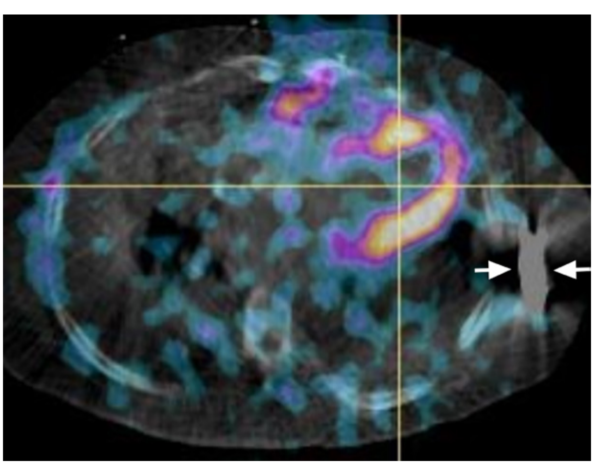

Fig. 1 *Computed tomographic fusion image shows our patient's pulse generator along the midaxillary line (arrows). Most of the myocardium is spared from potential attenuation artifact.*

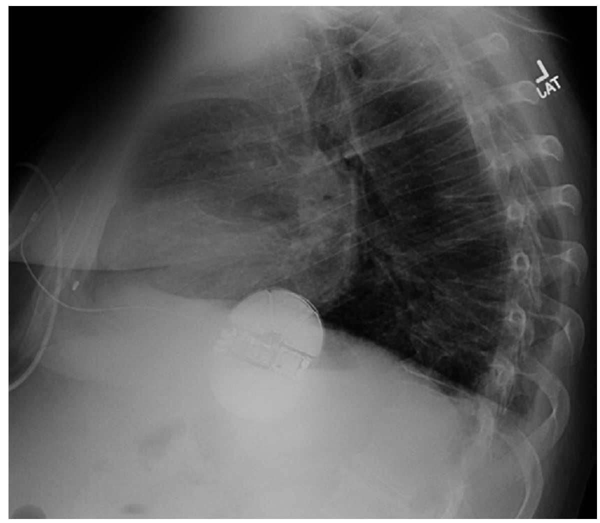

Fig. 2 *Illustrative chest radiograph (lateral view) in a different patient shows a pulse generator implanted too far anteriorly, so that it obscures the inferolateral wall.*

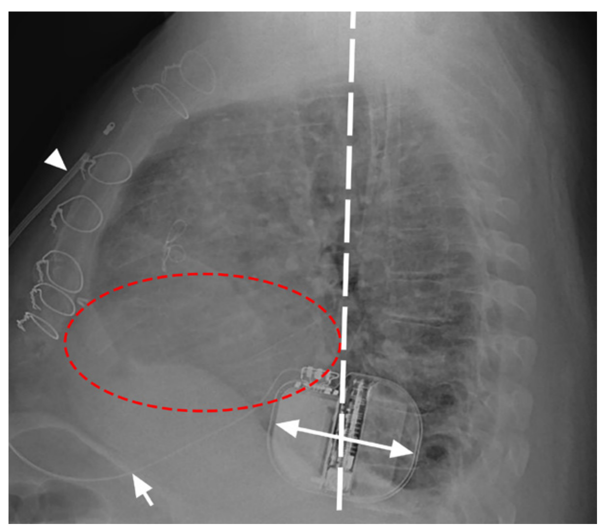

Fig. 3 *Illustrative chest radiograph (lateral view) in a third patient shows optimal positioning of the pulse generator, with the heart borders minimally obscured. Shown are the cardiac silhouette (oval), midaxillary borderline (dashed line), subcutaneous implantable cardioverter-defibrillator lead (arrow), and shock coil (arrowhead). The double arrow spans the length of the pulse generator and its center intersects the midaxillary line.*

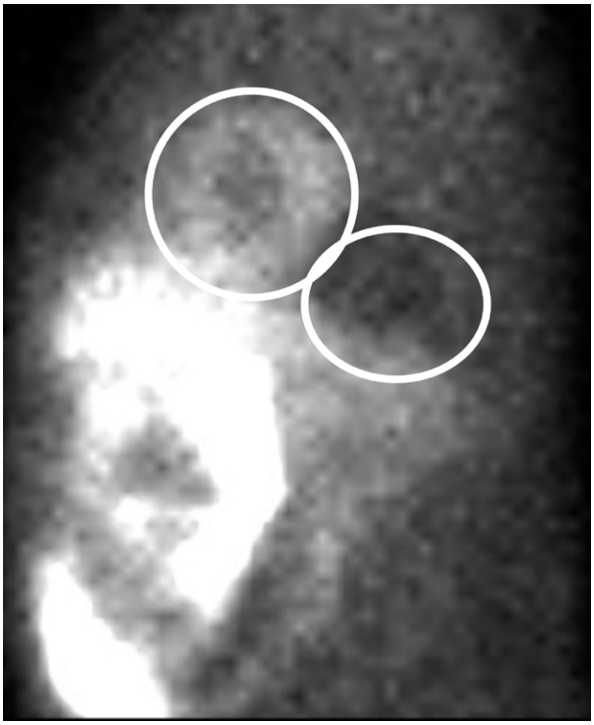

Fig. 4 *Raw computed tomogram in our patient (79° left anterior oblique projection) shows the myocardial borders (large circle) and the external dimensions of the pulse generator (small circle).*

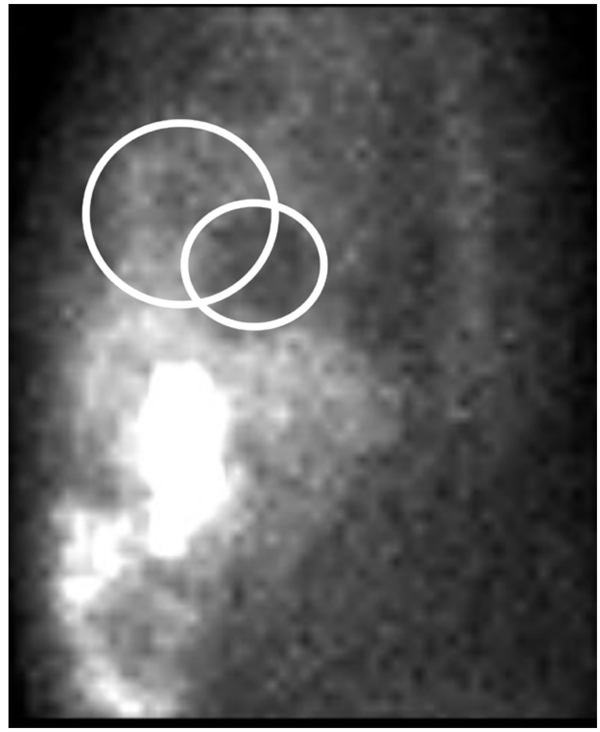

Fig. 5 *Raw computed tomogram in our patient (82° left anterior oblique projection) clearly shows the eclipse of the posterolateral wall, along with the myocardial borders (large circle) and the external dimensions of the pulse generator (small circle).*

risk of attenuation artifact during subsequent nuclear myocardial perfusion imaging.

Figure 1 clearly shows our patient's generator along the midaxillary line, with most of the myocardium spared from potential attenuation artifact. The only introduction of attenuation artifact in our patient might occur during imaging beyond 81° in the left anterior oblique (LAO) projection. Figure 4 shows our patient's raw CT image at 79° degrees in the LAO projection, whereas Figure 5, at 82°, clearly shows the eclipse of the posterolateral wall. Overall photon counts were low along the posterolateral wall distribution; accordingly, no meaningful diagnostic information—or attenuation artifact—could have been generated. Our experience emphasizes the need for optimal placement of SICDs in patients who might need future nuclear myocardial perfusion imaging.

References

1. Weiss R, Knight BP, Gold MR, Leon AR, Herre JM, Hood M, et al. Safety and efficacy of a totally subcutaneous implantable-cardioverter defibrillator. Circulation 2013;128(9):944-53.
2. Ezzat VA, Lee V, Ahsan S, Chow AW, Segal O, Rowland E, et al. A systematic review of ICD complications in randomised controlled trials versus registries: is our 'real-world' data an underestimation? Open Heart 2015;2(1):e000198.
3. Burke MC, Gold MR, Knight BP, Barr CS, Theuns DA, Boersma LV, et al. Safety and efficacy of the totally subcutaneous implantable defibrillator: 2-year results from a pooled analysis of the IDE study and EFFORTLESS registry. J Am Coll Cardiol 2015;65(16):1605-15.
4. Rowley CP, Gold MR. Subcutaneous implantable cardioverter defibrillator. Circulation Arrhythm Electrophysiol 2012;5(3):587-93.
5. Katz JS, Rajper N, Giedd KN. SPECT attenuation artifact in a patient with a subcutaneous implantable cardioverter-defibrillator. J Nucl Cardiol 2015;22(6):1326-8.