Inappropriate Shocks due to Subcutaneous Air in a Patient With a Subcutaneous Cardiac Defibrillator

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A 56-year-old man with a history of ischemic cardiomyopathy and a transvenous implanted cardiac defibrillator (ICD) for secondary prevention presented with device endocarditis requiring ICD removal and lead extraction. After extended therapy with intravenous antibiotics and resolution of systemic infection, a subcutaneous implantable cardiac defibrillator (S-ICD; Cameron Health/Boston Scientific, San Clemente, CA) was electively implanted with standard technique. Specifically, 3 subcutaneous pockets were created, a subaxillary pocket for the generator and 2 parasternal pockets, to which the defibrillator coil was tunneled. After the coil and generator were positioned and sutured and after the fascial layer was closed, sustained ventricular fibrillation was induced. Detection was successful in the primary vector, which involves the pulse generator and proximal parasternal sensing electrode (Figure 1). Sinus rhythm was effectively restored with a submaximal 65-J polarity shock with time to therapy of 13 seconds and impedance of 55 Ω. Device interrogation the next day was unremarkable; the device, per its automatic programming, chose the secondary vector for detection (which involves the pulse generator and distal parasternal sensing electrode; Figure 1). The postoperative course was otherwise uneventful, and the patient was discharged the following day.

The patient was readmitted <48 hours later with 7 inappropriate shocks because of oversensing of artifact on the programmed secondary vector (Figure 2). Tachycardia therapies were disabled, and device interrogation was performed. The artifact was replicated by manipulation over the distal parasternal sensing electrode and with the patient reaching across his chest with his contralateral arm; however, provocative maneuvers only produced artifact in the secondary and alternate vectors (Figure 3). Sensing in the primary vector (which excludes the distal electrode) was normal without artifact, suggesting that the artifact only involved the distal electrode. The cause of lead malfunction was revealed by chest radiography, which demonstrated entrapped subcutaneous air surrounding the distal electrode (Figure 4A). The patient was reprogrammed to the primary sensing vector and has had no further inappropriate shocks and no observed artifact on routine interrogation in follow-up. In addition, repeat chest radiography obtained 1-month postimplantation showed resolution of the subcutaneous air around the distal electrode and normal sensing in all vectors (Figure 4B). The artifact could not be reproduced using the same provocative maneuvers eliciting it earlier.

Discussion

Inappropriate shocks from the S-ICD are a known cause of morbidity. In a recent prospective study of 314 patients with S-ICDs, there was a high incidence of inappropriate shocks (41 patients, 13.1%) during a 11-month mean follow-up period. More than half of these inappropriate shocks were secondary to oversensing of T waves (22 patients). Other causes in this study included shocks for oversensing of external artifact while working with electric equipment (3 patients) and for supraventricular tachycardia in the high-rate zone (16 patients).

Although these recent data report on many potential causes of inappropriate shocks, this case is the first description of oversensing because of artifact from subcutaneous air leading to inappropriate shocks in a newly implanted S-ICD. Air entrapment within the inferior or superior parasternal lead pockets may produce S-ICD system malfunction if the sensing contact ring becomes insulated by the accumulation of air in the pocket. Entrapped air within the device pocket at the time of closure, otherwise termed a dry pocket, was a previously reported rare cause of loss of capture or sensing failure in older unipolar pacemaker systems that relied on reliable tissue contact with the anodal contact plate of the pacemaker pulse generator.

Failure to evacuate air at the time of closure of the sensing electrode parasternal pockets in the S-ICD system can be a significant cause of morbidity, and lead to ICD storm, as presented here. In our case, air entrapment insulated the distal electrode from surrounding tissue. This intermittent tissue contact led to artifact and oversensing, which was erroneously detected as ventricular fibrillation and resulted in inappropriate shocks.
The diagnosis and management of air entrapment can be noninvasive, prompt, and effective. Postoperative chest radiography in orthogonal views should be reviewed to exclude this as a possible cause of lead malfunction. If subcutaneous air is recognized on a postoperative radiograph, provocative maneuvers during interrogation should be performed and device reprogramming should be considered to exclude the involved sensing electrode ring.

Of note, sensing was normal during the immediate postimplantation device interrogation in the presented case, and lead malfunction only occurred after discharge. This highlights the potential intermittent nature of this problem and the need for vigilance in postimplant monitoring and testing. Furthermore, given the subcutaneous nature of the sensing electrodes, consideration of pocket manipulation should be made during the surgical procedure and immediately after implantation to exclude the possibility of oversensing because of pocket-related issues.

In summary, the S-ICD remains an alternative to the transvenous ICD system for some patients for the prevention of sudden cardiac death. Although not previously reported in association with the S-ICD, air entrapment leading to system malfunction is a known risk from prior experience with unipolar pacemakers. Awareness of this potential complication as the adoption of the S-ICD becomes more widespread is essential for the diagnosis and prevention of S-ICD lead malfunction.

**Disclosures**

Dr. Sauer receives educational grant funding from Boston Scientific Corporation, Medtronic, and St. Jude Medical and serves on the Advisory board for Boston Scientific Corporation. The other authors report no conflicts.

**References**


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**Figure 1.** Anteroposterior chest film after device implantation, with notations illustrating possible sensing vectors that can be programmed with the subcutaneous implantable cardioverter defibrillator.

**Figure 2.** Device electrograms at the time of 1 (of several) inappropriate shock, showing artifact and oversensing, with subsequent subcutaneous implantable cardioverter defibrillator discharge. Sensing had been programmed in the secondary vector.
Figure 3. Device interrogation electrograms after tachycardia therapies had been disabled. Provocative maneuvers, including manipulation over the distal sensing electrode, consistently reproduced oversensed artifact (marked by arrows) in the secondary (A) and alternate (B) vectors. Sensing was normal with provocative maneuvers without artifact in the primary vector (C), which excludes the distal sensing electrode, which was found to be insulated by subcutaneous air.

Figure 4. A, Lateral chest radiography taken shortly after device implantation at the time of device malfunction. The presence of radiolucent entrapped subcutaneous air surrounding the distal sensing electrode ring is noted (arrows). B, Chest radiography performed 1 month later demonstrated resolution of subcutaneous air. Repeat device interrogation at this time showed that abnormal sensing had also resolved.
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