**CASE REPORT**

An Inappropriate Shock Case Early after Implantation of a Subcutaneous Cardiac Defibrillator by Subcutaneous Entrapped Air

Yuka Taguchi, MD, Toshiyuki Ishikawa, MD, Katsumi Matsumoto, MD, Yutaka Ogino, MD, Hirooki Matsushita, MD, Kohei Iguchi, MD and Junya Hosoda, MD

**Summary**

A 17-year-old woman was resuscitated from cardiac arrest due to ventricular fibrillation and was diagnosed with concealed long QT syndrome. She underwent subcutaneous implantable cardiac defibrillator (S-ICD) implantation at our hospital. The device electrogram immediately after implantation was normal. Four days after implantation, she received an inappropriate shock. The device interrogation revealed a continuous baseline shift and frequent oversensing for low amplitude signals, followed by a shock. A chest radiograph in the orthogonal view showed entrapped subcutaneous air surrounding the distal electrode. Entrapped subcutaneous air can cause inappropriate shocks in the early period after S-ICD implantation.

(Key words: Sudden cardiac death, Long QT syndrome, Bystander cardiopulmonary resuscitation, Cardiac implantable electronic devices (CIEDs))

The subcutaneous implantable cardioverter-defibrillator (S-ICD; Boston Scientific, Marlborough, MA, USA) is a useful tool to prevent sudden cardiac death without intra-cardiac lead related complications. The shock lead is placed subcutaneously, and this may cause a new over-sensing issue. We here present a case of inappropriate shock caused by entrapped subcutaneous air surrounding the shock lead electrode.

**Case Report**

A 17-year-old woman who was three months postpartum experienced gasping breathing while sleeping. She went into cardiopulmonary arrest, and cardiopulmonary resuscitation was immediately performed by a bystander. An automated external defibrillator indicated ventricular fibrillation. After the return of spontaneous circulation by a defibrillation shock, an intensive treatment was performed and she fully recovered without neurological sequelae.

Echocardiography was normal, and coronary angiography showed no coronary stenosis. An electrocardiogram (ECG) at rest was normal, and an averaged electrocardiogram showed negative late potential. Contrast-enhanced magnetic resonance imaging showed no delayed enhanced effect on the myocardium. Infusion of epinephrine at a dose of 0.1 μg/kg revealed marked QTc prolongation from 0.47 to 0.56 seconds, and a reversible change with the withdrawal of epinephrine. She was diagnosed with concealed long QT syndrome, and implantation of a subcutaneous implantable cardiac defibrillator (S-ICD; Boston Scientific, Marlborough, MA, USA) was recommended for secondary prevention. S-ICD surface electrocardiogram screening was performed, and all 3 leads were eligible. She underwent S-ICD implantation by a conventional 3-incision technique. A defibrillation test was successful at 65J, and the device interrogation was normal immediately after implantation. The automatic programming algorithm selected the secondary vector for sensing, which involves the distal sensing electrode and the can.

She was discharged after a week, and came to the regular outpatient clinic at our hospital. The device interrogation revealed that she had received an inappropriate shock on the 4th day after implantation during hospitalization. She did not mention about the shock delivered. The device electrogram showed a baseline shift and frequent oversensing with subsequent shock (Figure 1). The charging episodes were recorded every day from the inappropriate shock day until 13th day after implantation, and thereafter no abnormality was recorded.

Chest radiography in an orthogonal view at the time of the inappropriate shock showed entrapped subcutaneous air surrounding the distal electrode (Figure 2A, B). The air was undetectable on day 12 after implantation (Figure 2C).
Figure 1. Device interrogation electrogram at the time of inappropriate shock showed a continuous baseline shift and frequent oversensing of low amplitude signals with subsequent shock. The secondary vector was used for sensing.

Figure 2. Chest radiograph (orthogonal view) showing entrapped subcutaneous air around the distal electrode at the time of an inappropriate shock on the 4th day after implantation (A, B). On the 12th day after implantation, the air could not be detected (C).

Discussion

Entirely subcutaneous implantable cardioverter defibrillators (S-ICD) are an alternative to transvenous implantable cardioverter-defibrillators (TV-ICDS) for the prevention of sudden cardiac death. They do not require intracardiac electrode placement, and their safety and effectiveness have been demonstrated by a pooled analysis of large prospective studies of 882 patients with S-ICDs.1) However, there was a high incidence of inappropriate shocks (13.1%) at 3 years,7) and a majority of the patients received the shocks in the first year postimplantation.

The main causes of inappropriate shocks were supraventricular arrhythmia in 24%, T-wave oversensing (TWOS) in 39%, low amplitude signal in 21%, and others.7) Oversensing can be caused by low amplitude as well as TWOS. Because the minimum sensibility of S-ICD is 0.08 mV, which is much lower than that of the TV-ICD, S-ICD are prone to oversensing due to their low amplitude signal compared to TV-ICD. Some of the oversensing due to the low amplitude may contribute to the entrapped subcutaneous air.
Zipse, et al first reported on inappropriate shocks caused by subcutaneous air surrounding the sensing electrode of S-ICD in the early period after S-ICD implantation. This was then followed by a few case reports.

The features of the inappropriate shocks include; 1) occurrence is often within a few days after the surgery, 2) an abrupt baseline shift and low amplitude signal in the device electrogram, 3) entrapped air around the sensing electrode in chest radiography, which often disappears in about a week, though in some cases there is no evidence of subcutaneous air, and 4) sensing failure could be avoided by changing the sensing vector to another available vector, thereby excluding the problematic electrode.

The subcutaneous air is considered to insulate the sensing electrode from the surrounding tissues, which caused intermittent tissue contact resulting in low amplitude signals and oversensing.

This sensing abnormality has been previously described with unipolar pacemakers, where the device implanted in the subcutaneous pocket was included in the sensing vector, in a case of subcutaneous emphysema associated with the complication of subclavian venipuncture.

In the present case, the daily charging episodes were recorded from the shock day to the 13th day after implantation, which was a long period that has not been reported in other cases, and seems to be related to increased patient activity after surgery and the period required for absorption of subcutaneous air. Notably, as with the other case reports, the sensing detection immediately after implantation was normal. Therefore, there might be many cases with only charging episodes or unrecorded short episodes of oversensing due to subcutaneous air that are clinically unnoticed.

This suggests that device reexamination within an early post S-ICD implantation period may be needed to prevent unnecessary shocks. Furthermore, evacuating the air at the time of pocket closure and careful observation of subcutaneous air with chest radiographies are important.

**Conclusion**

Inappropriate shock due to entrapped subcutaneous air can be prevented by the surgical procedure, careful observation of chest radiographies, and device interrogation (s) in the early period after S-ICD implantation.

**Disclosures**

**Conflicts of interest:** The authors have no conflicts of interest to disclose.

**References**

1. Burke MC, Gold MR, Knight BP, 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: 1605-15.
2. Zipse MM, Sauer WH, Varosy PD, Aleong RG, Nguyen DT. Inappropriate shocks due to subcutaneous air in a patient with a subcutaneous cardiac defibrillator. Circ Arrhythm Electrophysiol 2014; 7: 768-70.
3. Yap SC, Bhugwandien RE, Szili-Torok T, Theuns DAMJ. Air entrapment causing early inappropriate shocks in a patient with a subcutaneous cardioverter-defibrillator. HeartRhythm Case Rep 2015; 1: 156-8.
4. Chinitz JS, Nadraus P, Darge A, Cacciabaudo J, Altman EJ. Inappropriate shocks within 24 hours after implantation of a subcutaneous defibrillator with a two-incision technique. J Innovations Cardiac Rhythm Manag 2016; 7: 2295-8.
5. Hearne SF, Maloney JD. Pacemaker system failure secondary to air entrapment within the pulse generator pocket. A complication of subclavian venipuncture for lead placement. Chest 1982; 82: 651-4.