Humerus fracture during unsuccessful induction of ventricular fibrillation for subcutaneous implantable cardioverter-defibrillator testing

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Introduction

Since 2012, subcutaneous implantable cardioverter-defibrillators (S-ICD) have been approved as an alternative for transvenous ICD in select patients. They offer several advantages, the most important of which is the avoidance of transvenous leads and the associated complications.[1] We present a case of a 59-year-old woman who experienced a humerus fracture during defibrillation testing.

Case report

Past medical history

The patient, a 59-year-old woman, is known to have mitral annular disjunction. Holter electrocardiography revealed frequent ventricular premature complexes (7% of the tracing) with 2 dominant morphologies, and 19 episodes of nonsustained ventricular tachycardia. Cardiac magnetic resonance imaging showed mitral bileaflet prolapse and basal and mid lateral left ventricular hypokinesia with late gadolinium enhancement, along with normal overall left and right ventricular function. A decision was made to proceed with ICD implantation for primary prevention. Considering the patient's young age and absence of pacing requirements, decision was taken to implant an S-ICD. In addition to mitral annular disjunction, the patient's past medical history includes osteoporosis, which was diagnosed in 2020 following traumatic bilateral metacarpal fractures, hypothyroidism, and asthma. Her last bone mineral density in 2022 revealed a lumbar T-score of -3.2, and left femoral T-score of -1.7, indicating a moderate risk for fracture.[2] Her current medications were risedronate 35 mg once weekly, vitamin D3 10,000 IU once weekly, metoprolol 12.5 mg twice daily, levothyroxine 125 micrograms once daily, and budesonide inhalation 0.5 mg/2 mL twice daily.

Case presentation

The patient underwent S-ICD implantation on July 6, 2023. During the procedure, the usual recommended arm positioning[3] was performed: the left arm was externally rotated, stretched, and strapped on a horizontal sheet and abducted at an angle of approximately 60 degrees from the chest. The S-ICD implantation procedure was done using the 2-incision technique with no complications. The device was placed intermuscularly between the serratus anterior and the latissimus dorsi muscles. The procedure was done under local anesthesia and moderate sedation with midazolam and fentanyl. After the closure of the incision above the xiphisternum and the closure of the first layer of the lateral incision, defibrillation testing (DFT) was sought. The hand was

KEY TEACHING POINTS

- Defibrillation testing during subcutaneous implantable cardioverter-defibrillator (S-ICD) implantation procedure may carry a risk for musculoskeletal complications.
- Osteoporosis may be a potential risk factor for bone fractures during defibrillation testing. Careful arm positioning following the recommended maneuvers may reduce the risk of fractures.
- Shoulder and incisional pain are often seen after S-ICD implantation procedures and are often considered benign/positional. Significant and persistent pain, however, must be thoroughly investigated by physical examination, and potentially imaging, early on to avoid underdiagnosis of significant musculoskeletal complications.

KEYWORDS S-ICD; Defibrillation; Defibrillation testing; Fracture; Osteoporosis
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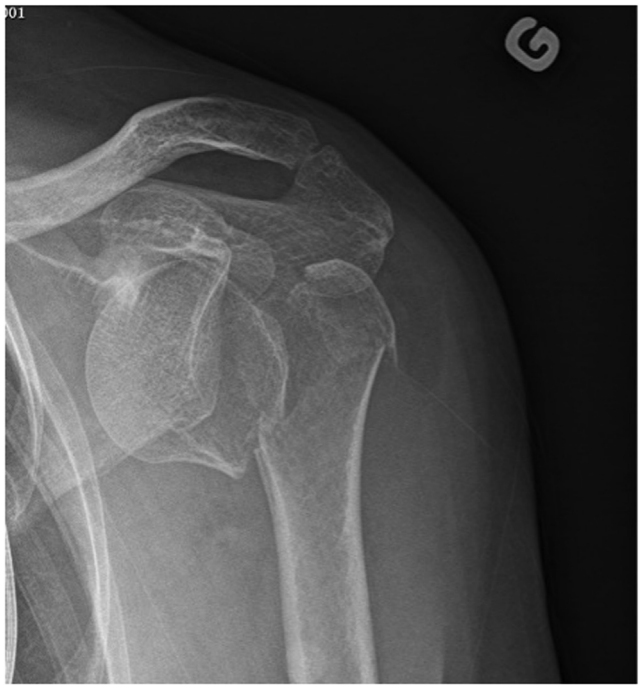

Figure 1 Radiograph of left shoulder showing head of humerus fracture and anterior dislocation.

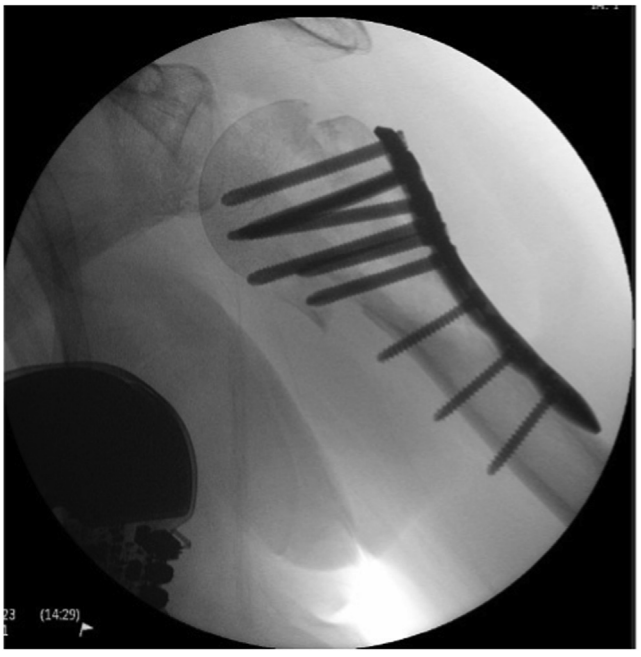

Figure 2 Postoperative radiograph of the fractured shoulder shown in Figure 1.

pronated with the thumb positioned on top as per the Boston Scientific user manual,[3] but without adduction or unstrapping of the arm; the latter 2 maneuvers are usually omitted in our practice owing to the risk of sterile field contamination. Intravenous propofol was infused until the patient reached Richmond Agitation Sedation Scale (RASS)-4. A first attempt of ventricular fibrillation induction with 50 Hz alternating current stimulation from the device was unsuccessful. As with every induction case, the induction was associated with intense contraction of the left chest muscles. The patient was still deeply sedated (RASS -4), so another ventricular fibrillation induction was attempted, but was again unsuccessful. Again, intense contraction of the muscles was noted. The patient was then in RASS -2, so a decision of not to test was taken. The lateral incision was closed completely with 3 layers of suture, and the sterile drape was removed. While trying to move the left upper arm of the patient, shoulder pain—a frequently seen event—was noted. Physical inspection showed symmetrical shoulders, and passive movement of the upper arm was possible with relatively tolerated pain. We assumed shoulder pain owing to prolonged abduction and external rotation of the left shoulder. The patient then received 30 mg of intravenous ketorolac and 5 mg of oral oxycodone for pain management. Four hours later, the patient was discharged home with no pain when the shoulder was not moved.

The next day, the patient called for persistent pain and shoulder edema despite oxycodone. She was advised to take paracetamol 1000 mg orally every 6 hours, and in case of persistent pain to come to the clinic for assessment. Four days later, she reported pain of 5 out of 10 with significant response to paracetamol. Six days later, the patient came to the pacemaker clinic because of persistent inability to move her shoulder. A bilateral shoulder radiograph was done (Figure 1) and showed a fracture into 3 parts at the level of the head of the humerus, with anterior dislocation. Note was made of radiolucent bones suggestive of advanced osteoporosis.

The patient then had an uncomplicated and successful orthopedic surgery on July 14, 2023 (Figure 2).

Discussion

For transvenous ICD implantations, DFT is no longer recommended as a routine practice for all patients. This is based on 2 large trials that showed noninferiority of no testing, namely SIMPLE[4] and NORDIC.[5] Even in the absence of clinical evidence supporting the avoidance of DFT during S-ICD implantation, many operators choose not to perform it on all patients. A study published in 2016 showed that among the patients who underwent S-ICD implantation, only 75% underwent DFT testing.[6] Nevertheless, DFT is still a class I recommendation for S-ICD implantation owing to many factors. First, to date, there does not exist any randomized controlled trial comparing DFT vs no DFT during S-ICD implantation. Second, in view of the use of anatomical landmarks for implantation, there are many possible implantation positions based on operator practice, patient body habitus, and absence of data on R-wave sensing. The PRAETORIAN-DFT is an ongoing trial expected to be published at the end of 2023. It will most likely give us insight on patient selection for DFT based on the PRAETORIAN

score.[7] This score divides the patients into low-, moderate-, and high-risk score for DFT failure.[8]

DFT is not without risk. Although rare, most adverse events are sequelae of anesthesia and/or prolonged resuscitation.[9] Other rare musculoskeletal adverse events were reported. Ismail and colleagues[10] have reported displacement of a recent healed clavicular fracture during DFT. Noheria and colleagues[11] have reported a case of anterior shoulder dislocation in a patient with prior shoulder injury. Elders and AlHashimi[12] reported a case of humeral head fracture during DFT. To our knowledge, this is the only reported case of shoulder fracture during DFT. Nevertheless, it was not clear whether it was the induction or the defibrillation therapy that caused the fracture. Our patient did not receive a defibrillation therapy; hence it is clear that the induction was the actual cause of the fracture.

Two of the previously reported cases[10,11] identify previous fracture or trauma as risk factors for musculoskeletal complications. Elders and AlHashimi[12] described the mechanism of humerus fracture during DFT: an induction by 50 Hz alternating current leads to sudden and severe contraction of the pectoralis muscle. The pectoralis muscle inserts on the lateral tip of the bicipital groove, and such a forceful contraction leads to a high-torque momentum on the humeral bone. Nevertheless, they did not identify any risk factor. In our case, the only identifiable risk factor is osteoporosis, which is a known risk factor for humerus fracture.[2] S-ICD is usually preserved for younger patients who are less likely to suffer from osteoporosis. But when osteoporosis is present, and as long as DFT is recommended for the patient, it appears to be crucial to apply the precautions recommended by the Boston Scientific user manual during DFT: pronation to thumb up, adduction, and loosening the strap of the arm. Although these maneuvers are indicated to reduce injury to the ulnar nerve and brachial plexus,[3] they also seem to reduce other musculoskeletal injury by providing sufficient arm stabilization.

Furthermore, our assumption of a benign etiology of left shoulder pain post implant has led to underdiagnosis of a fracture. If significant pain is noted post procedure, we recommend thorough physical examination and radiography of the chest/shoulder to rule out potential musculoskeletal complications.

Conclusion

Humerus fracture is a rare but serious complication of DFT in patients undergoing S-ICD implantation. Special care for adequate arm positioning before DFT appears to be crucial, especially in patients who are at high risk of this complication. In case of the presence of significant shoulder pain post procedure, thorough physical examination and radiography should be performed in a timely manner to avoid underdiagnosis of significant musculoskeletal complications.

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