

Cardiac implantable electronic device related chest pain: A focused review

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A B S T R A C T

More than 600,000 patients undergo cardiac implantable electronic device (CIED) implantation in a year, which comprise of pacemakers, implantable cardioverter defibrillators, and cardiac resynchronization therapy devices (CRT). The most common symptom experienced after a CIED implantation is chest pain. In this review, we describe CIED implantation and associated complications causing chest pain.

Keywords: Cardiac implantable electronic device (CIED), chest pain

Introduction

More than 1.5 million patients undergo cardiac implantable electronic device (CIED) implantation in a year.¹ These CIED implantations comprise cardiac resynchronization therapy devices (CRT), permanent pacemakers, and implantable cardiovascular defibrillators.² With the advent of modern equipment and standard-of-care in placement techniques, the device surgeries are considered safe. However, these procedures are not without risk, as several complications can occur after device implantation either acutely or in a delayed setting^{3,4} All the complications can differ in etiology, morbidity, and mortality but most of them have a common presentation of chest pain.⁵ The implantation procedure can itself cause chest pain so it is imperative to differentiate the etiology of chest pain, especially acute coronary syndrome (ACS). Interpreting an electrocardiogram in a ventricular paced rhythm is sometimes difficult as it can hide or mimic ST-T changes in ACS. The modified Sgarbossa criteria can be applied for diagnostic accuracy in these patients.⁶ As a result, it is paramount in diagnosing the cause of chest pain after

device implantation. In this review, we will discuss various causes of chest pain after CIED surgery.

Evaluation of chest pain after CIED implantation

Like every surgical procedure, lead placement and device implantation can stimulate numerous nerve endings and by itself produce chest pain, which can occur during the procedure, in the postoperative period, or well after CIED implantation. Hence, the etiology of chest pain can be divided by the time of occurrence: (i) chest pain during the procedure (ii) immediate post-procedural chest pain (iii) delayed presentation of chest pain.

i. Chest pain during the procedure:

A moderate sedation is given during CIED implantation because patients undergoing such procedures are usually elderly and have multiple comorbid conditions.⁷ This limits the use of proper analgesia and sedation to limit the adverse effects of sedatives and anaesthetics and imparts an important role of local anaesthesia for pain control. If local anaesthesia is not given adequately, patients might experience pain during different steps of device implantation. Even with sufficient

local anaesthesia, only subcutaneous tissue is effectively anesthetized and patients may experience sharp pain when deep tissue or bone is being manipulated.⁸ Muscles are especially prone to pain having sutures during lead or device fixation or cauterization for inadvertent bleeding. Hence, quick vascular access is important to minimize pain and other complications of CIED implantation. Most of the physicians at our institute use a sub clavicular approach for subclavian vein access but one of our study has shown the supra-clavicular approach to be non-inferior and time-efficient in temporary transvenous pacing.⁹ Hence, we prefer a supraclavicular approach in CIED surgeries as well.

One of the most dangerous complications during CIED surgery is pneumothorax and hemothorax.¹⁰ These complications are always evaded by implanting physicians because they can increase morbidity and mortality. One way to avoid these complications is by a 'buddy' microneedle puncture after contrast venography to identify the veins.¹¹ Similarly, ultrasound-guided access can be used to identify veins, and positioning of the patient according to their anatomy can help the physician in gaining access. The contrast tends to dilate and engorge the veins, so some physicians like to inject 2ml of contrast for easier venous access. Although CIED surgeries are done meticulously, sometimes pneumothorax does happen. Even when the vein is punctured outside the thorax, a pulmonary bleb formed due to chronic obstructive pulmonary disease can inadvertently cause pneumothorax upon entry.¹² Any air entry during venous puncture should alert the physician about a chance for pneumothorax and the syringe attached to the needle should be airtight. Otherwise, it can give a false perception of air aspiration into the syringe. Any development of chest pain, hypoxia, or cough can be a sign of evolving pneumothorax and during this situation, prompt fluoroscopy can help in identifying the cause of hemodynamic instability. Apart from pneumothorax, multiple venous or arterial punctures can cause mediastinal bleeding. Any bleed in the thorax during CIED implantation can cause acute chest pain. This can present as a diffuse pain that radiates to the back due to mediastinal reflection.¹³ Sympathetic stimulations can cause tachycardia and hypotension,

depending upon blood loss. There is a high chance of subclavian arterial puncture causing mediastinal bleed.

Hence, some physicians prefer axillary vein puncture at the level of the first rib because it allows for manual compression if a hematoma is suspected.¹⁴ After securing the central venous access, it is imperative to advance the guidewire below the diaphragm to ensure the placement within the right heart rather than the arterial side before sheath insertion. In this way, the chance of mediastinal bleeding can be minimized. In elderly patients, vessels are usually tortuous and the advancement of a guidewire and sheath should be very slow.¹⁵ If there is any resistance, further advancement should be done under fluoroscopic guidance.

In addition to mediastinal bleed, it is possible that during the procedure a patient suffers an acute pericardial bleed leading to pericardial effusion or tamponade.¹² These patients typically have chest pain along with hemodynamic instability and cardiogenic shock.¹⁶ As with the pericardial reflection, the chest pain can radiate to the shoulder blades of the scapula. Additionally, it can be due to the rubbing of the pleura with the pericardium.¹⁷ Perforation can occur at any level and superior vena cava, right atrium, right atrial appendage, right ventricle, and coronary sinus have been known to perforate during procedures^{3,18,19} When there is suspicion of pericardial effusion, transthoracic echocardiography is the imaging modality of choice, which can be carried out promptly so an appropriate treatment is undergone promptly. Lateral movement of the pericardium under fluoroscopy is another useful test to check for pericardial effusion. In this case, urgent Pericardiocentesis can be life-saving and lead extraction may be indicated depending on the clinical situation.

ii. **Immediate post-procedural chest pain**

As a consequence of every surgical procedure, there is some post-operative swelling at the incision site. This typically responds to simple analgesics or cold compression. One other cause can be a superficial placement of the subcutaneous device leading to a significant chest compression and lateral displacement of the device causing axillary nerve compression and entrapment.^{20,21} There is also a rare occurrence of allergic reactions to CIED material like chromium, titanium, and nickel.²² As the patients are advised to restrict right arm

movement after CIED surgery, it can produce shoulder pain similar to adhesive capsulitis.

As discussed in the previous section, pneumothorax, haemothorax, and pericardial effusion can produce symptoms of chest pain after a CIED procedure. This typically happens due to a discontinuity of the pleural or pericardial membrane by lead perforation.²³ If there is clinical suspicion of lead misplacement or dislodgement, lead revision would, in most cases, take care of the chest pain promptly.

Any procedure, even a minor surgery elevates stress levels and anxiety. Some patients can develop Takotsubo cardiomyopathy as a consequence. The incidence, however, is still unknown. Clinically, the patient may experience angina, shortness of breath, and palpitations owing to new-onset arrhythmias. Troponin levels are raised and transthoracic echocardiography will show apical ballooning with sparing of the basal septum.²⁴ Left heart catheterization shows unobstructed coronaries. The etiology of stress cardiomyopathy is not clear, although its pathophysiology is apparent in CIED surgeries. It can be induced secondary to the stressful events leading to device implantation, sedation and other medications, dyssynchronous pacing, or the CIED procedure itself.²⁵

A rare cause of chest pain in these patients can be diaphragmatic pacing by capture of the phrenic nerve.²⁶ This can manifest as hiccups or chest discomfort, manifesting in a certain posture. In CRT, coronary sinus lead is placed in the posterolateral or lateral branches which brushes off the lateral wall of the ventricle and this lead can capture phrenic nerve leading to diaphragmatic contractions.²⁷ The right ventricular lead, on the contrary, cannot pace the diaphragm unless there is lead-induced ventricular perforation. It is usually fixed with lead revisions.

iii. Delayed chest pain

Most of the patients with delayed onset chest pain present with some surgical site problems. Pain after surgery usually settles within one week. However, some people have increased sensitivity and a low pain threshold. Hence, a sizable percentage complain of prolonged chest discomfort. Other conditions include superficial placement of the device, nerve entrapment, hematoma, erosions, dehiscence, or infections.²⁰ The etiology of pain is the deciding factor towards lead

revision or reopening the device pocket. A major cause of lead revision is perforation which can be delayed secondary to CIED implantation. It is uncommon as compared to acute perforations and usually presents with vague clinical symptoms. Hence a high degree of suspicion should be maintained and the help of imaging modalities like X-ray and echocardiography should be advised promptly. These patients often require a multidisciplinary approach including electrophysiologists and cardiothoracic surgeons.²⁸

In addition to an iatrogenic cause of chest pain, some patients have underlying coronary artery disease, and pacing can induce angina by elevated heart rate.²⁹ In certain instances, dual-chamber pacemakers induce high atrial rates and cause ventricular pacing. Although pacemakers are programmed to minimize right ventricular pacing, sometimes it is inevitable and results in demand ischemia.³⁰ In the presence of subclinical ischemic heart disease, it can lead to classical angina. This phenomenon can be diagnosed by alternating the pacing rate and reprogramming the device to minimize right ventricular pacing can relieve the anginal symptoms, and subsequent revascularization for underlying coronary artery disease should be planned for complete resolution of chest pain.³¹

In a subset of patients with CRT implantation, a delayed onset, pleuritic chest pain can be precipitated, similar to Dressler's syndrome. Differentiating feature from other types of pericardial entity is that it does not produce pericardial effusion or tamponed. This syndrome is named post-cardiac injury syndrome (PCIS) and it refers to heterogeneous autoimmune-mediated conditions of pericarditis and myocarditis.³² There are no validated diagnostic criteria but patients suffering from PCIS seek medical care due to chest pain in 80% of the cases. Other clinical presentations include shortness of breath and fever. The initial trigger for PCIS seems to be a break in pericardial space in combination with blood entering the pericardium. There is evidence of elevated anti myocardial antibodies and the incidence of PCIS after cardiothoracic procedures. Taking the latency period between cardiac injury and favourable response to anti-inflammatory drugs, the hypothesis of autoimmune-mediated pathogenesis seems legitimate.³³

Most of the patients can bear right ventricular pacing without any noticeable side effects while others may

develop significant chest pain, irrespective of coronary artery disease.³⁴ Although the principal pathophysiology is unclear, several hypotheses exist in this view: asynchronous ventricular contraction due to abnormal septal motion, activation of neurons for interception ventricular pacing, and micro vascular ischemia. In view of current evidence, treatment of these patients is tough, but CRT therapy or His bundle pacing can be considered for a favourable response.

Conclusion

A significant proportion of patients that undergo CIED surgeries will have device-related chest pain with various etiologies depending upon the time of occurrence. The most common cause for CIED-mediated chest pain is surgical site pain. However, life-threatening complications like acute myocardial infarction or pneumothorax should be taken into account when investigating chest pain in these patients because prompt diagnosis and treatment are needed for better outcomes.

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