Case report - Cardiac general

Traumatic fracture of nitinol thermoreactive sternal clips

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Abstract

Median sternotomy can be associated with significant morbidity, including non-union, dehiscence and mediastinitis. The use of flexible thermoreactive sternal clips has been introduced recently as an alternative method of sternal closure and is advocated in patients at increased risk of sternal breakdown. It is associated with a decreased incidence of sternal complications as well as allowing faster sternal closure and easy removal on resternotomy. This report describes the case of a fractured thermoreactive clip following trauma, resulting in sternal dehiscence necessitating sternal rewiring.

Keywords: Thermoreactive sternal clips; Sternal closure

1. Introduction

Complications of median sternotomy include non-union, dehiscence, mediastinitis, superficial wound infection and fistula [1]. Following cardiac surgery, sternal wound complications occur in ~2–5% of patients [2]. There are multiple risk factors for these complications including obesity, diabetes, renal impairment, chronic obstructive pulmonary disease, steroids, advanced age, osteoporosis, smoking and harvesting bilateral internal mammary arteries [3, 4]. Routine closure of median sternotomy in adults usually involves 5–9 interrupted stainless steel wires used to achieve osseous apposition of the two hemisternums. The pressure point of contact during the closure is determined by the diameter of the wire. If bony apposition is not exact or if there is excessive movement, such as in patients with lower respiratory tract infections or chronic obstructive pulmonary disease, it is possible for the stainless steel wires to ‘cheesewire’ through the bone resulting in sternal dehiscence [5, 6]. Sternal closure using thermoclip, however, distributes the pressure over a wider area as the clips have a greater diameter at the point of contact [7]. Furthermore, their thermoreactive properties allow the clips to be slightly loose at insertion to allow accurate positioning followed by auto-tightening induced by body temperature, ensuring good osseous apposition. This report describes the use of thermoreactive clips in a high-risk patient and a complication of its use.

2. Case report

An 83-year-old man with a history of chronic obstructive pulmonary disease and chronic renal impairment, presented with chronic stable angina. Cardiac catheterisation demonstrated severe three-vessel coronary artery disease. He underwent coronary artery bypass grafting surgery, including the use of the left internal mammary artery. In view of his age, comorbidities and markedly osteoporotic sternum observed intraoperatively, the sternum was closed using nitinol thermoclip. Interrupted stainless steel wires were initially placed in the manubrium and a single wire placed inferiorly just above the level of the xiphoid process to achieve sternal approximation. Electrocautery was then used to create a passage through the 3rd, 4th and 5th intercostal spaces immediately adjacent to the sternal edge, taking care not to injure the remaining right internal mammary artery. Backaus forceps were placed into the spaces to determine the size of each clip (ranging between 20 mm and 40 mm). The clips were placed in ice-cooled water to achieve temperatures <9 °C until they became malleable. Following mounting on special insertion forceps, the clips were placed in the intercostal spaces. Once in situ, the clips then warm up to body temperature becoming more rigid and conforming to the curve of the intercostal spaces. The patient’s initial postoperative recovery was uneventful. On the 7th postoperative day, he sustained a fall and landed on the metallic edge of his bed, sustaining direct trauma to the sternum. Clinical examination and chest radiograph (Fig. 1) confirmed sternal disruption with fracture of the inferior thermoclip. In view of this, he underwent reoperation where multiple fractures of the sternum were observed with all four steel wires cut through the sternum. The inferior thermoclip (Fig. 2) was fractured with the middle clip dislodged but the superior clip still in situ. In view of the multiple sternal fractures, the sternum was reunited with steel wires in a figure-of-eight configuration. The patient was discharged two weeks after the
Fig. 1. Chest radiograph demonstrating the dislodged thermoclip (A) and the fractured inferior thermoclip (B).

Fig. 2. Intact superior thermoclip (a) and fractured inferior thermoclip (b).

second procedure with no further complications and remains well at six months follow-up.

3. Discussion

Sternal dehiscence following median sternotomy can have a major impact on health service resources and patient survival [1, 3]. Nitinol thermoreactive clips have been shown to reduce the incidence of sternal complications [4, 7, 8]. Nitinol sternal clips (Nickel Titanium Naval Ordinance Laboratory, Praesidia, Bologna, Italy) are characterized by shape memory and superelasticity. They become malleable at $<9^\circ$C and then by thermoelastic martensitic transformation return to their original shape when warmed to body temperatures, thereby able to apply compressive forces on the two hemisternums [7]. As the clips do not fully encircle the sternum, unlike sternal wires, and they possess a greater degree of flexibility, they allow a 10–15% deformation in shape during vigorous coughing [4]. At body temperature, the rigidity of the thermoclips means that when exposed to a high energy impact above a certain tensile force, the clips may fracture. These forces are, however, rarely exerted on the sternum and in our experience when applied, they also result in fracture of the sternal wires and sternal bone itself. Nitinol also has many physical advantages over stainless steel, in that it is more stable, less corrosive and more biocompatible. Furthermore, unlike stainless steel wires, the nitinol thermoreactive clips do not integrate into bone and being non-ferromagnetic are safe to use in magnetic resonance imaging [7].

Although these thermoreactive clips can be used in most situations, they were not used in this patient at the second operation as the sternum had multiple fractures. In this situation, there was no rigid foundation for the thermoclips to bind.

In summary, the use of thermoreactive nitinol clips is an effective technique for sternal closure but this case report demonstrates that when high impact forces are applied to the sternum, the thermoclips can fracture. One of the sternal clips, however, was still able to remain intact even when all the sternal wires and the sternal bone were fractured in several places.

References