Sternal Closure. Rigid fixation of sternum in high-risk patient using Titanium Sternal Fixation System

Clinical Case submitted by RS Farivar, MD, PhD
A 54-year-old male presented with symptomatic severe aortic stenosis. He was a diabetic, and weighed 166 kg. He had 7 cm of fat between his anterior sternal table and skin (Figure 1). We performed an aortic valve replacement with a 25 mechanical bileaflet valve and chose to perform closure with internal rigid fixation via Synthes plates.

Background
Wire cerclage with stainless steel wire, cable in its various manifestations is the most commonly used method for primary sternal closure. It offers speed, cost effectiveness and familiarity. Unfortunately, it is inadequate for certain high risk closures, and may contribute to sterile non-union, superficial and deep sternal wound infections, and sternal instability.

We have used sternal plating, both in combination with wires and as a stand alone for primary internal rigid fixation. We have also used this combination for the following situations:

- BMI > 40
- Renal failure
- Poor bone quality
- Bilateral mammary artery harvest
- Severe COPD (chronic obstructive pulmonary disease)
- Risk factor accumulation (more than 3 risk factors present) in BMI > 30
- Smokers
- Diabetes Mellitus
- Fractured sternum
- Off midline sternotomy
- Immunosuppression
- Delayed sternal closure (secondary closure)
- Mini J sternotomy closure
- Reoperation, especially minimally invasive J sternotomy

Results from case reports are not necessarily predictive of results in other cases. Results in other cases may vary.
Procedure
Routinely we decide at the onset of the case whether primary rigid closure will be employed. Our initial decision is based on the risk factors presented and the quality of bone. Thin osteoporotic bone, an off center sternotomy, fractured sternum and a heavy set patient all increase the likelihood of primary internal rigid fixation. We ask for our Synthes Titanium Sternal Fixation System and/or wire to be present.

Initially, we must decide whether to use a 3 plate system or a 2 plate system with wires at the manubrium and xiphoid. Both are FDA cleared uses of the sternal plating system.

In a typical 3 plate system, we will use a “star” plate in the manubrium, a double-T-plate in the sternum, and an angled plate at the xiphoid. We will illustrate a 3 plate system. For a 2 plate system, typically wires are used both cranially and caudally, and 2 plates are placed between the two wires.

Our initial step is to clear the sternum in the location that we plan to place the plates. We must have adequate soft tissue clearance to screw the plates into the sternal table. We typically use electrocautery and develop minimal flaps (Figure 2). Our flaps are most extensive at the xiphoid which is the area that requires the most lateral extension of the plates.

Our next step is to measure the sternum from anterior table to posterior table with the calipers in the set. Typically a screw is chosen that is 3 mm longer than the measured caliper length, to accommodate the plate thickness. It is preferable to achieve bicortical engagement. We will measure at the manubrium, midsternum and xiphoid and record these measurements (Figure 3).

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If a 3 plate system is used, we typically will bend the plates as we are ready to implant them. We start with the midsternum, and pick a plate (typically a “double T”) that covers the midsternum. Using the pliers, we will bend the plate to lie flat on the manubrium. An assistant will hold the plate, and the surgeon typically hand shapes the plate (Figure 4). After the shaping is completed, the plate is then screwed into the bone. It is essential that the locking screws be inserted perpendicular to the plate.

The titanium sternal locking screws have two different pitches – a coarser “wood screw” pitch and a finer “machine screw” pitch. The “wood screw” portion threads through the bone, and it is important that the “machine screw” portion mate with the titanium plate. This distributes the force correctly and prevents the screw from backing out. We place at least 4 screws on each side of the fracture. If we are concerned about bone quality, we will occupy all screw holes to further distribute the forces on each screw and minimize the likelihood of pulling out.

We will place large approximating clamps on either side of the sternum and use them to approximate the bone while working with the plates. We typically begin with the plate in midsternum for approximation (Figure 5).

We typically alternate the screwing in mechanism, switching sides. This tends to distribute forces most evenly. An assistant will also hold a plate in place while this is being done. Once one plate is in place, we will walk the clamps to the next location, which is typically cranially to the manubrium. Once these are shaped and screwed in, we typically will then place the inferiormost plate. Covering the plates is routine.

Completed plate placement, with at least 4 screws per side, and plates in good position. A star plate is in the manubrium, a double T-plate in the midsternum and an additional plate at the xiphoid. The curved central kotter pin is pointing cranially (Figure 6).
Postoperative care and sternal re-entry
No special precautions are needed with these plates post-operatively. If emergent re-entry is needed, the pins are removed with a Schnidt clamp or tonsil clamp. All pins are removed prior to separating each plate to minimize the chance of frictional locking of the last remaining pin. It is not necessary to remove the plates for sternal re-entry. A retractor can be placed within the plates. For closure, a new central kotter pin is inserted and can be hand guided and then tapped in with a mallet type device.

Results
Patient is doing well after three months of follow-up.

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