Best evidence topic - Cardiac general

Is the figure-of-eight superior to the simple wire technique for closure of the sternum?

Noman Khasatia, Rajesh Sivaprakasam, Joel Dunning

*a* Department of Cardiothoracic Surgery, Wythenshawe Hospital, South Moor Road, Manchester M23 9LT, UK

b Department of Cardiothoracic Surgery, Manchester Royal Infirmary, Oxford Road, Manchester M13 9WL, UK

Received 7 November 2003; accepted 10 November 2003

Summary

A best evidence topic in cardiac surgery was written according to a structured protocol. The question addressed is whether the figure-of-eight technique is superior to the simple wire technique for closing of the sternum.

Altogether 111 papers were found in Medline of which seven presented the best evidence to answer the clinical question. The author, journal, date and country of publication, patient group studied, study type, relevant outcomes, results, and study weaknesses of these papers are tabulated. We conclude that the figure-of-eight wire technique is not superior to the simple wire technique for closure of the sternum.

© 2004 Elsevier B.V. All rights reserved.

Keywords: Evidence-based medicine; Thoracic surgery; Bone wires; Sternum

1. Introduction

A best evidence topic was constructed according to a structured protocol. This protocol is fully described in the ICVTS [1].

2. Clinical scenario

You are assisting with an aortic valve replacement operation in an 85 year old female. She had a long-standing history of chronic obstructive airway disease and diabetes mellitus. The valve was severely calcified. You successfully excise and replace the valve and you are now asked to close the sternum by the consultant. He states that this patient is high risk for sternal dehiscence and thus you should use the figure-of-eight technique to close the sternum. You agree that this patient is high risk and you close the sternum using this technique but you wonder what evidence there is to support the benefit of this technique in high risk patients.

3. Three-part question

In (patients undergoing cardiac surgery) is closure of the sternotomy using (standard or figure-of-eight sternal wire closure) the most effective in preventing (sternal dehiscence).

4. Search strategy

Medline 1966–Aug 2003 using the OVID interface
(exp sternum/or stern$.mp) and (exp suture techniques/or exp bone wires/or bone wires.mp or wire$.mp) and (exp models,biological/or exp stress, mechanical/or exp surgical wound dehiscence/or dehiscence.mp or exp mediastinitis/or mediastinitis.mp or biomechanic$.mp or sternal union.mp)

5. Search outcome

One hundred and eleven papers were found from Medline and seven relevant papers were selected as providing the best evidence. [2–8]. These papers are presented in Table 1.
<table>
<thead>
<tr>
<th>Author, date and country</th>
<th>Patient group</th>
<th>Study type (level of evidence)</th>
<th>Outcomes</th>
<th>Key results</th>
<th>Study weaknesses</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dasika (2003) Ann Thorac Surg, USA [2]</td>
<td>Sternal replicas composed of a polyurethane foam bone analogue were divided in the midline and reapproximated using three stainless steel wire techniques: six simple wires (6S), six figure-of-eight wires (6F8), seven simple wires (7S) including an extra wire at the lower sternum. Sternal distraction was carried out to a maximum force of 400 N</td>
<td>Experimental study</td>
<td>Sternal distraction at 400 N at the lower sternum</td>
<td>Seven single wires, 1.64 ± 0.39 mm; six sternal wires, 4.92 ± 1.73 mm; figure-of-eight wires, 5.1 ± 1.43 mm; P = 0.003</td>
<td>Wires were placed around not through the sternum models. Sternal replicas used rather than true sternal tissue</td>
</tr>
<tr>
<td>Casha (2001) Eur J Card Thorac Surg, UK [3]</td>
<td>Sheep sternal model used to test the problem of wire cutting through the sternum by using fatigue testing. Standard steel wire closure, peristernal steel wire, trans-sternal figure-of-eight closure, polyester and sternal bands sternotomy closure techniques all assessed, in eight pairs of experiments</td>
<td>Experimental study</td>
<td>Percentage of cut-through on the 150th cycle of loading compared to a reference steel wire closure</td>
<td>Polyester closure 453% (± 137%); trans-sternal figure-of-eight 232% (± 35%); sternal wire (this was the reference standard) 100%; peristernal single wire 34% (± 7%); sternaband 23% (± 8%)</td>
<td>Well conducted experimental study</td>
</tr>
<tr>
<td>Losanoff (2001) J Surg Res, USA [4]</td>
<td>Single peristernal and pericostal figure-eight, were used in 14 fresh cadaveric porcine sterna. Technique A four single peristernal wires were used in seven pig sternums. Technique B utilized two pericostal figure-eight wires in seven pig sternums. Lateral, separating force applied</td>
<td>Experimental study</td>
<td>Force required to cause sternal or wire fracture</td>
<td>Single peristernal 916.9 ± 170.8 N; figure-eight pericostal 651.9 ± 80.7 N; P &lt; 0.0001</td>
<td>Peristernal closure technique used. Only four single or two fig-8 wires used in contrast to human technique of six–eight single or four fig-8</td>
</tr>
<tr>
<td>Casha (1999) Eur J Card Thorac Surg, UK [5]</td>
<td>Tested biomechanical characteristics of five sternotomy closure techniques using a metal sternal model on a materials testing machine. Techniques tested: straight wires, figure-of-eight wires, ‘repair’ technique (used when a wire breaks), sterna-band, ethibond, multitwist closure</td>
<td>Experimental study</td>
<td>Rrigidity (mean displacement in mm at 20 kg force) (this was found to be the tension at which wires begin to untwist)</td>
<td>Multi-twist, 0.37 mm; straight wires, 0.78 mm; figure-of-eight, 1.20 mm; sterna-band 1.37 mm; repair wires, 5.08 mm, ethibond 9.37 mm</td>
<td>A bone model was not used to test wires</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Maximum strength at which wire breaks (maximum force in kg)</td>
<td>Multi-twist, 77.1 kg; straight wires, 98.0 kg; figure-of-eight, 92.8 kg; sterna-band, 73.3 kg; repair wires, 46.0 kg; ethibond, 58.8 kg</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Mathematical model to calculate chest wall forces during coughing in order to determine the force placed upon a sternotomy closure</td>
<td>In a large man the force generated is 150 kg, or 25 kg across each wire if six wires are used</td>
<td></td>
</tr>
</tbody>
</table>

(continued on next page)
Two types of paper were found in this search. Several clinical papers documented the authors’ clinical experience of a particular technique, and the remaining papers looked at biomechanical testing of the various sternal wire techniques using ex vivo sternal models.

Three clinical papers are presented here. Casha et al. [5] described their particular technique of trans-sternal multitwist wire closure, and stated that over 10 years and 2000 cases their sternal complication rate was 0.5%. Murray et al. [7] reported that in 34 high-risk patients and an additional 84 consecutive patients there were no cases of dehiscence or mediastinitis using a figure-of-eight technique. DiMarco et al. [8] reported that in 978 patients who had peristernal figure-of-eight wires used to close the sternum, the major sternal complication rate was 0.9%. However no clinical studies have directly compared one closure technique to another, and thus it is difficult to come to any firm conclusion from the results of these uncontrolled, retrospective cohort studies.

In contrast, several well conducted biomechanical studies have been performed. Dasika et al. [2] used a polyurethane foam sternal model to compare six simple wires, seven simple wires and six figure-of-eight wires, all placed peristernally. They found that figure-of-eight wires performed similarly to the standard six simple wires and only adding a 7th simple wire reduced the distraction seen at 400 N of tension.

Losanoff et al. [4] directly compared peristernal simple wires with peristernal figure-of-eight wires in a porcine sternal model. They found that the single peristernal wire technique required a higher force to cause failure than the figure-of-eight technique.

Casha et al. [5] in 1999 studied five techniques of closure using a steel sternal model. They found that the displacement at 20 kg of tension was smaller for single wires than figure-of-eight and the breaking strain was similar for both techniques.
Cashar et al. [3] hypothesised that in fact single distraction testing was inferior to repeated cycles of loading which could mimic the clinical phenomenon of sternal cut-through of wires. They used sheep sternums to test a range of techniques and found that trans-sternal figure-of-eight wires performed more poorly than simple wires and peristernal simple wires were considerably superior to either technique in preventing cut-through. It is however important to note that they did not assess peristernal figure-of-eight wires.

None of these clinical or biomechanical studies demonstrated any superiority of the figure-of-eight wire technique over simple wiring, and in fact several of the biomechanical studies suggest that the issue of whether the wire is placed trans-sternally or peristernally may be a more important factor in promoting sternal stability.

7. Clinical Bottom line

The figure-of-eight wire technique is not superior to the simple wire technique for closure of the sternum.

References


Appendix A. ICVTS on-line discussion

Author: Prof. John Pepper, London Hospital Royal Brompton, Cardiothoracic Surgery Dept., Sydney Street, London SW3 6NP, UK

Date: 16-Dec-2003

Message: Criticism of a particular surgical technique is difficult as it depends so much on the skill of the operator. But sternal closure is so important and so frequently delegated to junior staff that any proposed technique must be simple, easy to teach and easily reproducible. The figure-of-eight is more difficult than a simple suture placed around the sternum and through the manubrium but fails on the test proposed above. Furthermore, in a paper which examined fatigue-testing, by Cooper and colleagues (Cashar AR, et al., Eur.J.Cardiocor. Surg. 2001; 19: 249–253) figure-of-eight sutures were the least satisfactory method of sternal closure.

Author: Dr. Sameh Ibrahim Sersar, Assistant Lecturer of Cardiothoracic Surgery, Mansoura University, Department of Cardiothoracic Surgery, Mansoura University, Mansoura, 123 Egypt

Date: 11-Jan-2004

Message: To determine the best method of sternal closure, there are certain factors to consider: (i) age above 65 years; (ii) diabetes mellitus; (iii) bilateral internal mammary artery is harvested; (iv) reoperations; (v) eccentric sternotomy; (vi) sternal reclassification for mediastinitis or dehiscence; (vii) obesity (body weight 20% higher than expected); and (viii) chronic obstructive pulmonary airway disease. The surgeon preference and experience also is an important factor as Pepper J. stated in his comment on this article.

Sharma et al. found that tension/wire no. is higher in Rob < PS < PS8 < APTS < PC8 < TS where APTS alternating peristernal and transsternal single wires; PC8 pericostal figure-eight wires; PS peristernal single wires; PS8 peristernal figure-eight wires; Rob Robicske; TS multiple transsternal single wires [1].

The factors assessing the efficacy of a method of sternal closure are: stiffness, proportional limit load, displacement at first cycle peak, displacement after 10 and 25 cycles, maximum displacement at the end of test, permanent displacement after the first, fifth and tenth cycles; and percent of catastrophic failures before each test’s conclusion [2].

References


Author: Mr. Joel Dunning, SpR Cardiothoracic Surgery, Freeman Hospital, Newcastle-upon-Tyne, Freeman Road, Newcastle-upon-Tyne, UK

Date: 30-Jan-2004

Message: This topic searched Medline from 1966 to Aug 2003. However one of the advantages of publishing and stating our search strategy in these topics is that the full search can be put into Ovid’s update service. This means that if a new paper is published that would have been included in the search strategy it is automatically E-mailed to us. This has occurred for this topic. In Jan 2004 Losanoff et al [1] published another paper in the Annals of Thoracic Surgery that in our opinion is the best published paper on this topic so far. They used Fifty-three fresh adult human cadaveric sternal plates with adjacent ribs, fixed with specially designed spiked stainless steel clamps. They assessed Single peristernal and transternal, alternating single peristernal and transternal, figure-eight peristernal, figure-eight pericostal, and Robicske closures using no. 5 stainless steel wires for a number of biomechanical parameters. They conclude that single peristernal and alternating peristernal/transternal are the best two techniques followed by figure-of-eight peristernal. Transsternal single wires and pericostal figure of eight performed most poorly.

Reference