Is a minimally invasive approach for mitral valve surgery more cost-effective than median sternotomy?

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Abstract

A best evidence topic in cardiac surgery was written according to a structured protocol. The question addressed was: is a minimally invasive approach for mitral valve surgery more cost-effective than median sternotomy? Altogether, 51 studies were found using the reported search, of which 7 represented the best evidence to answer the clinical question. The authors, journal, date and country of publication, patient group studied, study type, relevant outcomes and results of these papers were tabulated. No randomized controlled trials have assessed the cost-effectiveness of less invasive mitral valve surgery compared with median sternotomy, with the best evidence coming from retrospective and propensity-matched analyses. Five studies compared minithoracotomy versus sternotomy, one compared minimally invasive port-access surgery versus sternotomy and one compared video-assisted minithoracotomy versus sternotomy. The use of a minithoracotomy or a minimally invasive port-access approach for mitral valve surgery resulted in significant reductions in costs of cardiac imaging and laboratory tests, lower use of blood products, fewer perioperative infections, faster recovery, shorter hospital length of stay, fewer requirements for rehabilitation and lower readmission rates in the following postoperative year. We conclude that a minimally invasive approach for mitral valve surgery is safe, effective and significantly more cost-effective than median sternotomy.

Keywords: Minimally invasive • Mitral valve surgery • Median sternotomy • Cost • Resource utilization

INTRODUCTION

A best evidence topic was constructed according to a structured protocol, which has been previously described in the ICVTS [1].

THREE-PART QUESTION

In patients undergoing mitral valve surgery, is a [minimally invasive approach] more [cost-effective] than [median sternotomy]?

CLINICAL SCENARIO

You are attending a national conference hearing about the cost benefits of minimally invasive mitral valve surgery (MIMVS) over the conventional median sternotomy (ST) approach. An eminent speaker from the floor then stands up and contends that there have been no definitively proven cost benefits of MIMVS. He continues to say that the operative times are significantly longer in MIMVS, which may potentially increase costs. You resolve to check the literature yourself.

SEARCH STRATEGY

Medline 1995 to June 2015 using Pubmed interface: [mitral valve] AND [minimally invasive valve surgery OR less invasive valve surgery OR minithoracotomy OR ministernotomy] AND [cost OR resource]. Studies reporting on robotically assisted mitral valve operations were excluded.

SEARCH OUTCOME

Fifty-one studies were found using the reported search, of which 7 provided the best evidence to answer the question. The studies are summarized in Table 1.

RESULTS

Grossi et al. [2] retrospectively evaluated 367 patients undergoing minithoracotomy (MT) mitral valve repair with 367 propensity-matched patients who underwent ST. MT had a 17.2% lower hospitalization cost (~$8289), which was driven by a decreased rate of

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<table>
<thead>
<tr>
<th>Study type</th>
<th>Number of patients and demographics</th>
<th>Outcomes</th>
<th>Key results</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grossi et al. (2014), J Thorac Cardiovasc Surg, USA [2]</td>
<td>MT = 367, ST = 367</td>
<td>Operating, ICU, and total hospital costs</td>
<td>Mean operating costs of MT ($9602) exceeded that of ST ($8929)</td>
<td>MT provided significant cost savings, driven by a lower sepsis infection rate (1.1 vs 4.4%, $P = 0.0065$) and shorter hospital stay (7.9 vs 10.2 days), when compared with ST</td>
</tr>
<tr>
<td>Propensity-matched (level 3 evidence)</td>
<td></td>
<td></td>
<td>MT was associated with reduced median ICU cost ($2622 vs $4177) and total hospital cost ($31 515 vs $37 495), when compared with ST</td>
<td>Lower readmission rates observed in MT at 30 days (26.2 vs ST 35.7%, $P &lt; 0.0052$) and 90 days (31.6 vs 44.1%, $P &lt; 0.0005$) may translate into additional cost savings</td>
</tr>
<tr>
<td>Iribarne et al. (2012), J Thorac Cardiovasc Surg, USA [3]</td>
<td>MT = 70, ST = 105</td>
<td>Median costs: Total hospital cost</td>
<td>MT $37 069 vs ST $43 790, $P = 0.007$</td>
<td>MT was associated with reduced hospital costs, driven by decreased length of hospital stay and improved resource utilization and postoperative functional status when compared with ST</td>
</tr>
<tr>
<td>Retrospective study (level 3 evidence)</td>
<td>MT = 217, ST = 217</td>
<td>Mean costs of hospitalization</td>
<td>MT $41 006 vs ST $50 060, $P = 0.006$</td>
<td>MT was associated with similar morbidity and mortality, significant reductions in costs, more likely to be discharged home with no nursing services and lower readmission rates</td>
</tr>
<tr>
<td>Iribarne et al. (2011), J Thorac Cardiovasc Surg, USA [4]</td>
<td></td>
<td>Hospital length of stay</td>
<td>MT 7.1 vs ST 9.2 days, $P = 0.001$</td>
<td></td>
</tr>
<tr>
<td>Propensity-matched (level 3 evidence)</td>
<td></td>
<td>Discharged home with no nursing services</td>
<td>MT 66.8 vs ST 54.4%, $P = 0.018$</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>No readmission within 1 year</td>
<td>MT 93.2 vs ST 86.3%, $P = 0.023$</td>
<td></td>
</tr>
<tr>
<td>Gersak et al. (2005), Heart Surg Forum, Slovenia [5]</td>
<td>Minimally invasive port-access MV surgery = 105, ST = 110</td>
<td>Total hospital cost</td>
<td>The average total patient cost was 20% less for the port-access group, $P &lt; 0.0005$</td>
<td>Port-access surgery was associated with similar morbidity and mortality, with significant reductions in resource utilization and costs</td>
</tr>
<tr>
<td>Retrospective study (level 3 evidence)</td>
<td>Isolated MV surgery and combined tricuspid valve operations</td>
<td>Mortality and strokes</td>
<td>No difference in in-hospital mortality ($P = 1$) or stroke ($P = 0.53$), between port-access versus ST</td>
<td></td>
</tr>
</tbody>
</table>

Continued
Analysed 217 patients who underwent right MT and compared them with 217 patients who underwent an ST approach. MT surgery was associated with a $9054 ± $3302 lower mean total hospital cost ($P = 0.006). There were significant reductions in costs of cardiac imaging (~$132, $P = 0.002), laboratory tests (~$276, $P = 0.001), boarding and nursing (~$2210, $P < 0.001) and radiology (~$125, $P = 0.004), which was likely driven by less incidence of intubation > 72 h (2.8 vs 8.3%, $P = 0.019), and a significantly shorter hospital length of stay among the MT patients (7.12 ± 0.36 vs 9.19 ± 0.52 days, $P = 0.001). A higher proportion of MT patients were discharged home with no nursing services (66.8 vs 54.4%, $P = 0.018), and had lower 1-year readmission rates (93.2 vs 86.3%, $P = 0.023).

Gersak et al. [5] compared 105 minimally invasive port-access isolated mitral valve operations or mitral valve combined with tricuspid valve surgeries with 110 patients who underwent ST. Similar morbidity and mortality rates were observed between the

Table 1: (Continued)

<table>
<thead>
<tr>
<th>Author, date, journal and country (level of evidence)</th>
<th>Number of patients and demographics</th>
<th>Outcomes</th>
<th>Key results</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cosgrove et al. (1998), Ann Thorac Surg, USA [6]</td>
<td>MT = 49 ST = 40</td>
<td>Units of blood transfused</td>
<td>Port-access 2.1 vs ST 3.6 units, $P &lt; 0.0001</td>
<td>Low rates of complications in MT, including 0% mortality, 14% incidence of required blood transfusions and 4% incidence of stroke</td>
</tr>
<tr>
<td>Chitwood et al. (1997), J Thorac Cardiovasc Surg, USA [7]</td>
<td>Video-assisted minimally invasive MV surgery = 31 ST = 100</td>
<td>Hospital charges and costs per patient</td>
<td>Charges and costs per patient were $11 428 (27%) and $9145 (34%) lower in the video-assisted minimally invasive group ($P = 0.02 for both)</td>
<td>Video-assisted minimally invasive MV surgery was associated with significantly lower resource utilization, and a 34% reduction in total hospital costs</td>
</tr>
<tr>
<td>Cohn et al. (1997), Ann Surg, USA [8]</td>
<td>MIVS = 50 ST = 50</td>
<td>Requirement for post-rehabilitation and hospital charges</td>
<td>Post-rehabilitation requirements were less and hospital charges were 20% lower in the MIVS group</td>
<td>Patients undergoing mitral MIVS had less red blood cell transfusion requirements</td>
</tr>
<tr>
<td></td>
<td>MIVS included the initial 50 cases performed at Brigham and Women’s Hospital, comprising of AVR and MV surgery</td>
<td>Requirement of red blood cells</td>
<td>Mitral MIVS 0.8 vs ST 2.6 units</td>
<td>Patient satisfaction was greater, and hospital charges were less, with a less invasive approach to valve surgery</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Patient satisfaction</td>
<td>Return to normal activity: MIVS 4.6 vs ST 9.4 weeks, $P = 0.0002</td>
<td>'Feel like myself': MIVS 6.4 vs ST 10.3 weeks, $P = 0.009</td>
</tr>
</tbody>
</table>

AVR, aortic valve replacement; ICU, intensive care unit; MIVS, minimally invasive valve surgery; MT, minithoracotomy; MV, mitral valve; ST, median sternotomy.

sepsis and other infections (1.1 vs 4.4%, $P = 0.0065), and a 2-day reduction in the hospital length of stay (7.9 vs 10.2 days). Readmission rates at 30 days (26.2 vs 35.7%, $P < 0.0052) and 90 days (31.6 vs 44.1%, $P < 0.0005) were also lower with MT.

Iribarne et al. [3] retrospectively evaluated 70 patients ≥75 years old who underwent right MT mitral valve repair, and compared them with 105 who underwent ST. While longer operative times were observed in the MT group, the length of hospital stay was significantly shorter (5.1 ± 0.9 vs 8.6 ± 0.6 days, $P = 0.033). The MT approach was associated with a $6721 lower median cost of hospitalization ($P = 0.007) and a higher rate of discharge to home, routinely or with a health aide, rather than to rehabilitation (78 vs 58%, $P = 0.021). The MT patients also achieved faster rates of independent ambulation ($P = 0.039) and independent sit-to-stand activity ($P = 0.003).

In a separate propensity-matched analysis of all minimally invasive mitral valve operations performed, Iribarne et al. [4]
surgical approaches. However, they noted reductions in the use of blood products (2.1 units vs ST 3.6 units, \(P < 0.0001\)) and hospital length of stay (5.1 vs 8.6 days, \(P < 0.0001\)) in the minimally invasive port-access group, leading to an average reduction of the total patient cost of 20\% (\(P < 0.0005\)).

A study by Cosgrove III et al. [6] reported on 49 consecutive patients who underwent MT mitral valve surgery. Excluding the costs of the prosthetic valves utilized, the total direct hospital cost was 7\% less in MT, when compared with 40 ST mitral valve operations. Low rates of complications were reported, including 0\% mortality, a 14\% incidence of required blood transfusions and a 4\% incidence of stroke. Direct statistical comparison of outcomes between the surgical approaches was not reported, and there was no difference in the hospital length of stay.

Chitwood et al. [7] compared the outcomes of 31 video-assisted MT mitral valve operations with 100 ST mitral valve surgeries. The authors observed hospital charges and costs per patient to be $11,428 (27\%) and $9,165 (34\%) lower in the MIMVS group, \(P < 0.02\). This was driven by less blood product transfusions (2.1 vs 3.6 units) and a shorter hospital length of stay (5 vs 9 days) in the MT group (\(P < 0.05\) for both).

Cohn et al. [8] in 1997 evaluated the first 50 patients who had aortic or mitral valve surgery via a minimally invasive approach and compared them with 50 patients who underwent ST. In the minimally invasive group, blood product use was lower (0.8 vs 2.6 units) and charges were ~20\% lower. Finally, patients undergoing minimally invasive valve surgery had an expedited return to normal activities of daily living (4.6 vs 9.4 weeks, \(P = 0.0002\)).

**CLINICAL BOTTOM LINE**

A minimally invasive approach for mitral valve surgery via an MT or port access is more cost-effective than ST, which is due to reductions in costs of cardiac imaging and laboratory tests, lower use of blood products, fewer perioperative infections, faster recovery, shorter hospital length of stay, fewer requirements for rehabilitation and lower readmission rates in the following postoperative year.

**Conflict of interest:** none declared.

**REFERENCES**


**eComment. The effect of conversion rate on the cost-effectiveness of minimal access mitral valve repair**

Authors: Eleftheros Spartalis, Andreas S. Triantafyllis, Grigoris Karagiouzis and Periklis Tomos

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We read with great interest the best evidence topic by Santana et al. [1]. The Authors conclude that minimally invasive mitral valve repair (MIMVS) is safe and significantly more cost-effective than median sternotomy.

Cost-effectiveness is influenced by factors relating to the technique, the length of stay and the presence of postoperative complications. Owing to severe intraoperative difficulties, conversion to full sternotomy is also a serious complication of MIMVS that has not been mentioned in this article. Conversion to median sternotomy is a risk that raises the cost of MIMVS. Occasionally, conversion to a full sternotomy is required during minimally invasive mitral valve surgery for reasons that have not yet been well investigated.

The main reason for conversion reported in the literature is major bleeding. Other causes are severe pulmonary adhesions and aortic dissection type A. In all such converted cases, the operative course is significantly prolonged. Furthermore, Vollrath et al. [2] revealed that conversion to full sternotomy leads to severe perioperative morbidities and causes very high 30-day mortality i.e. above 23\%. In recent, large series, however, the incidence of conversion to a full sternotomy was 1\% [3], in contrast to previously reported studies where the conversion rate was between 2.4\% and 2.6\% [4].

Despite the fact that conversion from right lateral thoracotomy to full sternotomy occurs infrequently during minimally invasive mitral valve surgery, it still represents a rare but fatal complication and should be considered when assessing operative costs. Identification of potential risk factors and contraindications for the minimally invasive approach is essential to achieve excellent postoperative results.

**Conflict of interest:** none declared.

**References**


