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Can we use minimally invasive mitral valve surgery as a safe alternative to sternotomy in high-risk patients?

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Abstract

A best evidence topic in cardiac surgery was written according to a structured protocol. The question addressed was whether minimally invasive mitral valve surgery (MIMVS) should be considered as an alternative to conventional sternotomy (ST) in high-risk patients. Eighty-six papers were found by a systematic search, of which seven were comparing MIMVS with ST in high-risk patients and addressing the clinical question. Five were retrospective observational and two were propensity-matched studies. One paper included patients with infective endocarditis, one with preoperative renal failure, two papers the elderly, three papers compared redo surgery. Author, journal, date, patient group, country of publication, relevant outcomes, results and study weaknesses were tabulated. In total, these seven studies included 1254 high-risk patients (n = 523 MIMVS, 731 ST) undergoing mitral valve surgery, either repair or replacement. End-points of interest were mortality, intraoperative and postoperative outcomes and survival. With regard to MIMVS group, in-hospital mortality was lower in three studies and with no statistically significant differences in the other four; cardiopulmonary bypass (CPB) times were similar in one study, but were longer in three other studies. MIMVS led to reduced postoperative complications in six studies (one did not report complications); among studies that included late mortality, one reported better survival in the MIMVS group whereas the other two did not report differences. We conclude that, although MIMVS may be associated with longer CPB and cross-clamp times, it is at least as safe as ST in terms of both mortality and morbidity, in these high-risk groups.

Keywords: Mitral valve • Minimally invasive surgery • High-risk

INTRODUCTION

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

THREE-PART QUESTION

In [high-risk patients presenting with mitral disease], is [minimally invasive mitral valve surgery, MIMVS] a safe alternative to [standard sternotomy ST] in order to achieve [better survival and lower morbidity]?

CLINICAL SCENARIO

A 75-year old female is admitted in accident and emergency department with pulmonary oedema. Past medical history includes previous double CABG. Bedside echo shows severe mitral regurgitation with ruptured chordae and suspicion of vegetation. After stabilization, she is transferred to the cardiac catheterization laboratory, and the coronary angiogram shows patent left internal mammary artery to left anterior descending artery and vein graft to right coronary artery. As the cardiac surgeon on-call, you are asked to consider her for surgery at a certain point, and your trainee asks whether MIMVS rather than sternotomy (ST) would provide better outcomes in this high-risk patient.

SEARCH STRATEGY

A literature search was performed using PubMed, Ovid, Embase and Cochrane databases using the terms: 'mitral valve surgery', 'minimally invasive' and 'high-risk'; moreover, mesh term 'minimally invasive' was used in combination with EuroSCORE II patient-, cardiac- and operation-related factors. The search date was 1 February 2015.

SEARCH OUTCOME

Eighty-six papers were found of which seven provided the best evidence for this topic [2–8]. A summary is presented in Table 1.

Table 1: Best evidence papers

Author, date, journal and country Study type	High-risk group	Outcomes	Key results	Comments
Mihos *et al.* (2014), J Heart Valve Dis, USA [2] Retrospective observational study	Fifty patients with infective endocarditis 22 MIMVS 28 ST	No different in-hospital mortality rate ($P = 0.25$) MIMVS had less composite complications ($P = 0.02$), incidence of sepsis ($P = 0.02$), use of blood products ($P = 0.004$), higher rate of repair ($P = 0.03$), shorter ICU length of stay ($P = 0.009$) No difference in survival rate at 2.5 years ($P = 0.33$)	In-hospital mortality: 5% MIMVS vs 14% ST, $P = 0.25$ Postoperative composite complications: 41% MIMVS vs 75% ST, $P = 0.02$ Incidence of sepsis: 0% MIMVS vs 21% ST, $P = 0.02$ Use of intraoperative blood products: 59% MIMVS vs 93% ST, $P = 0.004$ Rates of mitral valve repair: 55% MIMVS vs 25% ST, $P = 0.03$ ICU length of stay (h): 56 MIMVS vs 114 ST, $P = 0.009$ Survival rate at 2.5 years: 80% MIMVS vs 68% ST, $P = 0.33$	Conclusions: MIMVS for native mitral valve IE provided a safe and feasible alternative to conventional median ST surgery with improved outcomes conferred by valve repair Limitations: Small numbers, outcome to be also accounted to the superior number of repair performed in the MIMVS group
Tang *et al.* (2013), Innovation, USA [3] Propensity-matched study	One hundred and eighty patients with chronic renal impairment (creatinine of 1.3 mg/dl or greater) 90 MIMVS 90 ST	MIMVS had lower in-hospital mortality ($P = 0.037$), acute renal failure ($P = 0.05$), stroke ($P = 0.017$), pacemaker insertion ($P = 0.044$), chest drain output ($P < 0.001$)	Early mortality: 20% lower in MIMVS group ($P = 0.037$) (Mantel–Cox statistic) Acute renal failure: 10% MIMVS vs 21% ST, $P = 0.05$ Stroke: 1 vs 9%, $P = 0.017$ Permanent pacemaker insertion: 3% MIMVS vs 11% ST, $P = 0.044$ Chest tube outputs (ml): 503 MIMVS vs 1333 ST, $P < 0.001$	Conclusions: MIMVS approach was associated with lower postoperative mortality and morbidity in patients with impaired renal function Limitations: Number of matched patients with preoperative renal disease was small enough to limit statistical power in detecting effects of the ST versus the MIMVS approach
Iribarne *et al.* (2012), J Thorac Cardiovasc Surg, USA [4] Retrospective observational study	One hundred and seventy-five patients with age ≥75 70 MIMVS 105 ST	Mortality rate was similar in between groups ($P = 0.18$) MIMVS had prolonged CPB and cross-clamp time ($P = 0.037$ and $P = 0.01$), shorter postoperative length of stay ($P = 0.033$) No different rate of major postop complications ($P = 0.85$) and similar long-term survival ($P = 0.60$) MIMVS group had faster recovery of functional status and less resource utilization ($P = 0.007$)	Early mortality rate: 7.1% MIMVS vs 2.8% ST, $P = 0.18$ Cross-clamp time (min): 84.4 ± 4.0 MIMVS vs 75.2 ± 2.4 ST, $P = 0.037$ Bypass time (min): 135.7 ± 5.3 MIMVS vs 110.4 ± 3.0 ST, $P = 0.001$ Length of stay (days): 8.7 ± 0.72 MIMVS vs 11.7 ± 1.1 ST, $P = 0.033$ Similar major postoperative complications ($P = 0.85$) Long-term survival: 90% MIMVS vs 80.4% ST, $P = 0.60$ Median cost of hospitalization ($): 45 897 ± 2586 MIMVS vs 60 289 ± 4843 ST, $P = 0.007$	Conclusions: MIMVS in elderly patients was associated with slightly longer cross-clamp and CPB times but with equivalent morbidity and mortality and shorter hospitalization, decreased resource use and improved postoperative functional status Limitations: Retrospective analysis

Continued

Table 1: (*Continued*)

Author, date, journal and country Study type	High-risk group	Outcomes	Key results	Comments
			Discharge home: 78.1% MIMVS vs 58.2% ST, $P = 0.21$	
			Kaplan–Meier estimates showed faster rates of independent ambulation ($P = 0.039$) and independent sit-to-stand activity ($P = 0.003$) in the MIMVS group; No differences in time to independent stair climbing ($P = 0.31$)	
		Rate of readmission at 1 year was similar in between the two groups ($P = 0.54$)	No readmission rate differences at 1 year ($P = 0.54$)	
Holzhey *et al*. (2011), Ann Thorac Surg, Germany [5]	Two hundred and eighty-six patients with age >70	Early mortality was similar in between the two groups ($P = 0.082$)	30-day mortality: 7.7% MIMVS vs 6.3% ST, $P = 0.82$	Conclusions: MIMVS was at least as good and safe as ST in elderly patients
Propensity-matched study	143 MIMVS 143 ST	MIMVS had longer duration of surgery ($P = 0.001$), CPB and cross-clamp time ($P = 0.0001$ and 0.0015)	Duration of surgery (min): 186 ± 61 MIMVS vs 169 ± 59 ST, $P = 0.01$	Limitations: Retrospective analysis
			CPB time (min): 142 ± 54 MIMVS vs 102 ± 45 ST, $P = 0.0001$	
			Cross-clamp time (min): 74 ± 44 MIMVS vs 64 ± 28 ST, $P = 0.0015$	
		There was no difference in the rate of combined major adverse cardiac and cerebrovascular events ($P = 0.86$), or other postoperative outcomes	No different rate of combined major adverse cardiac and cerebrovascular events ($P = 0.86$), or other postoperative outcome	
		MIMVS had a lower rate of postop arrhythmias ($P = 0.023$) and pacemaker insertion ($P = 0.059$)	Postoperative arrhythmias: 50.3% MIMVS vs 65.7% ST, $P = 0.023$	
			Pacemaker implant: 10.5% MIMVS vs 18.9% ST, $P = 0.059$	
		Long-term survival was similar between the two groups ($P = 0.43$)	Long-term survival: 66 ± 5.6 vs 56 ± 5.5% at 5 years and 35 ± 12 vs 40 ± 7.9% at 8 years in the MIMVS and ST, respectively, $P = 0.43$	
Sharony *et al*. (2006), J Card Surg, USA [6] Retrospective observational study	Two hundred and seventy-seven patients with previous cardiac surgery 100 MIMVS 177 ST	Mortality was statistically significant lower in the MIMVS group ($P = 0.004$)	Early mortality rate: 5% MIMVS vs 21.4% ST, $P = 0.004$	Conclusions: MIMVS resulted in significant lower mortality rate than ST Limitations: Mixed group with minimally invasive aortic valve without the possibility to separate outcomes of interest for mitral rather than mortality

Continued

Table 1: (*Continued*)

Author, date, journal and country Study type	High-risk group	Outcomes	Key results	Comments
Bolotin *et al*. (2004), J Heart Valve Dis, USA [7] Retrospective observational study	Seventy-one patients with previous cardiac surgery 38 MIMVS 33 ST	MIMVS led to similar operative mortality ($P = 0.976$), similar CPB, operating room and ICU times ($P = 0.98$, 0.29 and 0.26, respectively) MIMVS had lower postop ventilation time ($P = 0.008$), reduced blood transfusion and blood product requirement ($P = 0.001$) and reduced length of hospital stay ($P = 0.001$)	Early mortality: 5.7% MIMVS vs 5.9% ST, $P = 0.976$ CPB time (min): 160 ± 10.5 MIMVS vs 157 ± 9.4 ST, $P = 0.98$ Operating room time (h): 4.5 ± 0.25 MIMVS vs 4.9 ± 0.32 ST, $P = 0.29$ ICU time (days): 2.44 ± 0.7 MIMVS vs 2.71 ± 0.5 ST, $P = 0.26$ Postoperative intubation time (h): 29.1 ± 8.9 MIMVS vs 38 ± 9.9 ST, $P = 0.008$ Blood transfusion (units): 2.86 ± 0.6 MIMVS vs 5.5 ± 0.5 ST, $P = 0.001$ Blood products (units): 5.4 ± 1.8 MIMVS vs 16.6 ± 1.6 ST, $P = 0.001$ Length of hospital stay (days): 7.1 ± 1.3 MIMVS vs 11.2 ± 1.1 ST, $P = 0.001$	Conclusions: MIMVS was performed safely and efficiently in patients with prior cardiac surgery and advantages include fewer red blood cell and blood product transfusions, as well as decreased intubation time and length of hospital stay Limitations: Retrospective study and there was a trend towards older patients and a significantly lower preoperative ejection fraction in the MIMVS group although more urgent operations were performed in the redo ST group
Burfeind *et al*. (2002), Ann Thorac Surg, USA [8] Retrospective observational study	Two hundred and fifteen patients with previous cardiac surgery 60 MIMVS 155 ST	Mortality was lower in the MIMVS group as well as number of red cell transfused, chest drain output whereas CPB time was shorter in the ST group	In-hospital mortality: 0/60 (0%, MIMVS) vs 21/155 (14%, ST) Red cell transfusion (units): 3 ± 4 MIMVS vs 12 ± 12 ST Chest tube output (ml): 352 ± 361 MIMVS vs 1683 ± 3939 ST CPB time (min): 208 ± 76 MIMVS vs 157 ± 53 ST	Conclusions: MIMVS was an acceptable alternative to ST in reoperation for mitral valve disease, with potential advantages of avoiding redo sternotomy and reducing the surgical incision; however, these benefits may come at the expense of longer CPB times Limitations: Retrospective analysis, small number

CPB: cardiopulmonary bypass; IE: infective endocarditis; MIMVS: minimally invasive mitral valve surgery; ST: sternotomy; ICU: intensive care unit.

BEST EVIDENCE TOPIC

RESULTS

All studies (but one which did not report separate outcomes for mitral surgery) concluded that MIMVS in high-risk patients led to reduced postoperative complications. In terms of mortality, MIMVS was comparable with ST.

Mihos *et al*. [2] retrospectively compared 22 MIMVS and 28 ST patients with infective endocarditis (IE). There were no differences in terms of baseline characteristics; chronicity of IE and disease burden were also similar in both groups. Mean CPB and cross-clamp time were longer in the MIMVS group ($P = 0.001$). There were no differences in terms of in-hospital mortality in between groups ($P = 0.25$). MIMVS group had fewer postoperative composite complications (41 vs 75%, $P = 0.02$), decreased incidence of sepsis (0 vs 21%, $P = 0.02$), less use of intraoperative blood products (59 vs 93%, $P = 0.004$), higher mitral valve repair rate (55 vs 25%, $P = 0.03$), shorter intensive care unit (ICU) length of stay (56 vs 114 h, $P = 0.009$), whereas there was no difference in survival rate at 2.5 years.

Tang *et al*. [3] in a propensity-matched study compared outcomes of 180 patients with chronic renal disease. Mortality was 20% lower in the MIMVS group ($P = 0.037$). Postoperative complications were also lower, such as acute renal failure (10 vs 21%, $P = 0.05$), stroke (1 vs 9%, $P = 0.017$), pacemaker insertion (3 vs 11%, $P = 0.044$) and chest tube outputs (503 vs 1333 ml, $P < 0.001$).

Iribarne *et al*. [4] reported outcomes in 75 patients above 75 years old, among them 70 were MIMVS and 105 ST. Minimally invasive technique was associated with prolonged cross-clamp and bypass time ($P = 0.037$ and 0.001) but with 3.1-day shorter

hospitalization ($P = 0.033$); there were no differences in terms of rate of major postoperative complications or long-term survival; however, MIMVS led to a lower cost of hospitalization ($P = 0.007$) and more common discharge to home, faster rates of independent ambulation ($P = 0.039$) and independent sit-to-stand activity ($P = 0.003$), although there were no differences in time to independent stair climbing ($P = 0.31$). There was no difference in terms of readmission rate at 1 year ($P = 0.31$) and in terms of long-term survival ($P = 0.60$) between groups.

Holzhey *et al*. [5] in a propensity-matched study analysed outcomes of 286 patients with age >70 (143 MIMVS vs 143 ST). MIMVS led to longer duration of surgery ($P = 0.01$), cardiopulmonary bypass ($P = 0.0001$) and cross-clamp time ($P = 0.0015$). There were no differences with regard to 30-day mortality ($P = 0.82$) or combined major adverse cardiac and cerebrovascular events ($P = 0.86$). The incidence of arrhythmias and pacemaker implants was higher in ST group ($P = 0.023$ and $P = 0.059$, respectively).

Sharony *et al*. [6] conducted an observational study in 270 patients with previous cardiac surgery, 100 and 177 were MIMVS and ST, respectively; mortality for MIMVS was significantly lower than ST ($P = 0.004$), other outcomes were amalgamated with minimally invasive aortic valve surgery, hence were not reported.

In a retrospective analysis, Bolotin *et al*. [7] compared 38 MIMVS and 33 ST mitral patients who had previous cardiac surgery. There was similar operative mortality in both groups ($P = 0.976$), similar cardiopulmonary bypass, operating room and ICU times, but shorter postoperative intubation time ($P = 0.008$), reduced blood transfusion requirements ($P = 0.001$) and reduced length of hospital stay in the MIMVS group ($P = 0.001$).

Burfeind *et al*. [8] performed a retrospective analysis on 60 and 155 MIMVS and ST mitral patients, respectively, who had previous cardiac surgery. In-hospital mortality was 0/60 (0%) vs 21/155 (14%), red cell transfusion was 3 ± 4 vs 12 ± 12 units, chest tube output was 352 ± 361 vs 1683 ± 3939 ml whereas cardiopulmonary bypass times were 208 ± 76 vs 157 ± 53 min for MIMVS and ST groups, respectively.

CLINICAL BOTTOM LINE

MIMVS has acceptable short- and long-term results in patients at high risks such as those who have undergone redo surgery, the elderly, those with renal impairment and IE. Despite the heterogeneous populations included, we conclude that MIMVS is at least as safe as conventional ST in these high-risk patient groups.

Conflict of interest: none declared.

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