Ministernotomy versus conventional sternotomy for aortic valve replacement: matched propensity score analysis of 808 patients†

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Abstract

OBJECTIVES: The proportion of minimally invasive approaches is rising in cardiac surgery, in part driven by increasing patient demand. This study aimed to perform a risk-adjusted comparison of mortality, rate of stroke and perioperative morbidity of aortic valve replacement (AVR) conducted through either partial ministernotomy or conventional sternotomy.

METHODS: Between July 2009 and July 2012, data from 984 consecutive patients undergoing isolated AVR were prospectively recorded. In 44.3% (n = 436), the less invasive partial ministernotomy was used. Propensity score matching was performed based on 15 preoperative risk factors to correct for selection bias. In-hospital mortality, stroke rate as well as other major complications in the minimally invasive group and conventional sternotomy group were compared in 404 matched patient pairs (total 808).

RESULTS: In-hospital mortality and rate of postoperative intra-aortic balloon pump use were identical for propensity-matched patients, 1.0% (4 in each group). The rate of stroke [OR (95% confidence interval (CI)): 0.80 (0.22–2.98)], perioperative myocardial infarction [OR (95% CI): 2.00 (0.18–22.06)], low-output syndrome [OR (95% CI): 0.90 (0.37–2.22)], new onset of dialysis [OR (95% CI): 1.25 (0.49–3.17)] and re-exploration for bleeding [OR (95% CI): 0.88 (0.50–1.56)] were similar. Likewise, resource utilization (operation time, duration of stay in the intensive care unit and in-hospital stay) and valve selection (type and size) was not affected by the surgical approach either.

CONCLUSIONS: AVR can be safely conducted through a partial ministernotomy. This approach is not associated with an increased rate of complications. However, wide CIs reflect the still prevailing statistical uncertainty in estimates, not excluding patient-relevant differences between approaches. Large trials, which also address end points, such as postoperative pain, duration of postoperative recovery and quality of life, are needed to clarify the role of minimally invasive AVR.

Keywords: Aortic valve replacement • Minimally invasive cardiac surgery • Propensity score analysis

INTRODUCTION

Nowadays, aortic valve replacements (AVRs) can be performed with very low morbidity and mortality. In the 1990s, less invasive approaches were developed for the benefit of the patients, involving decreased pain and cosmetic advantages [1]. The limited exposure via the small incision could present more surgical difficulties than conventional AVR with a median full sternotomy. However, patients are increasingly self-educated and often request less invasive operations. Various techniques have been developed for a minimally invasive approach for AVR (MIC-AVR): upper or lower ministernotomy, small right anterolateral thoracotomy, inverse-T partial sternotomy, transverse sternotomy and right parasternal incision. Observational studies have also shown some benefits of the less invasive approach (reduced blood loss, fewer blood transfusions, shortened length of hospital stay, preservation of lung function, less incidence of atrial fibrillation, more rapid return to functional activity [2–7]). However, potential disadvantages of minimally invasive approaches have also been reported, such as longer cardiopulmonary bypass (CPB) time and cross-clamp time (CCT), difficulties with deairing and increased risk of paravalvular leak [8–11]. Although previous clinical studies have reached different conclusions, there have been few confirmatory large studies.

We analysed 984 patients who underwent isolated AVR, and performed a propensity score (PS)-matched comparison of patients who underwent MIC-AVR via upper ministernotomy with patients who had median full sternotomy.
MATERIALS AND METHODS

Patients

Between July 2009 and July 2012, a total of 984 patients underwent isolated AVR at our institution. Data were prospectively collected and entered into a database. Conventional aortic valve replacement (CONV-AVR) was used in 55.7% (n = 548) of patients, while 44.3% (n = 436) underwent AVRs via partial upper ministernotomy (MIC-AVR). Surgeons chose which method to use.

Surgical techniques

Conventional general anaesthesia was used in all patients. External defibrillator pads were placed. Transoesophageal echocardiography (TOE) was set up. MIC-AVR patients had a 7–8 cm skin incision from the sternomanubrial junction to the level of the third or fourth intercostal space. The upper sternotomy was performed by a standard sternal saw and extended from the midline into the right fourth intercostal space. After pericardiectomy and pericardial traction sutures, the ascending aorta and right atrium were exposed. Patients were fully heparinized (target activated clotting time ≥450 s). Aortic cannulation (EOPA 3D™ Arterial Cannulae, Medtronic, Germany) and a dual-stage venous cannula (VC2™ Atrial Caval Venous Cannulae, Medtronic, Germany) were placed. A 1 cm subxiphoidal skin incision was made and tunneled into the pericardial cavity. Through this tunnel, the venous cannula was inserted via the right atrial appendage into the inferior vena cava. A left-ventricular vent was inserted from the upper right pulmonary vein. The extracorporeal circulation (ECC) system comprised a roller pump (Maquet, Rastatt, Germany), a membrane oxygenator (Quadrox-I Adult, Maquet, Rastatt, Germany) and tubing system (Raumedic, München, Germany). The operations were performed with moderate cooling. After aortic cross-clamping, warm Calafiore cardioplegic solution was instilled via the aortic root. In cases of significant aortic insufficiency, cardioplegia was administered directly into the coronary ostia. Carbon dioxide was continuously infused in the operative field to decrease the risk of air embolism. AVR was then performed by the standard technique. Before declamping, a ventricular pacing wire was placed on the anterior surface of the right-ventricular wall. After weaning from ECC and confirming the function of the prosthetic valve by TOE, protamine was administered. De-airing of the heart was performed with an aortic needle vent with TOE guidance. A pericardial drainage tube was placed from the same incision as for the prior insertion of the venous cannula before.

Patients in both groups received high molecular-weight heparin intravenously, aiming for an aPTT of 40–60 s. On the second postoperative day, all patients were placed on warfarin orally, plus weight-adjusted subcutaneous low molecular-weight heparin. The target of the international normalized ratio level was 2.0–3.0 for biological valves, and 2.5–3.5 for mechanical valves. Patients with biological valves received warfarin for 3 months postoperatively, and then warfarin was switched to 100 mg of acetylsalicylic acid. Patients with mechanical valves received lifelong warfarin.

Preoperative patient characteristics

The following preoperative variables were recorded for each patient: age, sex, body mass index (BMI), left-ventricular ejection fraction (LVEF), treated hypertension, diabetes mellitus, chronic obstructive pulmonary disease (COPD), renal failure (requiring dialysis or creatinine ≥200 mg/dl), preoperative stroke, peripheral arterial occlusive disease (PAOD) stage II or higher, at least one previous cardiac surgical procedure, cerebrovascular disease, heart failure classified by New York Heart Association Functional Classification, European System for Cardiac Operative Risk Evaluation (EuroSCORE) and AKL score (German Aortic Valve Score) [12]. All 15 variables were included into the PS model for risk adjustment.

Categorical and continuous outcomes

Primary end points were death before hospital discharge and new stroke. Additional categorical outcomes were perioperative myocardial infarction (ST-segment anomalies and/or new Q waves) associated with significant troponin I elevation, low-output syndrome (LOS) [cardiac index ≤2.0 l/(min × m^2 body surface area)], postoperative intra-aortic balloon pump (IABP) support, new indication for postoperative dialysis and re-exploration for bleeding. Continuous outcomes were operative time, cross-clamp time, CPB time, hours on the ventilator, days in intensive care, duration of hospitalization and size of prosthetic valves.

Statistical analysis

Because of non-randomized group assignment, we performed a matched PS analysis [13] to assess treatment effects. A logistic regression model including all the covariates from Table 1 was used to estimate the PS. Following recommendations in the current literature, 1:1 matching was performed with the logit-transformed PS. For this, an optimal-matching algorithm with a caliper width of 0.1 standard deviations (SDs) of the linear predictor was used. We initially had planned to use a caliper width of 0.2, but this was seen to yield still too large imbalances between treatment groups. Balance of risk factors was judged by the recently proposed z-difference [14]. This balance measure has the advantage of assessing binary, ordinal and continuous variables on the same scale. Moreover, plotting z-differences before and after matching in a Q–Q plot allows comparing balance to that of a randomized trial and a perfectly matched PS analysis. To measure the treatment effect, we calculated odds ratios (ORs) for binary and differences in means for continuous end points. All analyses adjusted for PS matching using conditional methods, that is, conditional logistic regression and linear mixed models for binary and continuous end points, respectively. As PS matching inevitably reduces sample size, we performed a PS-based sensitivity analysis on the complete sample. For this task, we used a multivariate adjustment for the PS, that is, we calculated standard regression models with the respective clinical outcomes as the dependent and the treatment and the logit of the PS as independent variables. Parameter estimates are given with their 95% confidence intervals (CIs). All calculations were performed with SAS 9.3 (SAS Institute, Inc., Cary, NC, USA).

RESULTS

Table 1 summarized the preoperative patient variables before and after PS matching. Between July 2009 and July 2012, a total of 984
Table 1: Preoperative patient variables before and after propensity score matching

<table>
<thead>
<tr>
<th>Variable</th>
<th>All patients (n = 984)</th>
<th>Propensity score-matched pairs (n = 808)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>MIC (n = 436)</td>
<td>Sternotomy (n = 548)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>z-difference</td>
</tr>
<tr>
<td>Age [years] (SD)</td>
<td>68 (12)</td>
<td>70 (11)</td>
</tr>
<tr>
<td>Female gender (%)</td>
<td>42</td>
<td>48</td>
</tr>
<tr>
<td>BMI [kg/m²] (SD)</td>
<td>27 (5)</td>
<td>28 (5)</td>
</tr>
<tr>
<td>LVEF (%) (SD)</td>
<td>60 (10)</td>
<td>58 (12)</td>
</tr>
<tr>
<td>Hypertension (%)</td>
<td>67</td>
<td>75</td>
</tr>
<tr>
<td>Diabetes mellitus (%)</td>
<td>17</td>
<td>23</td>
</tr>
<tr>
<td>COPD (%)</td>
<td>7</td>
<td>12</td>
</tr>
<tr>
<td>Renal insufficiency (%)</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Stroke (%)</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>PAOD (%)</td>
<td>3</td>
<td>6</td>
</tr>
<tr>
<td>CVD (%)</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>At least one previous cardiac surgery (%)</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>NYHA class (%)</td>
<td>I</td>
<td>13</td>
</tr>
<tr>
<td></td>
<td>II</td>
<td>41</td>
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<td>III</td>
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SD: standard deviation; BMI: body mass index; COPD: chronic obstructive pulmonary disease; CVD: cerebrovascular disease; IABP: intra-aortic balloon pump; LVEF: left-ventricular ejection fraction; MIC: minimally invasive approach; PAOD: peripheral arterial occlusive disease.
patients underwent isolated AVR, 548 (55.7%) with CONV-AVR and 436 (44.3%) with MIC-AVR. PS matching resulted in 404 pairs not differing in terms of their preoperative risk factors. According to the z-differences in Table 1 and the Q–Q plot in Fig. 1, balance of risk factors has dramatically improved after PS matching. In the matched sample, balance is better than in a randomized trial and very close to a perfectly matched PS analysis.

Table 2 depicts the results for the categorical and continuous outcomes in the propensity score-matched sample. Mortality was identical in both approaches leading to an OR of 1.0 with a 95% CI of 0.25–4.00. There were no significant differences in stroke, the combined end point of mortality or stroke, perioperative myocardial infarction, LOS, postoperative IABP, new-onset dialysis or re-exploration rate (Table 2). The operation time (difference in means: 6.2 min, 95% CI: 1.6–10.8) and cross-clamp time (difference in means: 4.1 min, 95% CI: 2.0–6.2) were slightly longer in the MIC-AVR group than in the CONV-AVR group. No difference was found between groups with respect to CPB time, duration of artificial ventilation or duration of hospitalization (Table 2). The size of implanted valves was the same in both groups (difference in means: 0.4 mm, 95% CI: 0.1–0.6). Results from the sensitivity analysis using multivariate adjustment for the PS in the whole sample were similar to the results in the matched sample.

**DISCUSSION**

The PS analysis showed no significant differences between MIC-AVR and CONV-AVR for perioperative mortality, nor for the incidence of the complications cerebrovascular accident (CVA), a combined end point of death or CVA, perioperative myocardial infarction, LOS, postoperative IABP, renal failure and re-exploration. MIC-AVR was introduced in the 1990s [1] and the surgical technique has been improved and refined in the 20 years since. There are many reports of advantages of MIC-AVR, including lower morbidity, superior cosmetic results, reduced tissue trauma, reduced blood transfusion, reduced incidence of atrial fibrillation, preservation of postoperative respiratory function, shorter ventilation time and shorter hospital length of stay [2–7]. However, the potential disadvantages of MIC-AVR have also been reported, namely that MIC-AVR is technically demanding with a limited surgical field, causing longer cross-clamp and CPB time, which in turn increase morbidity and mortality [8–11]. There is concern about higher incidence of neurological complications caused by inadequate de-airing of the heart.

In February 2009, we started our series of minimally invasive surgical interventions at the Heart and Diabetes Center North-Rhine Westphalia. We confirmed that minimally invasive approaches can provide equivalent results to conventional procedures. We gradually

![Q-Q plot for judging balance (via z-differences; see Table 1) of the 15 preoperative patient variables before and after propensity score matching. z-differences from a randomized trial would follow the broken light blue line, z-differences from a perfectly matched propensity score analysis would follow the solid light blue line.](image-url)
shifted isolated valve operations to minimally invasive approaches, now becoming our first-line strategy.

The minimally invasive approaches for AVR most commonly used today are right minithoracotomy and upper ministernotomy. In contrast to right minithoracotomy, upper ministernotomy provides a wider operative view for the surgeon and assistant, and enables full access to the ascending aorta and arch. This is particularly important in patients with a diffusely sclerotic aorta, where cannulation and cross-clamping should be carefully performed. There are some other advantages in the upper ministernotomy approach, compared with the right minithoracotomy approach. The upper ministernotomy can be easily converted to a median full sternotomy. The right internal mammary artery is generally preserved, which contributes to sternal healing. Femoral incision and cannulation can be avoided, which is needed in the right minithoracotomy approach. Femoral cannulation may cause greater neurological consequences, and there is a risk of embolism from iliac or abdominal aortic calcifications, as well as a risk of dissection with retrograde flow [15]. Limited exposure of the heart is one of the potential disadvantages of MIC-AVR, making assessment of the volume load of the ventricles, removal of air from the heart and the operative procedure itself all difficult. In our procedure, the venous cannula is inserted from the subxiphoidal small skin incision, where the pericardial drainage is placed after the AVR procedure. This does not hinder the operative field, but rather enables good exposure by caudally drawing the venous cannula, which can remove the right atrial appendage from the operative field completely, facilitating the placement of annular sutures and tying of knots. Adequate exposure of the aorta and the right atrium is important in order to achieve favourable results with MIC-AVR. Johnston et al. [3] reported that 18 out of 34 conversions to median full sternotomy occurred because adequate exposure could not be obtained. Tabata et al. [16] reported that the incidence rate of conversion from upper ministernotomy was 2.6% and the most common reasons were bleeding, ventricular dysfunction and poor exposure, and that the mortality rate of the converted cases was 33.3%. Conversions are often associated with serious morbidity and mortality. Tabata et al. used a retrograde cardioplegia catheter placed into the coronary sinus through the right atrial appendage. We did not use retrograde cardioplegia because placing the retrograde cardioplegia cannula with a limited operative field is more difficult than via a median full sternotomy, and it is not absolutely necessary. There is a risk of coronary sinus injury from the manoeuvre for placement of a retrograde cardioplegia cannula, leading to mandatory conversion to full sternotomy in some cases [16].

The difficulty of de-airing of the heart at the end of the procedure is suggested as one of the disadvantages of MIC-AVR. By continuous flow of carbon dioxide into the surgical field, aortic needle aspiration and TOE confirmation of the absence of air bubbles, sufficient de-airing of the heart can be achieved. Some studies reported no statistical difference in neurological outcome between MIC-AVR and CONV-AVR [7, 17]. However, retrograde arterial perfusion is associated with increased neurological risk [17]. We performed all operations in this AVR series with antegrade perfusion, and we found no significant difference in the incidence of stroke (1.0% in MIC-AVR, 1.2% in CONV-AVR, OR: 0.8, 95% CI: 0.22–2.98). The incidence of perioperative stroke in AVR is not associated with the choice between a minimally invasive approach and conventional sternotomy, but with other factors, such as retrograde perfusion, atrial fibrillation, age or cerebrovascular disease.

In our series, we found no patient with significant paravalvular leakage (PVL) that required a second aortic valve operation. We performed postoperative transthoracic echocardiography on all patients before discharge. Christiansen et al. [10] reported no early PVL in either group, but minor PVL at the 1-year follow-up in 18.2% of the MIC-AVR group and 13.0% in the CONV-AVR group. Although we do not think that the minimally invasive approach itself causes a higher incidence of PVL, further investigation could be needed for long-term results.

Some studies demonstrated decreased length of stay, less postoperative pain, less pain medication usage and a faster return to normal activity in MIC-AVR groups, compared with CONV-AVR [3–7]. In our series, there was no significant difference in length of hospital stay. However, in Germany, duration of hospitalization is mostly determined by reimbursement issues based on the diagnosis-related groups (DRGs) system and is therefore unsuitable for gauging the postoperative course.

The average operation time and cross-clamp time were slightly but statistically significantly longer in the MIC-AVR group (162 vs 155 min and 59 vs 54 min, respectively). We do not think that these differences were clinically relevant (6.2 min, 95% CI: 1.6–10.8, and 4.1 min, 95% CI: 2.0–6.2, respectively). Although some studies reported that one of the disadvantages of MIC-AVR was the prolongation of CPB time, which is associated with higher rates of morbidity and mortality [8–10], in our series there was no significant difference in CPB time (79.2 vs 79.7 min). Prolongation of CPB time could be associated with the development of a systemic inflammatory response syndrome, which can cause, in turn, organ dysfunction [18, 19]. However, many studies reported that MIC-AVR has many benefits, such as less blood transfusion, lower incidence of atrial fibrillation, preservation of postoperative respiratory function and shorter ventilation time, although MIC-AVR had a significantly longer CPB time than CONV-AVR. In a recent meta-analysis of 26 studies on 4586 patients, Brown et al. [6] demonstrated that the CCT and CPB time were longer in the MIC-AVR group (7.9 and 11.5 min as the weighted mean difference, respectively), although these differences were probably not clinically important. Cardiac surgery with a minimally invasive approach can reduce the inflammatory insult by minimizing surgical trauma and tissue manipulation [19]. In addition, less bleeding and less blood transfusion lead to a decrease in inflammatory response. A smaller area of exposed sternal bone marrow in the ministernotomy approach and minimized surgical dissection can reduce bleeding compared with the median full sternotomy approach.

Better stability of the sternum and thorax with MIC-AVR prevents sternal dehiscence and deep wound infection, helps patients’ respiratory function and leads to earlier and easier mobilization and return to daily life activities. These benefits are particularly important for elderly patients, more likely to be associated with diabetes mellitus, COPD, renal insufficiency and osteoporosis, which are well known as risks of sternal wound infection.

In our analysis, the median time to extubation was shorter in the MIC-AVR group (median: 7.6 h vs 7.8 h, respectively), and other studies have also indicated that MIC operations were associated with shortening of ventilation time, which can relieve patients sooner from discomfort and pain of ventilation, and avoid postoperative respiratory complications [2, 3, 6].

CONV-AVR isfavoured in patients with significant obesity or chest wall abnormality, which makes it difficult to obtain adequate exposure because of the depth of incision. In addition, defibrillation with external defibrillation pads may occasionally be difficult...
in patients with obesity, such as those with a BMI >30 [11]. Santana et al. [20] demonstrated that minimally invasive valve surgery could be performed as safely in obese patients as median sternotomy, and adequate exposure of the surgical field was obtained in all minimally invasive operations, although the CPB time was longer in the minimally invasive group than the median sternotomy group (median 129 and 96 min, respectively). Salis et al. [21] demonstrated by an adjusted analysis that increasing CPB duration, by 30-min increments, was independently associated with postoperative death and complications. The indication of MIC-AVR in obese patients should be deliberated in order to avoid prolongation of CPB time. Patients with coronary artery disease or other valvular diseases that may require concomitant procedures are not considered optimal for MIC-AVR. Elderly patients undergoing cardiac surgery are more likely to be suffering from chronic disorders. All of the potential advantages of MIC-AVR, including improvement in postoperative pain and respiratory function, as well as earlier return to daily activities, are greater benefits for patients of advanced aged than the cosmetic benefit.

Limitations

This study is limited as a single-centre experience, based on retrospective analysis of our institutional observational prospectively collected database. The surgical teams that performed the operations for each approach were different, introducing a potential confounder. The present study lacked assessment of patient satisfaction, postoperative pain and cost-effectiveness, which are also important outcomes that need to be further researched. PS analysis was used to adjust for differences in preoperative risk factors. This analysis is useful for reducing bias in observational studies.

Whether risk-adjusted observational studies or randomized, controlled trials (RCTs) are superior in providing the clearest conclusions on true treatment value is currently under debate: randomization can control known and unknown risk factors, ensuring complete internal validity. Disadvantages of RCTs include patient selection, that is, they do not represent the typical day-to-day patient population, and have insufficient power to detect differences between infrequent events. Observational studies, on the other hand, represent large unselected populations with high external validity, but are limited because they are based on statistical models designed for risk adjustment, which cannot correct for all possible, and especially not for the unknown or unobserved, confounders. It is commonly believed that such population differences between observational studies and RCTs are the reason for apparent differences between treatment effects.

CONCLUSION

Our risk-adjusted study showed that AVR can be safely conducted through a partial ministernotomy. This approach is not associated with an increased rate of complications. However, wide CIs reflect the still prevailing statistical uncertainty in estimates, not excluding patient-relevant differences between approaches. Large trials, which also address end points, such as postoperative pain, duration of postoperative recovery and quality-of-life, are needed to clarify the role of minimally invasive AVR.

Conflict of interest: none declared.

REFERENCES


APPENDIX. CONFERENCE DISCUSSION

Dr M. Rinaldi (Turin, Italy): This is a large cohort study of more than 800 patients with a very sophisticated statistical analysis. You have done a propensity score with a Z-difference balance. You have clearly demonstrated the non-inferiority of ministernotomy compared with full sternotomy in aortic valve replacement: basically 1% mortality, 1% stroke, is the same as in sternotomy.
But the study actually failed to show any advantage, especially regarding the ICU stay, ventilation time, and better lung function, as other studies have already shown. Watch your OR movie, I noted that your surgical approach was quite invasive. Maybe you could have used a less invasive approach, driving your sternotomy into the third intercostal space, avoiding spreading the sternum too much, and avoiding central cannulation. In this case I advise percutaneous venous cannulation through the femoral vein, which is very safe and it could reduce your percentage of A-Fib, for instance. Another technical point: it’s very risky to put a vent into the left ventricle through the upper left pulmonary vein without manual control.

So I would like to know your opinion about this less invasive approach which I prefer. Don’t you think that its use would have changed things in terms of intensive care unit stay, ventilation time, etc? This is my first question.

Secondly, you don’t give us any information whatsoever about the number of red packed cells transfused, and the amount of bleeding from the drain; you present only the percentage of rethoracotomy for bleeding in these two groups. I would expect an advantage in these percentages for the ministernotomy group. The third point is a comment and a question in regard to the high-risk population. What you have done in applying this propensity score is to exclude the high-risk patient from your analysis. This is too bad, because I think that these high-risk patients, for example obese patients, are the ones that can benefit more from this mini-invasive technique. Would you comment on that as well.

**Dr Furukawa**: The first question was about the advantages of MIC-AVR. Some studies have already reported that MIC-AVR has a lot of advantages. But the aim of our study was more to describe the safety and efficacy of introducing MIC-AVR in our institution. This study reports only three years, from 2009 to 2012. We are right now involved in the analysis of these data and we have not yet looked at our data on blood transfusion. Femoral cannulation is associated with some complications, for example, infection, stroke, and the vascular problem.

**Dr Rinaldi**: I agree – and I’m sorry to interrupt you - I would always do an antegrade perfusion cannulating the arch. What I was questioning is venous cannulation which is much easier through the femoral vein percutaneously.

**Dr Furukawa**: As I’ve shown, the venous cannula doesn’t prevent the operative procedure. It also helps us to obtain good exposure and, in my opinion, it is also an advantage for our procedure.

Concerning your question about high-risk or obese patients, to be honest, in our institution we do not yet have clear-cut criteria for MIC-AVR. But in my opinion, obese patients or patients with a greater distance between the sternum and aorta, may be not optimal for MIC-AVR because the operation for such patients is, of course, more difficult than for normal patients. I think that an operation through minimal access but with a very long operative time, or very long cardiopulmonary bypass time, cannot simply be named minimally invasive surgery, this is my opinion.

**Dr O. Wendler** (London, United Kingdom): I think in fairness to the speaker and to the group presenting the data, one needs to say that they are absolutely right, of course, in the fact that there is no difference in terms of mortality between the two groups. But the reason for that is not because the minimally invasive group has done so badly but actually because the conventional surgery group has done so very well indeed. If you compare the mortalities, here 1%, in the other paper it was 0.4%, but the difference in this presentation is that the conventional group has a mortality of 1% instead of 2.4% as before. Therefore I think that the authors have done quite a good job.

**Dr S. Saleh** (Amman, Jordan): Very interesting presentation. But nothing was mentioned about a mini approach, ministernotomy, transverse sternotomy with maybe extension into the third space on both sides giving a very good exposure of the aorta. And the sternum handles very well, it’s a transverse anatomy, so it’s not a big bone. And we found this, we do it in all patients whose coronaries are normal, because most of the time the internal mammarys are going to go. And patients seem to mobilize easier out of bed and move around and so on with no shoulder pain, they lift up their shoulders and their arms very easily. Nobody mentioned such an approach.

**Dr Wendler**: It works also in the second intercostal space. But let’s move on.