Associations between valve repair and reduced operative mortality in 21 056 mitral/tricuspid double valve procedures†

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Abstract

OBJECTIVES: Repair of either the mitral (M) or tricuspid (T) valve in single valve surgery is associated with reduced operative mortality. It is unclear, however, how valve repair influences mortality in combined MT procedures. This topic was evaluated in the Society of Thoracic Surgeons database.

METHODS: From 1993 through 2007, 21 056 patients underwent concomitant MT valve surgery. Group I had M&T replacement (n = 1130), Group II had M repair and T replacement (n = 216), Group III had M replacement and T repair (n = 11 448) and Group IV had both M&T repair (n = 8262). Unadjusted operative mortalities (UOMs) and morbidities of Groups I–IV were assessed, and logistic regression analysis adjusted for differences in baseline patient profiles. Surgical outcomes were expressed as UOMs, and also adjusted odds ratios (ORs) for mortality.

RESULTS: Group IV was older with more coronary artery bypass grafting and generally less comorbidity, and Group I had more endocarditis, mitral stenosis and reoperation. UOM values were: Group I = 16.8, Group II = 10.2, Group III = 10.3 and Group IV = 8.0%. In the multivariable model, factors influencing mortality included: age (per 5-year increase, OR = 1.15), renal failure with dialysis (OR = 3.22), emergency status (OR = 3.14), second or more reoperations (OR = 1.92) and later surgical date (OR = 0.63). Both M and T repair were independently associated with lower operative mortalities vs prosthetic valve replacement (OR = 0.83 and 0.60, respectively, P < 0.003).

CONCLUSIONS: In MT double valve surgery, repair of either valve is associated with lower risk-adjusted mortality when compared with replacement and, when feasible, multiple valve repair should be considered the optimal treatment. Within the limitations of observational analysis, these data support continued efforts to increase M&T repair rates.

Keywords: Multiple valve surgery • Mitral valve repair • Tricuspid valve repair

INTRODUCTION

It is now established that repair of either atrio-ventricular valve is independently associated with improved outcomes when compared with prosthetic valve replacement [1–5]. A similar principle, however, has not been investigated for multiple valve surgery involving both the mitral (M) and tricuspid (T) valves. Surgery for multiple valve disease comprises 11–12 % of valve cases performed in North America [6, 7], but most previous analyses have been limited by single-centre experiences or small sample sizes [8–15]. To overcome this limitation, preoperative risk profiles and postoperative outcomes of patients undergoing combined M and T double valve surgery were analysed over a 15-year period from 1993 through 2007 using data from the Society of Thoracic Surgeons (STS) Database. Particular emphasis was placed on assessing risk-adjusted prognostic benefits associated with performing M and T valve repair in this setting.

MATERIALS AND METHODS

The STS database currently records >90% of adult cardiac surgical procedures in North America. The STS data set contains a comprehensive array of prognostic variables, a detailed description of which can be viewed online (http://www.sts.org). Since

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1993, individual patient information has been harvested quarterly, including baseline and operative characteristics, and mortality and morbidity outcome statistics. Patients selected for this study underwent MT double valve surgery over a 15-year period from January 1993 through December 2007. All patients were analysed, irrespective of the severity of risk profiles. Patients receiving arrhythmia ablations were included. Patients were excluded only if they had pulmonary valve operations, aortic dissection, aortic root reconstruction, aortic aneurysm, cardiac trauma, cardiac transplant or other significant non-cardiac procedures. This process yielded a total of 21,056 MT double valve procedures for analysis. There were: 1130 M&T replacements (Group I), 216 M repair and T replacements (Group II), 11,448 M replacement and T repairs (Group III) and 8262 M&T repairs (Group IV).

Pearson $\chi^2$ tests compared the four procedural groups with respect to all STS variables (http://www.sts.org): gender, diabetes, hypertension, dyslipidaemia, renal failure, infective endocarditis, chronic lung disease, previous cardiovascular interventions (including first valve surgery after previous coronary artery bypass, first-time redo valve surgery after one valve operation and second or more reoperations after several prior valve procedures), presence of congestive heart failure, cardiogenic shock, New York Heart Association class, status of presentation, concomitant coronary artery bypass grafting and preoperative intra-aortic balloon pump, etc. Kruskal-Wallis tests compared valve categories with respect to age and ejection fraction (EF). Unadjusted operative mortalities (UOMs) and major complications, as well as a composite of mortality and morbidity, were compared using $\chi^2$ tests. These and all other STS data variables (http://www.sts.org) were included in the subsequent multivariable modelling procedure. The STS definition for operative mortality was: any death occurring during the index hospitalization, no matter the time, or any death in the first 30 days, no matter the venue.

A logistic regression model was developed to compute adjusted odds ratios (ORs) for mortality for the various risk factors in each procedural group. Within the model, less than 5% of data were missing and were handled as follows: categorical variables were imputed to their most common value and continuous variables were imputed to median values using the non-missing value. For body surface area, missing values were imputed to conditional median on gender. The independent effects of individual variables on mortality were assessed by comparing risk-adjusted ORs for mortality, including the primary variables of interest: repair vs replacement of the M and T valves. Finally, the 15-year study time was divided into three 5-year periods: 1993-1997 = Period I; 1998–2002 = Period II and 2003–2007 = Period III, and Periods II and III were referenced to Period I as independent covariates in the model. This procedure allowed independent evaluation of time-varying improvements in general patient care. This study was approved by the Duke University Institutional Review Board.

RESULTS

Baseline characteristics of the 21,056 MT procedures analysed in this study and sub-grouped for the four specific operations are summarized in Table 1. Patient profiles differed significantly between the four procedural groups. Group IV (M&T repair) generally had less severe risk profiles, except for older age and more coronary bypass. Throughout the study, Group I (M&T replacement) was <10% of overall patients. Almost half of Group I procedures were reoperations, while 31% had mitral stenosis. Group II consistently accounted for only 1% of patients and seemed to be somewhat unique, with a higher incidence of repair and endocarditis. Comparing Groups III with IV, Group III had more reoperation, endocarditis and mitral stenosis, and differences in baseline characteristics could (at least partially) explain the choice of M valve replacement over repair.

Over the entire 15 years, 40% of MT patients received M valve repair, and 94% had T valve repair. However, this number is skewed towards the increasing STS database sample in more recent years. Over the duration of the study, repair rates increased for both valves, so that for Period I, repair values were M = 21.5 and T = 89.5%, and valve repair increased in Period III to M = 48 and T = 95%, respectively. This trend influenced the prevalence of the four procedures over time, and the distribution of patients (across Groups I–II–III–IV) changed significantly: Period I (9.4, 1.1, 69.1 and 20.4%); Period II (6.1, 1.0, 59.2 and 33.7%); Period III (4.0, 1.0, 48.3 and 46.6%). Thus, M&T replacement fell by over 50%, and M&T repair more than doubled. Throughout all periods, M replacement and T repair was the dominant procedure; but over time, this approach gradually converted to M&T repair. In Period III, M repair and replacement rates became approximately equivalent. As described above, the M repair and T replacement procedure seemed to occur at a constant 1% throughout the 15 years.

In Table 2, UOMs and morbidities are listed overall and for the four individual procedures. Also documented are the overall UOM data for the three 5-year periods. Overall, UOM for the 15 years was 9.7%, and a gradient in UOM existed from 16.8 in Group I, to 10.2 (Group II) and 10.3% (Group III) if one valve was repaired, to 8.0% for repair of both M&T valves (P < 0.0001). A similar gradient existed for most morbidities, especially prolonged ventilation, so that the unadjusted composite of mortality and morbidity also decreased significantly with more valves repaired (P < 0.0001; Table 2). One consistent finding, however, was that UOM for MT surgery was consistently twice that observed for single valve procedures [1–6, 15–17].

Results of the logistic regression analysis are summarized in Table 3, with variables ranked according to the magnitude of adjusted ORs for mortality. As with most cardiac surgery, preoperative renal failure/dialysis, emergency presentation and reoperation constituted the highest risk variables. Age in the setting of elderly patients also was very important. The adjusted OR from Period I to 2 was 0.78, and from Period I to III was 0.63. When tested as independent covariates in the logistic regression, valve repair vs replacement also was protective for mortality: 0.83 for the M valve and 0.60 for the T valve. STS perioperative variables not listed in this table did not prove to be significant in the model.

DISCUSSION

Operative mortality for multiple valve surgery is twice that for single valves [6], and this subject represents a prime candidate for outcome improvement. Baseline risk variables for multiple valve patients are little different from single valves, and ranking/magnitude of risk factors for mortality are also similar [7]. While the exact cause of higher multiple valve mortality is not clear, it may relate to something as simple as longer cardiopulmonary bypass and cardiac arrest times. Specific advances in
cardiopulmonary bypass, myocardial protection and postoperative care techniques could improve results [18]. A consistent trend in the STS database has been decreasing valve surgery mortality over time [6], and this trend is also evident in the MT population (Tables 2 and 3). Several different factors may be influencing this decline. First, time-varying independent outcome improvements are apparent (Table 3) and are consistent with general progress in the quality of patient care. Improvements in MT mortality may also relate to time-dependent conversion from valve replacement to lower risk reparative procedures. Over the 15 years, the incidence of M&T replacement fell by half, and M&T repair more than doubled, and when combined with the general risk reduction, overall UOM fell by 29% (Table 2).

Evidence continues to accumulate that autologous valve repair (when compared with prosthetic replacement) is associated with reduced early mortality [1–5]. The risk-adjusted ORs in this study were 0.83 for M repair and 0.60 for T repair. This finding has been uniform in the STS database, with a direction and magnitude that is consistent for every valve procedure subgroup examined [2, 19]. Risk-adjusted late survival also has been better after mitral repair in studies of the single valve population [3]. Thus, these observations almost have to be valid, although in observational studies such as these, one must properly qualify the findings. In MT surgery, confounding variables and treatment selection biases were certainly operative. In fact, as seen in Table 1, differences in baseline characteristics between groups explain, to some extent, several selection biases that seemed to be involved with the procedural choice. Group I patients (only 4% of MT operations in Period III) had a 47% incidence of reoperation, and surgery for prosthetic valve or repair failure could have mandated M&T replacement. Moreover, active endocarditis was present in 7% and mitral stenosis in another 31%. Thus, higher mortality for valve replacement could have been somewhat due to greater surgical complexity associated with these pathologies, even though all of the variables (such as reoperation and endocarditis) were independently evaluated in the model.

### Table 1: Differences in important baseline risk factors for the four procedural groups

<table>
<thead>
<tr>
<th>Preoperative risk factor</th>
<th>All</th>
<th>Gp I</th>
<th>Gp II</th>
<th>Gp III</th>
<th>Gp IV</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of patients</td>
<td>21 056</td>
<td>1130</td>
<td>216</td>
<td>11 448</td>
<td>8262</td>
<td></td>
</tr>
<tr>
<td>Non-elective status</td>
<td>31%</td>
<td>37%</td>
<td>29%</td>
<td>31%</td>
<td>29%</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Renal failure with dialysis</td>
<td>3.4%</td>
<td>4.3%</td>
<td>6.4%</td>
<td>4.5%</td>
<td>6.7%</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Second reoperation</td>
<td>5.5%</td>
<td>11.1%</td>
<td>14.6%</td>
<td>6.7%</td>
<td>2.8%</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Renal failure without dialysis</td>
<td>8.6%</td>
<td>18.8%</td>
<td>12.0%</td>
<td>8.3%</td>
<td>4.8%</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Cardiogenic shock</td>
<td>2.5%</td>
<td>3.1%</td>
<td>1.4%</td>
<td>2.8%</td>
<td>2.1%</td>
<td>0.005</td>
</tr>
<tr>
<td>First reoperation</td>
<td>24%</td>
<td>36%</td>
<td>29%</td>
<td>29%</td>
<td>15%</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Median ejection fraction</td>
<td>0.50</td>
<td>0.54</td>
<td>0.53</td>
<td>0.55</td>
<td>0.50</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Insulin-dependent diabetes</td>
<td>8.0%</td>
<td>8.8%</td>
<td>7.4%</td>
<td>7.4%</td>
<td>8.7%</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Concomitant CABG</td>
<td>30.1%</td>
<td>18.1%</td>
<td>20.4%</td>
<td>25.1%</td>
<td>39.0%</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Active endocarditis</td>
<td>2.2%</td>
<td>7.4%</td>
<td>4.2%</td>
<td>2.7%</td>
<td>0.8%</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Median age (years)</td>
<td>69</td>
<td>66</td>
<td>67</td>
<td>69</td>
<td>70</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Arrhythmia</td>
<td>58%</td>
<td>60%</td>
<td>55%</td>
<td>62%</td>
<td>54%</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>CVD</td>
<td>12%</td>
<td>17%</td>
<td>6%</td>
<td>14%</td>
<td>9%</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Mitral stenosis</td>
<td>24%</td>
<td>31%</td>
<td>7%</td>
<td>17%</td>
<td>6%</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Years 1993–1997 (Period I), n</td>
<td>3328</td>
<td>312</td>
<td>35</td>
<td>2301</td>
<td>680</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Years 1998–2002 (Period II), n</td>
<td>5316</td>
<td>322</td>
<td>52</td>
<td>3149</td>
<td>1793</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Years 2003–2007 (Period III), n</td>
<td>12 412</td>
<td>496</td>
<td>129</td>
<td>5998</td>
<td>5789</td>
<td>&lt;0.0001</td>
</tr>
</tbody>
</table>

Gp: procedural group; CABG: coronary artery bypass grafting; CVD: history of cerebrovascular disease.

### Table 2: Unadjusted operative mortality and morbidity by procedural type

<table>
<thead>
<tr>
<th>Procedural group</th>
<th>All (%)</th>
<th>Gp I (%)</th>
<th>Gp II (%)</th>
<th>Gp III (%)</th>
<th>Gp IV (%)</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Overall operative mortality</td>
<td>9.7</td>
<td>16.8</td>
<td>10.2</td>
<td>10.3</td>
<td>8.0</td>
<td>0.0001</td>
</tr>
<tr>
<td>Operative mortality 1993–1997</td>
<td>12.3</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Operative mortality 1998–2002</td>
<td>10.6</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Operative mortality 2003–2007</td>
<td>8.7</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Any neurological complication</td>
<td>4.8</td>
<td>5.9</td>
<td>5.1</td>
<td>4.9</td>
<td>4.6</td>
<td>0.1429</td>
</tr>
<tr>
<td>Postoperative renal failure</td>
<td>11.6</td>
<td>14.6</td>
<td>14.4</td>
<td>11.4</td>
<td>11.4</td>
<td>0.0063</td>
</tr>
<tr>
<td>Prolonged ventilation</td>
<td>23.9</td>
<td>31.5</td>
<td>25.0</td>
<td>24.2</td>
<td>22.3</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Pneumonia</td>
<td>7.3</td>
<td>8.7</td>
<td>7.9</td>
<td>7.6</td>
<td>6.6</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Multiorgan failure</td>
<td>3.9</td>
<td>6.9</td>
<td>4.2</td>
<td>4.0</td>
<td>3.3</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Mortality/morbidity composite</td>
<td>32.9</td>
<td>43.2</td>
<td>35.7</td>
<td>33.5</td>
<td>30.6</td>
<td>&lt;0.0001</td>
</tr>
</tbody>
</table>

Gp: procedural group.
Failed repair and acute conversion to replacement also could increase mortality, and it is difficult to quantify the various conversion scenarios in the STS data set. However, most mitral repair surgeons would suggest that conversion now should be rare with current techniques [18]. Recent development of advanced methods of mitral repair also allows autologous reconstruction for most of the pathologies in the historical replacement group in this study [20]. Therefore, comparison may be less confounded at this point in the history of mitral and tricuspid valve repair. However, repair/replacement ORs still need to be interpreted within this context: repair-associated mortality benefits probably are valid, but possibly are influenced to some extent by patient selection bias and undefined clinical variables.

Group II patients constituted a previously un-described cohort, consistently accounting for only 1% of MT procedures. In addition, it was possible to identify possible reasons for performing T replacement (in a setting where 95% of T valves were being repaired overall). These include the highest second reoperation incidence (14%) and a relatively high endocarditis rate (4%). Then in considering Groups III and IV, we are left with the 95% of the population in Period III who all received T repair, and who were evenly distributed between M replacement (Group III—48%) and M repair (Group IV—47%). These groups appeared similar except for twice the incidence of reoperation (36 in Group III vs 18% in Group IV) and more mitral stenosis (17 vs 6%, respectively), which could have prompted M replacement. As stated above, these Groups have been gradually converting towards M repair over the years, so even considering the reoperation and stenosis incidence, the choice of M replacement may still be somewhat discretionary. Thus, it might be possible to select more Group III patients for repair, especially with improved techniques for complex reconstruction [20]. Even by conservative standards, considerable room may exist in Group III for future M repair conversion.

The findings of this study would support further increases in valve repair rates in MT, as a mechanism to continue outcome improvement. Conversion to T repair occurred in the decade prior to this data set, since 89% of T valves were already being repaired in Period I. With 95% of T valves currently being repaired overall, not much room exists for conversion. However, techniques now are available for repairing almost all T valves, including gluteraldehyde-fixed autologous pericardial patches, artificial chordal replacement and ring annuloplasty [21]. The benefits of further conversion to T repair include lower valve-related complications, such as valve thrombosis and endocarditis, and better long-term right ventricular function.

In considering future repair conversion for the M valve, the more difficult prolapse cases in Group III, such as Barlow’s or bi-leaflet prolapse, currently are being repaired routinely in many centres with techniques such as artificial chordal replacement. Similarly, most endocarditis and rheumatic valves now can undergo reconstruction, using artificial chords, pericardial patches and annuloplasty rings [20, 22, 23]. Even in failed repairs, re-repair has become routine [24, 25]. Recent availability of validated methods for complex M repair could allow further repair expansion into Group III and continue improvement in early and late results.

Operative mortality in multiple valve surgery is very risk factor sensitive [7]. In previous analyses, surgical intervention with low-risk profiles (elective presentation, age <65 years and EF >0.4) was associated with UOMs of 1–3%. Simply flipping these three variables increases UOM into the mid-teen range. Thus, variables that can be controlled, such as referral of elderly patients under elective conditions, should be emphasized. It is striking that non-elective presentation is the highest risk variable in almost all studies, and yet a third of MT patients are still being medically treated until urgent or emergency status arises. Such a scenario in MT disease can be especially difficult, since symptoms in T regurgitation can be subtle and successfully treated medically until advanced organ failure occurs from systemic venous hypertension. This type of patient then becomes a very difficult subset of the MT population, representing an especially high mortality and morbidity group. Finally, urgent status in the STS database is continuing to increase in broad valve surgery series [6], which is somewhat perplexing. As surgical specialists, we need to continue to emphasize earlier referral of MT patients, under elective conditions.

In conclusion, MT double valve surgery is continually changing, with conversion to M and T valve repair and falling operative mortalities. Repair of either valve seems to be associated with lower risk-adjusted mortality when compared with replacement. Whenever feasible, multiple valve repair should be considered the optimal treatment. Finally, this in-depth analysis of trends in contemporary valve surgery illustrates the value of a large national cardiac surgery database.

Conflict of interest: none declared.

REFERENCES

APPENDIX. CONFERENCE DISCUSSION

Dr T. Doenst (Jena, Germany): Scott Rankin and colleagues have presented a difficult and well-prepared analysis of a survival benefit for valve repair over replacement in multiple valve disease from the STS database. This is an important paper because it provides desperately needed evidence and great food for discussion resulting in better patient care as you have shown.

Of the many possible points to discuss, I would like to ask two questions. First, replacement groups in retrospective studies comparing repair versus replacement may always contain the failed repairs, so that may, of course, skew the results a little bit. So the first question is, what do you think is the impact of this possibility in this study?

And the second question is, what is the basis for the reduction in mortality over time? Because we are getting more aggressive in approaching the tricuspid valve, are we maybe just (because we are more aggressive with the tricuspid valve) operating on less sick people?

Dr Rankin: To answer the first question, it is a definite disadvantage of observational analysis to have patients in this series who had failed repairs and then conversions to replacement. It has been shown clearly that repair conversion increases mortality. We do not have information in many patients, but several years ago, conversion variables were added to the STS database and conversion is now occurring in 2–11% depending on which variable is examined.

I have we all gotten a lot better with repair, and especially for prolapse, virtually 100% of patients get artificial chords in many practices. With the newer techniques it has become a lot easier than in the old days, but that is a definite potential problem, although the probability is rare now. There are also several other possibilities for confounding variables and undefined treatment selection biases, so we always have to qualify an observational analysis like this.

Regarding the basis of decreasing mortality over time, in Rick Lee’s paper, which was the first in this series, we showed that over the 15 years, the baseline characteristics were getting worse. The population was getting older, there was more diabetes, LV dysfunction, coronary disease, and so on. So we know that just related to changes in baseline characteristics, the mortality should be going up, and it is not.

So the two factors that we can identify here are, one, there seems to be an independent effect of time alone, and that probably relates to better patient management, advances in cardiopulmonary bypass, better postoperative care, and so on. That factor seems to be about half of the reduced mortality, but the other half appears to be conversion to valve repair. And if we look at what we can do in the future to improve outcomes in mitral-tricuspid disease, one possibility is to increase from 50% mitral repair to 70%, 75%. I think that in this present retrospective study, we do not know anything about the decussal chords in many practices. With the newer techniques it has become a lot easier than in the old days, but that is a definite disadvantage of observing the results a little bit. So the first question is, what do you think is the impact of this possibility in this study?

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So the two factors that we can identify here are, one, there seems to be an independent effect of time alone, and that probably relates to better patient management, advances in cardiopulmonary bypass, better postoperative care, and so on. That factor seems to be about half of the reduced mortality, but the other half appears to be conversion to valve repair. And if we look at what we can do in the future to improve outcomes in mitral-tricuspid disease, one possibility is to increase from 50% mitral repair to 70%, 75%. I think that in this present retrospective study, we do not know anything about the decussal chords in many practices. With the newer techniques it has become a lot easier than in the old days, but that is a definite disadvantage of observing the results a little bit. So the first question is, what do you think is the impact of this possibility in this study?

So the second question is, what is the basis for the reduction in mortality over time? Because we are getting more aggressive in approaching the tricuspid valve, are we maybe just (because we are more aggressive with the tricuspid valve) operating on less sick people?

Dr Rankin: To answer the first question, it is a definite disadvantage of observational analysis to have patients in this series who had failed repairs and then conversions to replacement. It has been shown clearly that repair conversion increases mortality. We do not have information in many patients, but several years ago, conversion variables were added to the STS database and conversion is now occurring in 2–11% depending on which variable is examined.

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Dr Colli: Yes, I have been.
Dr Rankin: It was an eye opener for me, and I am getting better at aortic valve repair all the time. I still have a long way to go. I am learning a lot from Laurent and his group, but I think it is important for all of us to continue to evolve. And the repairs are going to get better, and it is going to help the patients.

Regarding the subvalvular mitral apparatus, we actually looked at that briefly in the Duke database; it was part of the mitral repair versus replacement series of papers that we published, and we had documentation of the sub-mitral preservation in the replacements. Now, the problem with the data was that there were 19 different surgeons and probably several different techniques included in the analysis. But we did not see a benefit to sub-mitral preservation in the mitral replacement series. I do not know for sure; it may be important, but I think it has been overemphasized. That is my personal opinion.