Valves in the Heart of the Big Apple VI: Evaluation and Management of Valvular Heart Diseases 2010

Second Annual Joint Meeting of the Heart Valve Society of America and Society of Heart Valve Diseases, New York City, N.Y., April 15–17, 2010

Clinical Predictors of Prosthetic-Patient Mismatch after Aortic Valve Replacement for Aortic Stenosis

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Objective: We sought to ascertain the clinical predictors of prosthetic-patient mismatch (PPM) in patients with severe aortic stenosis (AS). Methods: We analyzed 1952 cardiac surgeries between January 2005 and June 2009 to identify bioprosthetic AVRs for AS. We defined non-significant, moderate, and severe PPM as an effective orifice area (EOA) index $\geq 1.05$ cm$^2$/m$^2$, 0.85–0.66 cm$^2$/m$^2$, and $\leq 0.65$ cm$^2$/m$^2$, respectively. Results: The incidence of non-significant, moderate, and severe PPM for 311 AVRs for severe AS was 129 (41%), 132 (42%), and 50 (16%). Females accounted for 82% of the patients with severe PPM ($p < 0.001$). The perfusion and cross clamp times were lower in severe PPM compared with nonsignificant PPM ($p = 0.002$ and $p = 0.004$, respectively) as well as moderate PPM ($p = 0.03$ and $p = 0.04$, respectively). Patients with severe PPM had the highest total intensive care unit (ICU) hours and hospital stay ($p < 0.001$). Body surface area was lower in severe PPM when compared to moderate PPM ($p = 0.001$). In-hospital mortality in patients with non-significant, moderate, and severe PPM was 3 (2.3%), 8 (6.1%), and 4 (8%), ($p = 0.19$, respectively). Minimally invasive surgery was associated with moderate PPM in 49% of the patients, but in none with severe PPM ($p < 0.001$). Conclusions: Severe PPM is more common in females, and in those with lower body surface areas. Although, the operative times were shorter in these patients, their ICU and hospital lengths of stay were longer. The clinical predictors of PPM should be considered when selecting valve size.
Severity of Valvular Involvement in Rheumatic Heart Disease on Echocardiography

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**Objective:** RHD continues to be a major public health problem in developing countries like Pakistan. We conducted this study to analyze the severity of valvular lesions on echocardiography in patients pre-diagnosed with Rheumatic Heart Disease (RHD).

**Methods:** The transthoracic echocardiographic records of RHD patients from 2004–2008 were retrospectively reviewed for type and degree of valvular involvement according to AHA/ACC guidelines. **Results:** A total of 13,414 patients [7,219 males (53.8%), 6,195 females (46.2%)] ranging from 11 to 90 years with a mean age of 42.33 (±18.976) were studied. On echocardiography, 7,500 (56%) had mitral regurgitation (8.8% severe MR), 6,449 (48.2%) had tricuspid regurgitation (7.1% severe TR) and 5,550 (41.4%) had aortic regurgitation (4.8% severe AR). MS was detected in 2,729 (20.3%) patients, MS in 102 (0.8%) and TS in 31 (0.2%) patients. Mixed mitral valve disease was seen in 3,185 (23.7%), mixed aortic valve disease in (222) 1.7% and mixed tricuspid valve disease in 47 (0.4%) patients. All three valves were involved in 2,826 (21.06%) patients, combination of mitral and aortic valves in 3,103 (23.13%), mitral and tricuspid in 3,784 (28.2%), and mitral only in 3,701 (27.59%) patients. There was some mitral valve abnormality in all patients. **Conclusion:** Mitral valve was most commonly affected, while regurgitant lesions were more common than stenotic lesions, and most severe in younger patients. All valvular lesions had almost an equal distribution among the sexes, except aortic regurgitation, which was more common in females. Therefore, echocardiography should be done routinely for patients with RHD, focusing on younger population, to facilitate diagnosis and definitive treatment before complications set in.

Long-Term Outcome of Multiple Valve Surgery in Octogenarians – A Single Centre Experience

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**Objectives:** Cardiac surgery in octogenarians has seen a dramatic increase in the last decade. Aim of this study was to assess in hospital mortality and long-term outcome of octogenarians undergoing more than one valve operation in our institution.

**Methods:** Retrospective analysis of prospectively collected data for all the patients underwent multiple valve surgery over a period of 12 years was done. Demographic and perioperative variables were analyzed to identify the risk factors for hospital mortality. Discharged patients were assessed in the follow up clinic and telephonic survey was conducted to assess functional status. **Results:** Between 1997 and 2009, 69 patients underwent multiple valve surgery. Median age was 82 years [range: 80 to 89]. 54% were male. Mitral and aortic valve surgery, mitral and tricuspid valve surgery, aortic valve and tricuspid valve surgery and triple valve surgery were performed in 58, 28, 4 and 10%, respectively. Preoperative pulmonary hypertension, renal dysfunction and atrial fibrillation were present in 26, 39 and 67%, respectively. 32% had coronary artery disease. Urgent operations were done in 20%. In hospital mortality was 16%. One year and five year survival rate was 75% and 50%, respectively. Univariate and multivariate analyses predicted urgent surgical procedures as a significant risk factor for in hospital mortality ([p = 0.038] OR: 0.22 [95%CI: 0.055–0.88]). Telephonic survey revealed that 70% of long-term survivors showed improved NYHA status at least by one grade. **Conclusions:** Multiple valve procedures can be safely performed in octogenarians with acceptable in hospital mortality and long-term survival. Majority of long-term survivors have an improved functional status.

A Common Reference System for Fluoroscopic and Two-Dimensional Transoesophageal Echocardiographic Localization and Guidance of Mitral Periprosthetic Transcatheter Leak Reduction

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**Background:** Transcatheter reduction (TCR) represents a modern and attractive alternative to surgery for the treatment of mitral periprosthetic leak (PPL) in patients with high operative risk. Accurate localization of PPL and precise communication between echocardiographer and interventional cardiologist are essential for success. The objective was to describe and compare a novel fluoroscopic and a transoesophageal echocardiographic (2D-TEE) method to localize mitral PPL for TCR. **Methods:** We analysed TEE and fluoroscopic images of patients with mitral PPL who underwent multplane 2D-TEE guided TCR procedures in our institution. The 12-hour surgeon’s view system was used prospectively to localize PPL by TEE. An echocardiographer blinded to procedural TEE findings later retrospectively reviewed TEE examinations. A corresponding 12-hour time-clock system was plotted for fluoroscopic PPL localization. PPLs were localized offline using fluoroscopic images by an independent interventional cardiologist blinded to TEE results using the crossing guidewire position in the left anterior oblique view as reference for PPL localization. Agreement between methods was evaluated. **Results:** Complete imaging data were available for analysis in 20 patients who, between 2002 and 2009, underwent TCR where the defect was successfully crossed. There was excellent agreement between procedural TEE and retrospective TEE review for PPL localization (100%; p < 0.0001), and between fluoroscopic and procedural TEE localization (90%; CI = [77%; 100%]; p = 0.0003). In only two cases where there was disagreement, fluoroscopic PPL localization was adjacent to TEE localization. **Conclusion:** Localization of PPL with this novel fluoroscopic system shows very good agreement with the highly reproducible TEE method.
Early Results of the Investigational St. Jude Medical Trifecta™ Pericardial Aortic Valve Bioprosthesis

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Objective: Concern about optimizing hemodynamics in tissue valves has led to innovations in aortic valve design. The St. Jude Medical (SJM) Trifecta™ valve is an investigational pericardial bioprosthesis which optimizes hemodynamics with a unique stent and sewing ring designed for supra-annular placement. We present the first clinical experience with this valve. Methods: At a single institution, 99 Trifecta™ valves were implanted in the aortic position as part of a prospective FDA IDE study. Perioperative variables were gathered with clinical follow-up data at discharge, 6, and 12 months. Echocardiograms were evaluated by a core lab. Results: Mean patient age was 74.2 ± 8.4 years. 70 (75%) patients were male and 30 (32%) had history of diabetes. 23 (25%) patients had previous cardiac surgery and concomitant CABG was performed in 38 (41%). There was 1 perioperative mortality and 4 perioperative non-permanent neurological events. There were no instances of structural valve deterioration, paravalvular leak, or valve-related death in the first year. There were two valve explants: one due to compromise of an aberrant left coronary artery and the other for endocarditis. As seen in table 1, the average mean gradients of 72 patients at discharge, 6 months, and 1 year were 7.0 ± 3.8, 6.2 ± 3.1, and 6.8 ± 3.4 mm Hg, respectively. Measured indexed effective orifice area remained stable during the study period. Conclusion: The novel SJM Trifecta™ valve provides hemodynamics which remain stable in the early period. This data is important as this may be the last "standard" aortic valve designed as we enter the transcatheter AVR revolution.

Transcatheter Aortic Valve Implantation after Previous Mechanical Mitral Valve Replacement: Expanding Indications for Catheter-Based Aortic Valves?


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Objective: Operation for severe aortic stenosis in old and multimorbid patients after previous mitral valve replacement is a surgical challenge. Transcatheter aortic valve implantation (TAVI) after previous mechanical mitral valve replacement is so far considered as high-risk procedure due to possible interference with the mitral valve prosthesis. Methods: Since August 2008 four female high-risk patients with severe aortic stenosis and previous mitral valve replacement (mean age: 81.5 ± 4.9 years; logistic EuroScore: 44.4 ± 19.7%) underwent TAVI using a pericardial xenograft fixed with a stainless, balloon-expandable stent (Edwards SAPIEN). Transapical approach was used in three patients, transfemoral approach in one patient. In addition to TEE, multi-detector computer tomography was used for preoperative planning and assessment of feasibility. Distance between aortic annulus and mitral valve prosthesis was 10 ± 9–11 mm in all cases. Results: TAVI was performed successfully in all 4 patients. There were no direct or functional interferences with the mechanical mitral valve prostheses. Echocardiography revealed good valve function with maximal mild paravalvular incompetence early postoperatively and during routine follow-up. There were no neurological events. However, two patients died after initial uneventful course due to fulminant pneumonia at POD 4 and 48, with good aortic

Table 1. Hemodynamic performance through 1 year follow-up

<table>
<thead>
<tr>
<th>Valve size, mm</th>
<th>Mean gradient ± SD, mm Hg</th>
<th>Peak gradient ± SD, mm Hg</th>
<th>Indexed EOA ± SD, cm²/m²</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>discharge 6 months 1 year</td>
<td>discharge 6 months 1 year</td>
<td>discharge 6 months 1 year</td>
</tr>
<tr>
<td>19 n</td>
<td>9.8 ± 6.5 8.0 ± 2.2 6.8 ± 0.7</td>
<td>19.0 ± 11.9 14.2 ± 4.0 13.1 ± 2.4</td>
<td>0.94 ± 0.23 0.89 ± 0.24 0.94 ± 0.05</td>
</tr>
<tr>
<td>21 n</td>
<td>7.2 ± 2.5 7.2 ± 3.5 8.1 ± 4.3</td>
<td>14.1 ± 4.5 13.3 ± 6.3 15.8 ± 7.7</td>
<td>0.99 ± 0.26 0.96 ± 0.20 0.93 ± 0.22</td>
</tr>
<tr>
<td>23 n</td>
<td>14 ± 10 7</td>
<td>14.5 ± 7.0 14.3 ± 5.5 13.9 ± 5.1</td>
<td>1.01 ± 0.17 0.98 ± 0.17 0.88 ± 0.20</td>
</tr>
<tr>
<td>25 n</td>
<td>7.7 ± 3.8 6.9 ± 3.3 7.7 ± 3.7</td>
<td>10.5 ± 3.3 8.8 ± 2.6 8.7 ± 3.0</td>
<td>1.03 ± 0.17 1.02 ± 0.13 1.01 ± 0.14</td>
</tr>
<tr>
<td>27 n</td>
<td>13 ± 9 6</td>
<td>13 ± 9 6</td>
<td>1.05 ± 0.18 1.09 ± 0.03</td>
</tr>
<tr>
<td>29 n</td>
<td>3.8 ± 0.3 3.1 ± 0.4 5.2</td>
<td>6.6 ± 1.0 6.0 ± 0.5 11.0</td>
<td>1.17 ± 0.27 1.06 ± 0.20 1.12</td>
</tr>
<tr>
<td>Total n</td>
<td>7.0 ± 3.8 6.2 ± 3.1 6.8 ± 3.4</td>
<td>13.6 ± 6.9 12.2 ± 5.3 13.1 ± 5.6</td>
<td>1.01 ± 0.20 0.98 ± 0.17 0.94 ± 0.19</td>
</tr>
</tbody>
</table>
valve function at the most recent echo. **Conclusion:** TAVI in high-risk patients after previous mechanical mitral valve replacement is technically feasible. However, careful patient selection with respect to preoperative clinical status and anatomic dimensions regarding the distance between aortic annulus and mitral valve prosthesis is mandatory.

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**Carpentier-Edwards Magna Ease versus Magna: Comparison of in vitro Valve Hydrodynamic Performance**

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**Objectives:** Previous studies have shown that the Carpentier-Edwards Magna (CEM) represents an excellent bioprosthesis in terms of systolic performance. In fact, various authors consider this valve to be the gold standard for the current generation of supra-annular tissue valves and it has even been described as a stented valve with stentless performance. However, valve performance is not only a matter of gradients, it is also necessary to evaluate the diastolic-phase. Our previous in vitro studies demonstrate that CEM has an excessive total-regurgitant-volume. The aim of this study was to compare the hydrodynamics of CEM, with the new evolution of this valve, CEM Ease (CEME).

**Methods:** Carpentier-Edwards-Magna-21 (CEM) and Carpentier-Edwards-Magna-Ease-21 (CEME), were tested in the aortic chamber (23-mm in diameter) of the Sheffield-Pulse-Duplicator. The tests were carried out at increasing pulse-rates (70–110 beats/min), and at each pulse-rate the valve was tested at different SVs (45–65 ml). Forward-flow-pressure-drop, closing-leakage-volumes, effective-orifice-area and stroke work loss were recorded. **Results:** CEM and CEME showed a comparable systolic-phase performance. There were no significant differences in terms of transvalvular gradient, EOA and stroke-work-loss regardless of pulse-rates and stroke volume. On the contrary, the new CEME exhibited a significantly improved diastolic performance. In fact, total-regurgitant-volume was significantly lower, especially due to reduced leakage-volume and to a lesser extent closing volume and leaflets-coaptation-time. **Conclusions:** According to our results, the new CEME maintains the excellent systolic performance of the previous model with a significantly improved diastolic performance.

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**Effects of Different Methods of Decellularization on the Hydrodynamic Performance of Porcine Aortic Valve: Considerations on in vitro Testing**

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**Objectives:** The goal of the current heart valve tissue engineering research is the development of an ‘ideal’ valve prosthesis. Decellularized heart valve matrix was suggested as a scaffold for tissue engineering, providing the natural valve architecture and ideal conditions for repopulation with recipient cells. The ‘ideal’ decellularization method for porcine aortic valves is still controversial. The aim of this study was to investigate the effects of decellularization on the in vitro hydrodynamic performance of porcine aortic valves pre- and post-TRI-COL, TRI-DOC and SDS (0.1 and 0.03%) treatments and to compare them with untreated control valves. **Methods:** Fifteen fresh porcine aortic valves were tested in the aortic chamber of the Sheffield-Pulse-Duplicator. The valves were inserted in the rigid aortic chamber after suturing to an aortic root made of silicone and then hydrodynamically tested. After in vitro testing, three fresh porcine aortic valves were decellularized with TRI-COL, three TRI-DOC, three with SDS 0.1%, three with SDS 0.03% and three served as untreated controls. A further hydrodynamic test was then performed on each treated valve in the same system, adopting conditions identical to previous tests. Forward flow pressure drop, closing leakage volumes, effective orifice area and stroke work loss were recorded. **Results:** TRICOL and TRIDOC treated valves showed lower transvalvular gradients and significantly improved EOA, stroke work loss and valvular resistance, compared to controls. However, we also observed increased regurgitant volume, which was related to closing volume and coaptation time. On the contrary, SDS 0.1 and 0.03% treated valves showed comparable results pre- and post-decellularization as also seen with untreated control valves pre- and post-storage. **Conclusions:** TRI-COL and TRI-DOC treatments modify the normal porcine aortic valve hydrodynamic behaviour, with improved systolic function and prolonged diastolic coaptation phase, while SDS treatment does not significantly modify the normal hydrodynamic behaviour, showing comparable systolic and diastolic performances before and after treatment.
Endothelial pannus and thrombus formation on bileaflet mechanical heart valves can block the hinge-leaflet mechanism and cause embolic events. The present study analyzes the power spectra calculated from the phonocardiographic signals corresponding to prostheses’ sounds as acquired in vitro, in order to check for the presence of differently shaped thrombotic deposits. Data were acquired during simulations in the aortic position with the Sheffield Pulse Duplicator. Different working conditions were investigated, changing the pulse rate and the stroke volume. Thrombotic deposits of different weight and shape were placed on the valve leaflet and onto the annular housing, including the case of a thrombus completely blocking one leaflet. Power spectra were classified by an artificial neural network, specifically designed for this purpose. Thrombotic event classification was applied to five commercially available mechanical prostheses. The results obtained allow implementation of a diagnostic tool for the early detection of thrombotic deposit formation: it will result in an appropriate calibration of the anticoagulant therapy, preventing mechanical heart valve dysfunctions and thromboembolic complications.

**Early Thrombosis Risk in Patients with Biologic Valves in the Aortic Position**

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**Objective:** Patients who require aortic valve replacement are increasingly receiving biologic rather than mechanical valves, to avoid long-term anticoagulation. The long-term thromboembolic risk of bioprosthetic valves is reportedly low. Our objective was to review the incidence of early valve thrombosis in patients who received a bioprosthetic valve in the aortic position. **Methods:** We reviewed all adult patients who had a biologic valve implanted in the aortic position between 1993 and July 2009. Records were reviewed for all cases of reoperation which occurred less than 2 years postoperatively. Incidence rates of valve thrombosis were calculated including 95% Poisson confidence intervals. **Results:** During the study interval, 4,568 biologic valves were implanted in the aortic position. We identified 8 patients who had reoperation to re-replace the aortic valve because of thrombosis present on the aortic side of the valve that resulted in functional aortic stenosis. The median age of the patients at time of reoperation was 77 years (range 52–86) and the median time to reoperation was 398 days (range 106 to 626). All patients with valve thrombosis received a stented porcine valve (4 St. Jude Biocor, 2 Medtronic Mosaic, 2 Medtronic Hancock). The calculated incidence of valve thrombosis was 1.29% (CI 0.57–2.01%) for the Biocor, 0.37% (CI 0.19–0.56%) for the Mosaic, and 0.84% (CI 0.42–1.25%) for the Hancock. There were no cases of valve thrombosis in patients who received a pericardial valve (5,923 patient-years) or stentless valve (172 patient-years). All patients with thrombosis were on aspirin therapy and 3 patients had received warfarin therapy for 3 months postoperatively. No patients had evidence of endocarditis (bacterial cultures or fever), no patients had known hypercoagulable disorders, and 1 patient had active renal cell cancer. Pathological diagnosis excluded any structural abnormalities of the valves. **Conclusion:** The incidence of early valve thrombosis in porcine bioprostheses in the aortic position was greater than generally reported in the literature. However, there were no cases of thrombosis in pericardial bioprostheses. The cause of these early cases of valve thrombosis is unknown. Avoiding stented porcine bioprostheses in patients with risk factors for thrombosis may be prudent.

**Regression in Left Ventricular Mass after Aortic Valve Replacement for Chronic Aortic Regurgitation Is Unrelated to Prosthetic Valve Size**

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**Objectives:** We examined the predictors of left ventricular (LV) mass regression following aortic valve replacement (AVR) for chronic aortic valve regurgitation (AR), including patient-prosthesis mismatch (PPM). **Methods:** We selected patients who had complete preoperative and follow-up echocardiograms with measurement of LV mass. Patients were excluded who had ≥moderate aortic valve stenosis, concomitant coronary artery bypass grafting, or mitral valve procedures. **Results:** Patients’ mean age was 55 ± 17 years; 21% were female. The mean preoperative LVMI was 150 ± 45 g/m². Patients with mildly (n = 44, mean LVMI 126 ± 15 g/m²), moderately (n = 31, mean LVMI 168 ± 11 g/m²), or severely (n = 15, mean LVMI 241 ± 34 g/m²) increased preoperative LVMI were similar, except for lower ejection fractions, larger end-diastolic dimensions, and larger ventricular wall thicknesses in the severely enlarged group (p < 0.001). Thirteen patients had PPM and were similar to patients without PPM, except for a greater body surface area, more mechanical valves, and smaller valve sizes in those with PPM (p < 0.05). At a mean follow-up of 3.2 ± 2.4 years, the average reduction in LVMI was 50 ± 38 g/m²; late mass regression was unrelated to labeled valve size, PPM, or measured indexed effective aortic valve area. A greater preoperative LVMI (p < 0.001) was an independent predictor of greater LV mass regression. Despite having greater LV mass regression, patients with severe preoperative LVMI did not return to normal values (mean 142 ± 25 g/m²). **Conclusions:** LV mass regression after AVR for chronic AR is unrelated to indexed prosthetic valve area. Although incomplete, regression is greatest in patients with the largest preoperative LVMI.
Impact of Patient-Prosthesis Mismatch on Short-Term Outcome after Aortic Valve Replacement Surgery

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**Background:** There is conflicting evidence about the prognostic impact of mismatch (MM) in the short term. **Objective:** To evaluate the prognostic value of MM in the immediate postoperative period of aortic valve replacement surgery (AVR). **Methods and Materials:** 462 patients underwent AVR, between 01/01/1999 and 31/12/2005. It was considered MM when the EOA indexed by body surface area (BSA) was <0.85 and severe when it was <0.6. The primary endpoint was hospital mortality and morbidity, including: low cardiac output, reoperation, atrial fibrillation, stroke and death. Of the 462 patients included, 319 (69%) were males, aged 67 ± 14. A mechanical prosthesis was implanted in 273 (59%) and a biological one in 189 (41%). The most commonly used valve size was N° 23, the BSA average was 1.9 cm².

**Results:** 181 patients had MM (39.18%) and 14 patients (3%) had severe MM. These patients were older and most of them had history of hypertension and diabetes. Patients with MM had a higher incidence of atrial fibrillation (24.31 vs. 12.81%, p = 0.001), low cardiac output (16 vs. 9.96%, p = 0.053) and the combined endpoint of morbi-mortality (25.97 vs. 16.01%, p = 0.009). Adjusting by the main predictors of morbi-mortality in cardiac surgery, MM turned out to be an independent predictor of the primary endpoint (OR 1.795% CI 1.04–2.79, p = 0.033) together with cardiovascular bypass time (OR 1.01 CI 1.00–1.017; p = 0.000) and age (OR 1.02 95% CI 1.00–1.04, p = 0.018). Severe MM was not a predictor of morbi-mortality (p = 0.239). **Conclusion:** MM is associated independently with higher morbi-mortality in the immediate postoperative period of AVR surgery. The lack of correlation between severe MM and higher morbidity and mortality is probably due to the low number of patients.

Does the Severity of Preoperative Symptoms Predict Operative Risk in Mitral Regurgitation?

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**Background:** Patients with severe degenerative mitral regurgitation (SDMR) referred to surgery present diverse clinical presentations; while some patients are asymptomatic with preserved ventricular function, others have functional class IV dyspnea and systolic dysfunction. Current guidelines are helpful to recognize timing of mitral valve surgery; however, reality is sometimes far from ideal and defines daily practice. **Objective:** To analyze the impact of preoperative functional class (FC) on in-hospital and on long-term outcomes of patients undergoing surgery for SDMR. **Material and Methods:** We conducted a retrospective analysis of 254 consecutive patients who underwent surgery due to SDMR between July 1997 and July 2007. Patients were divided into two groups according to their NYHA FC for dyspnea. Group 1 included 87 patients in FC I–II and group 2 included 167 patients in FC III–IV. **Results:** Patients in group 1 were more likely to undergo mitral valve repair (56.3 vs. 37.7%; p = 0.005); conversely, associated myocardial revascularization was less frequent (10.3 vs. 27.5%; p = 0.002). During postoperative, patients in group 2 presented greater morbidity and mortality rates (27.5 vs. 13.7%; p = 0.01) and greater in-hospital mortality (9.5% versus 2.3%; p = 0.03). Global actuarial survival at 10 years was 92.9% with a median follow-up of 1,182 days/patient. During long-term follow-up, more patients in group 1 were free of associated events (mortality and reimplantation) than subjects in group 2 (HR 3.3; p = 0.01 95% CI 1.27–8.99). The degree of preoperative dyspnea was an independent predictor of adverse outcomes in multivariate analysis. The sub-analysis of patients without coronary artery disease also demonstrated that the severity of preoperative dys-
pnea is an independent predictor of in-hospital and long-term morbidity and mortality. **Conclusion:** In patients with SDMR, preoperative FC III-IV dyspnea is associated with worse outcomes.

**Do We Have to Preseed Tissue Engineered Aortic Valve before Implantation?**
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**Purpose:** Heart Valve Tissue Engineering (TE) imposes the usage of autologous cell seeding. On the other hand, implantation of decellularized scaffolds induces in-vivo self-remodeling by repopulation with autologous cells. We investigated the advantages of autologous cell seeding for aortic valve (AV) replacement using TE substitute. **Methods:** Ovine AVs were decellularized using detergents, reseeded with autologous endothelial cells (EC) and cultured for 7 days in a high-flow pulsatile bioreactor under physiological conditions. Recellularized grafts (Group A = 3) and cell-free scaffolds (Group B = 3) were implanted as root with reimplantation of coronary ostia in sheep. After 3 months, valves were investigated for function and morphological appearance including graft rejection and calcification. **Results:** Detergent treatment converted AV conduits in cell-free scaffolds. AV reseeded in bioreactor exhibited typical EC markers (eNOS, CD31, vWF), on the surface of aortic wall, sinus and cusps. In both groups the valves provided normal function with no signs of graft dilatation, stenosis or reduction of cusps mobility. Transvalvular gradient was low (Group A = 0.7 ± 0.6 mm Hg; Group B = 4.7 ± 1.8 mm Hg) and AV insufficiency was trivial to mild in all cases. In contrast to pre-seeded grafts, decellularized valves exhibited reduced re-endothelialization of the aortic wall and valvular cusps. In 2 cases (Group B) some micro-thrombi were detected on the cusps surface. Histology revealed partial repopulation of the scaffolds with interstitial cells (α-SMA), and no signs of valve rejection (CD45) or calcification (von-Kossa) in all cases. **Conclusions:** Both valve types remain functionally intact and do not exhibit signs of degeneration. Reendothelialization of TE valves prior implantation reduces early thrombosis, thus preventing leftsided embolism. An impact of autologous cells pre-seeding on TE aortic valve durability has to be investigated during the long-term follow-up.

**How to Rebuild the Prolapsing Mitral Valve: Four Years Echocardiographic Follow-Up**
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**Aim:** To assess the stability of the MV repair and geometry after complex MV plasty. **Methods:** One hundred patients were analyzed preoperatively, postoperatively and at 4 years follow-up using the echocardiographic concept of the ‘triangle of coaptation’ (ToC). It defines the normal geometry of the MV and it is delineated by the coaptation point and by two other points placed on the septal and lateral MV annulus. The coaptation length (CL) and height (CH) were also assessed. **Results:** Feasibility of MV repair was 98% with no deaths. After surgery the mitral regurgitation virtually disappeared: PreOp PISA 87.7 vs. PostOp 3.2 vs. Follow-up PISA 4.5 ml/s. The mean follow-up period was 4 years. Two patients required re-intervention at follow-up. Preoperatively the ToC was absent in 93% of cases. Postoperatively the ToC was achieved in 98% of patients, the mean CL was 6.9 mm and mean CH was 6.9; at follow-up the ToC was present in 91% of patients, the mean CL was 6.2 mm and the mean CH was 5.7 mm. **Conclusions:** MV repair was feasible in 98% of cases. The use of ToC as geometric echocardiographic concept aiming to restore MV shape and coaptation is a crucial point to improve surgical approach and the outcome. The MV geometry defined by the ToC, CL and CH remained stable at 4 years follow-up. Mitral valve repair for degenerative disease can achieve a competent and durable single-orifice native valve in almost all cases, with low mortality and morbidity rates and stable late results.

**Predictors of Left Ventricular Ejection Fraction Recovery following Aortic Valve Replacement in Patients with Low Flow, Low Gradient, Aortic Stenosis: The Multicenter TOPAS (True or Pseudo Severe Aortic Stenosis) Study**
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**Objective:** The objective of this study was to identify predictors of change in LV ejection fraction (LVEF) in patients with low flow, low gradient, aortic stenosis (LFLG AS). **Methods:** 142 patients with LFLG AS (AVA ≤ 1.2 cm² and indexed AVA ≤ 0.6 cm²/m²; LVEF ≤ 40% and mean gradient ≤ 40 mm Hg) underwent dobutamine stress echocardiography (DSE) at entry in the TOPAS study. Among these patients, 58 underwent a second DSE at 1-year follow-up (FU). The severity of the stenosis was assessed with the use of the projected aortic valve area at a normal transvalvular flow rate (AVAproj), which has been shown to be superior to traditional Doppler-echocardiographic indices for differentiating true-severe from pseudo-severe stenosis. **Results:** The resting LVEF increased significantly following AVR (absolute increase [ΔLVEF] = +7 ± 8%, relative increase [Δ%LVEF] = +30 ± 35%; p < 0.001). On univariate analysis, lower preoperative LVEF (r = -0.35, p = 0.04), presence of prosthesis-patient mismatch (–0.39, p = 0.02) and larger augmentation in AVAproj with AVR (ΔAVAproj = AVAproj at 1 year − AVAproj at baseline; r = 0.45; p = 0.03) were associated with larger Δ%LVEF following AVR. On multivariate analysis, only larger ΔAVAproj (p = 0.003) was independently associated with larger Δ%LVEF. As previously demonstrated, the LV contractile reserve estimated by the relative increase in stroke volume was not significantly related to Δ%LVEF. **Conclusion:** The
main determinant of the postoperative improvement in LVEF is the augmentation of AVA\text{proj} provided by AVR. These findings further emphasize the importance of implanting prostheses with superior hemodynamic performance in order to avoid prosthesis-patient mismatch in patients with LFLG AS undergoing AVR.

Validation of Conventional and Simplified Methods to Calculate Projected Valve Area at Normal Flow Rate in Patients with Low Flow, Low Gradient Aortic Stenosis. The Multicenter TOPAS (True Or Pseudo Severe Aortic Stenosis) Study

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Background: We previously demonstrated that the projected aortic valve area at a normal flow rate (AVA\text{proj}), is superior to traditional dobutamine stress echocardiography (DSE) indices to discriminate true-severe (TS) from pseudo-severe (PS) low gradient aortic stenosis (AS). The objectives were to validate AVA\text{proj} in a large series of patients and to propose a new simplified method to estimate AVA\text{proj}. Methods: AVA\text{proj} was calculated in 142 low flow AS patients using 2 methods: Conventional Method: AVA is plotted against mean transvalvular flow (Q) at each DSE stage and the AVA at a flow rate of 250 ml/s is projected from the regression line fitting the AVA vs. Q plot: AVA\text{proj} = AVA + Slope\textsubscript{regr} \times (250 - Q\text{rest}). Simplified Method: Using the above equation, the slope of the regression line is estimated by dividing the DSE-induced change in AVA by the change in Q. Results: Fifty-two patients underwent aortic valve replacement and had the underlying AS severity assessed by the surgeon. Conventional and simplified AVA\text{proj} demonstrated a similar performance in discriminating TS from PSAS (percentage of correct classification [%CC] of AVA\text{proj} ≤1 cm\textsuperscript{2}: 94 and 92%, respectively), and were superior to traditional indices [%CC: 60–77%]. Both conventional and simplified AVA\text{proj} correlated well with valve weight (r = 0.52 and 0.58) whereas traditional indices did not. In the 84 patients who were treated medically, AVA\text{proj} was an independent predictor of mortality. Conclusion: In patients with low flow AS, simplified AVA\text{proj} better predicts underlying AS severity and patient outcome than traditional DSE indices. Simplified AVA\text{proj} is easier to calculate, facilitating the use of AVA\text{proj} in practice.

Comparison between Surgical and Transcatheter Prosthetic Valve Implantation in Patients with Severe Aortic Stenosis and Left Ventricular Systolic Dysfunction

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Background: Transcatheter Aortic Valve Implantation (TAVI) has emerged as an alternative to Surgical Aortic Valve Replacement (SAVR) for patients with symptomatic severe AS considered at prohibitive operative risk. The objective of this study was to compare TAVI and SAVR with respect to postoperative recovery of LV ejection fraction (LVEF) in patients with severe AS and reduced LV systolic function. Methods and Results: We compared echocardiographic data prospectively collected before and after procedure in 200 patients undergoing SAVR and 83 patients undergoing TAVI for severe AS (Aortic Valve Area [AVA] ≤1 cm\textsuperscript{2}) with reduced LV systolic function (LVEF ≤50%). TAVI patients had more comorbidities (logistic EuroSCORE 32 ± 18 vs. 17 ± 14%, p < 0.0001) compared to SAVR patients. Despite similar baseline LVEF (34 ± 11% vs. 34 ± 10%), TAVI patients had better recovery of LVEF compared to SAVR patients (ΔLVEF = +14 ± 15 vs. +7 ± 11%, p = 0.005). At 1 year follow-up, 58% of TAVI patients had a normalization of LVEF (>50%) as opposed to 20% in the SAVR group. On multivariate analysis, TAVI (p = 0.01) were independently associated with better LVEF recovery. Overall survival rate was significantly (p = 0.02) lower in the TAVI group (1-year: 63 ± 6%, 2-year: 57 ± 6%) than in the SAVR group (1-year: 80 ± 3%, 2-year: 72 ± 4%) but the difference was no longer significant after adjusting for differences in baseline risk profile. Conclusion: In patients with severe AS and depressed LV systolic function, TAVI is associated with better recovery of LVEF compared to SAVR. TAVI may provide an interesting alternative to SAVR in patients with depressed LV systolic function considered at high surgical risk.

Combined Transcatheter Aortic Valve Implantation and Percutaneous Coronary Intervention – An Alternative to Combined Cardiac Surgery for High-Risk Patients?

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Objectives: Calcified aortic stenosis and coronary artery disease share a similar pathogenesis and co-incidence of the two entities is significant. While aortic valve replacement (AVR) and concomitant coronary artery bypass grafting yield good results...
even in high-risk patients, there is need for less invasive alternatives for selected patients. We report our experience in combined interventional AVR and percutaneous coronary intervention (PCI) for patients with contraindications to surgery. **Methods:** From March 2008 through November 2009, 124 patients underwent interventional AVR via a transapical (n = 65, 52.4%) or transfemoral (n = 59, 47.6%) approach. In 17 patients (13.7%), additional PCI was performed either as a staged approach up to 4 weeks prior to interventional AVR (n = 12) or in a single-stage procedure (n = 5). **Results:** Mean logEuroSCORE of 17 patients was 30.3 ± 3.6%, mean age was 81.1 ± 1.7 years. Left ventricular function was determined at a mean of 46.9 ± 2.4% ejection fraction. 30 day mortality was 5.9% (1/17 patients). No periprocedural strokes or acute myocardial infarctions occurred. In cases of single-stage PCI and interventional AVR, procedure time was slightly prolonged as compared to the staged approach (112.0 ± 22.8 vs. 95.8 ± 5.9 min). PCI was directed to the right coronary artery in 10 cases, to the LAD in 9 cases, to the circumflex artery in 4 cases and to the left main stem in one case. **Conclusions:** Our preliminary experience suggests combined interventional strategies are safe in high-risk patients. Results must be compared to outcomes after combined surgical procedures. Longer follow-up and higher patient numbers are needed to validate this approach.

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**Treatment of Complicated Aortic Valve Endocarditis with Periannular Abscess Using a Pericardial Stentless Bioprosthesis**

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**Objective:** The optimal strategy for the management of post-endocarditis aortic periannular abscesses and aorto-ventricular discontinuity is still a challenge. Purpose of this study is to analyze results of aortic annular reconstruction using a pericardial stentless bioprosthesis. **Methods:** From 4/2000 to 5/2009, 18 patients with post-endocarditis annular abscesses underwent aortic valve replacement with the Sorin Pericarbon Freedom (SPF). Mean age was 64.3 ± 13.5 years (range, 30–80). All patients were in NYHA class IV and were operated on under urgent/emergency basis. Thirteen patients had native valve endocarditis, and 5 had prosthetic endocarditis. The inflow pericardial skirt of the prostheses was used to obliterate the abscessual cavities and to reconstruct a normal aorto-ventricular junction. Mean cross-clamp and cardiopulmonary bypass times were 101.3 ± 36 and 148 ± 47 min, respectively. All patients underwent clinical and echocardiographic follow-up and the total cumulative follow-up was 25.5 patient/years (mean, 1.5 ± 2.2; range, 1 month–9 years). **Results:** Three patients (16.7%) died during hospitalization. Late mortality occurred in 4 patients (16% patient/years), of these none was valve-related. Overall survival was: 51 ± 13% at 8 years. Freedom from recurrent infection and from reoperation was 100%. In all surviving patients the aorto-ventricular junction has a normal echocardiographic aspect with no residual abscessual cavity. All patients have absent or trivial aortic regurgitation and are in NYHA class I–II. **Conclusions:** SPF is an effective treatment for periannular abscess deriving from aortic valve endocarditis. The inflow pericardial skirt allows to perform a complete obliteration of the abscessual cavities and the absence of any syntenic material reduces the hazard of prosthesis infection.

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**Tight Glucose Control after Heart Valve Surgery: Iatrogenic Hypoglycemia Is an Independent Predictor for Renal Failure and Perioperative Mortality**

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**Objective:** Iatrogenic hypoglycemia resulting from tight glucose control may increase ICU morbidity and mortality. **Methods:** Insulin drip and 5% dextrose infusion was used to target ICU glucose levels between 80–126 mg/dl in 655 consecutive valve surgery patients. Hourly ICU glucose levels were prospectively recorded. **Results:** Median age was 67 years, 126 (19.2%) patients had diabetes, 68 (10.4%) depressed LVEF, 30 (4.6%) impaired renal function, and 7 (1.1%) were on dialysis. Surgery on MV was performed in 297 (45%) patients, AV in 319 (48%), TV in 9 (1.4%), aortic surgery in 30 (4.5%), combined valve procedures in 34 (5.2%). Mean ICU glucose level was 128 ± 12 mg/dl, mean ICU glucose standard deviation was 26.1 ± 12.0 mg/dl, and in 100 (15%) patients occurred at least one episode of hypoglycemia (<65 mg/dl). At multivariate analysis, patient ICU glucose average and maximum glucose level, and glucose standard deviation were not independently correlated to M/M data. Glucose ICU minimum level was inversely correlated to mortality (p = 0.03; OR = 0.9), perioperative renal impairment (p = 0.03; OR = 0.9), and requirement for post-operative dialysis (p = 0.01; OR = 0.9) (the lower the glucose level the higher the risks). ROC curves showed maximal specificity and sensitivity for ICU glucose cut-offs values of 68 (for mortality), 77 (for dialysis), and 80 (for renal impairment) mg/dl. **Conclusion:** Target glucose levels in patients undergoing valve surgery should be re-discussed. Hypoglycemia risks offset tight normoglycemia benefits and increase mortality rate and morbidities such as renal failure. Iatrogenic hypoglycemia may become even more deleterious in diabetic patients.
Myocardial Inferior Segments Necrosis Is the Strongest Independent Determinant for Ischemic Mitral Valve Regurgitation: A Cardiac Magnetic Resonance Imaging Study

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Introduction: We hypothesized that regional myocardial vitality, assessed by cardiac MRI, has the most important role in ischemic mitral valve regurgitation (IMVR) development. Methods: Cardiac MRI was performed in 40 patients with 3 vessels CAD. Two groups were identified: CAD without IMVR (CAD), and with IMVR (IMVR). Univariate and multivariable analysis were used to chase determinants for IMVR. Results: CAD group included 17 patients and 23 were in the IMVR group. MV regurgitant volume was higher in the IMVR group (25 vs. 5 mL; p < 0.0001). Median LVEF% was 34% in the CAD group versus 27% in the IMVR group (p < 0.05). MV septo-lateral annular diameters, anterior leaflet length, coaptation depth, tenting area, inter-papillary muscles distance (PMD), and LV volumes were comparable in the two groups (p = ns). MV inter-commisural diameter in systole and diastole was significantly higher in the IMVR group (p = 0.03). At MRI vitality study, inferior myocardial necrosis occurred in 62% of IMVR patients versus 5% of CAD ones (p < 0.005). Papillary muscles distance (PMD), and LV volumes were inversely correlated to LVEF% (r = –0.7; p < 0.0001). At multivariate analysis, inferior myocardial necrosis was the strongest independent determinant for IMVR (p = 0.01; OR = 409) followed by MV inter-commisural diameter (p = 0.04; OR = 2.3). Conclusions: IMVR can not be simply explained by modifications of the LV and MV geometrical and functional variables and seems to result partly from an enlargement of the inter-commisural annular diameters but mainly from necrotic involvement of the inferior myocardium. These findings should help identifying patients at risk for IMVR development/worsening that may benefit from a tailored staging and treatment.

Bridging Anticoagulation after Heart Valve Surgery: Low-Dose Subcutaneous Fractioned Heparin and Thromboembolic Events

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Background: Perioperative ‘bridging’ anticoagulation after valve surgery remains controversial. We have evaluated the results with a simplified in-hospital low-dose subcutaneous enoxaparin protocol. Methods: Patients undergoing valve surgery were reviewed. From the first post-operative day till discharge all patients received low-dose subcutaneous enoxaparin (0.5 mg/kg twice daily) independently by the type of valve surgery. A single daily dose was used for patients over 80, nephropatic, and those with coagulation disorders. Oral warfarin was started at discharge. Results: A total of 482 underwent 519 procedures: 167 MV repair, 196 biological AVR, 18 biological MVR, 81 mechanical AVR, 57 mechanical MVR. Double valve surgery was performed in 38 patients. Cerebral thromboembolic events (TE) were recorded in 6 (1%) patients, major bleeding in 9 (2%), respiratory failure in 50 (10%), renal failure in 19 (4%), sepsis in 30 (6%), wound infection in 14 (3%), and mortality in 10 (2%). Discharge and 30-day follow-up echocardiography excluded valve thrombosis in all patients. At multivariate analysis, redo surgery was the sole determinant for TE (p = 0.006; OR = 21). Pre-operative dialysis, pre-operative creatinine >2, and respiratory failure were determinants for major post-operative bleeding (p = 0.0003, OR = 378; p = 0.003, OR = 24; p = 0.01, OR = 20). Postoperative dialysis and major post-operative bleeding were determinants for mortality (p = 0.003, OR = 129; p = 0.004, OR = 53). Enoxaparin dose had no correlation with outcomes. Conclusions: In spite of very low-dose heparinization, TEs are seldom. On the contrary, bleeding is more frequent and often correlated to mortality. For this reason, we suggest an even more conservative anticoagulation management in nephropatic patients undergoing valve surgery.

Surgical Treatment of Ischemic Mitral Valve Regurgitation: Mid-Term Follow-Up with Stress Echocardiography and Cardiac Magnetic Resonance Imaging

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Introduction: Surgical treatment of ischemic mitral valve regurgitation (IMVR) remains controversial. Preoperative patients’ selection with cardiac MRI may improve outcomes. Methods: CABG plus MV annuloplasty was performed in 46 consecutive patients with CAD and severe IMVR. Patients underwent preoperative cardiac MRI to evaluate ventricular and MV morpho-functional parameters as well as myocardial vitality. Patients with extended transmural myocardial necrosis were referred to alternative forms of treatment. Mid-term follow-up with physical stress echocardiography and cardiac MRI was performed in the surviving patients. Results: Mean age was 65 ± 10 years and LVEF% was 34 ± 13%. Ventriloplasty was also performed in 13 patients (28%). Perioperative mortality was 13% with a higher trend in patients with depressed LVEF% and with associated ventriculoplasty (p = 0.06). Cardiac mortality at 2.5 years mean follow-up was 15%. At rest echocardiography, mean MV regurgitation was 0.9 (0 to 4 grading) and none of the patients had severe MVR. Mean LVEF was 36.8 ± 11% and mean LV wall motion score index was 1.6. At stress echocardiography although there was no increase in MVR rate, there was a significant increment in mean trans-MV gradient (rest 3.2 ± 1.2 mm Hg vs. stress 7.8 ± 3 mm Hg; p < 0.0001). Cardiac MRI confirmed echocardiography MV and LV function. Furthermore, at gadolinium perfusion...
study, an average of 2.2/17 myocardial segments showed transmural necrosis. **Conclusion:** CABG plus MV annuloplasty has acceptable mid-term outcomes in adequately selected patients with IMVR. Cardiac MRI may help stratifying surgical candidates and following their outcome. Follow-up stress echocardiography confirms continence of MV and suggests an increase in trans-MV stress gradients after restrictive MV annuloplasty.

### Influence of Coronary Artery Disease on Long-Term Survival after Mitral Valve Procedures

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**Purpose:** Studies have shown that coronary artery disease (CAD) in patients undergoing mitral valve (MV) surgery (S) adversely influences long-term survival. However, this information was generated before modern coronary bypass (CABG) and statistical methodology. This study examined the effects of CAD treated with contemporary CABG on late survival after MVS.

**Methods:** From 1996–2006, 2,056 patients underwent primary isolated MVS: 1,250 without CAD (60%; Gp 1); 557 with CAD and internal mammary artery (IMA) grafting (27%; Gp 2), 89 having saphenous vein grafting (SVG) to the LAD (4%; Gp 3), and 160 having CABG without LAD disease (8%; Gp 4). Late survival differences were assessed using a Cox proportional hazards model that adjusted for patient profiles. Baseline and operative characteristics were input variables, and all-cause death the outcome variable. Maximal followup was 20-years with a median of 5-years, and was complete in 93%.

**Results:** Baseline and operative variables are shown in the table 1. Different from Gp 1 (fig. 1; p > 0.6). **Conclusions:** In the current era, MV patients requiring CABG receive primarily IMA grafts to the LAD. Using contemporary statistical and coronary bypass techniques, CAD in patients undergoing MV procedures does not seem to influence late risk-adjusted survival.

#### Table 1.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Group</th>
<th>p value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number per group</td>
<td>1,250</td>
<td>557 89 160 –</td>
</tr>
<tr>
<td>Mean age, years</td>
<td>58 67 71 66 &lt;0.0001</td>
<td></td>
</tr>
<tr>
<td>Acute presentation</td>
<td>24% 42% 43% 32% &lt;0.0001</td>
<td></td>
</tr>
<tr>
<td>Diabetes</td>
<td>8% 33% 24% 24% &lt;0.0001</td>
<td></td>
</tr>
<tr>
<td>Ejection fraction</td>
<td>0.54 0.42 0.44 0.46 &lt;0.0001</td>
<td></td>
</tr>
<tr>
<td>3-vessel disease</td>
<td>– 61% 61% 21% &lt;0.0001</td>
<td></td>
</tr>
<tr>
<td>Etiology = degen.</td>
<td>53% 25% 24% 26% &lt;0.0001</td>
<td></td>
</tr>
<tr>
<td>Etiology = ischemic</td>
<td>– 54% 47% 48% &lt;0.0001</td>
<td></td>
</tr>
<tr>
<td>Etiology = rheumatic</td>
<td>27% 8% 15% 11% &lt;0.0001</td>
<td></td>
</tr>
<tr>
<td>Valve repair</td>
<td>52% 73% 47% 55% &lt;0.0001</td>
<td></td>
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</tbody>
</table>

Gp 1 patients were younger with fewer risk factors, and Gp 3 was older. Patients having LAD disease predominantly received IMA grafts, and Gp 3 was small. Large differences in unadjusted survival were observed between groups, with Gp 3 being the lowest (figure). After adjustment for age and other variables, survival for MV/CAD patients (Gps 2, 3, and 4 combined) was not statistically different from Gp 1 (fig. 1; p > 0.6). **Conclusions:** In the current era, MV patients requiring CABG receive primarily IMA grafts to the LAD. Using contemporary statistical and coronary bypass techniques, CAD in patients undergoing MV procedures does not seem to influence late risk-adjusted survival.

### Screening for Valve Disease in the UK Population: Preliminary Data from the OxVALVE Population Cohort Study


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**Introduction:** Contemporary studies of the epidemiology and natural history of valvular heart disease (VHD) are scarce but demonstrate increasing prevalence with age, associated with significant morbidity and mortality. There are no European or UK studies to date. The UK provides health care free at source with a comprehensive primary care network making community epide-
making epidemiological studies more feasible than in other nations. We are developing a large prospective community echocardiographic screening study within the adult Oxfordshire population to determine the epidemiological characteristics of VHD and acceptability of screening, and to establish VHD cohorts with well-characterised genetic and echocardiographic phenotypes. We herein present data for the first 183 patients but anticipate enrolment of >500 by April 2010. Methods: Patients >65 years with no known VHD were invited to participate. Demographic and cardiac data were collected, a focused examination undertaken and standard transthoracic echocardiographic performed. Each participant completed a shortened Spielberger STAI questionnaire. Results: Uptake was 52% (age range 65–92 years; M:F ratio 1:1.3). Threshold for inclusion in the screen positive group was deliberately low to capture all VHD which was detected in 46%. Prevalence increased with age and mild VHD in the majority (85%). Mitral and aortic regurgitation were the most common lesions detected (25 and 18.6%, respectively). Less than 1% of participants experienced significant anxiety associated with screening. Conclusions: Prevalence of VHD in adults >65 years in this population is 46% and increases with age. Mitral regurgitation is the most common lesion and most detected VHD is mild. Echocardiographic screening for VHD is acceptable.

### Surgical Ventricular Reconstruction Cannot Improve Mitral Regurgitation: MRI-Based Study of Mitral Subvalvular Apparatus Geometry

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Objectives: Controversies whether surgical ventricular reconstruction (SVR) improves mitral regurgitation exist. This study was performed to assess the influence of SVR on the subvalvular apparatus and MV geometry. Methods: Ten patients with ischemic cardiomyopathy (EF <35%) treated with CABS and SVR were subjected to ECG-gated cine-MRI before operation and 4 months thereafter. Short axis, two-chamber and four-chamber views were used to measure distances, areas and angles describing MV geometry. LV volumes and function were assessed. No patient showed more than mild mitral regurgitation before and 4 months postoperatively. Results: SVR decreased LV end-diastolic volume from 287 ± 49 ml to 193 ± 73 ml (p = 0.007) and end-systolic volume from 219 ± 43 ml to 144 ± 58 ml (p = 0.007). The EF increase was not significant 23.7 ± 5.4% to 25.9 ± 4.6% (p = 0.2). Postoperative systolic MV area increased from 7.68 ± 1.18 cm² to 9.05 ± 1.90 (p = 0.01) and diastolic MV area from 8.43 ± 1.20 cm² to 9.43 ± 1.89 cm² (p = 0.02). Systolic annulus septolateral diameter decreased from 3.55 ± 0.31 cm to 3.34 ± 0.31 cm (p = 0.01) and diastolic from 3.80 ± 0.47 cm to 3.55 ± 0.33 cm (p = 0.009). Coaptation decreased from 5.7 ± 1.0 mm to 4.1 ± 0.9 mm (p = 0.008). Diastolic anterior papillary muscle tethering distance decreased by 5.6 ± 4.7 mm (p = 0.03) and the posterior papillary muscle tethering did not change (p = 0.2). The angle of anterior papillary muscle and mitral annulus plane increased of 23.75 mm OD and 0.44 mm thickness was made from a nitinol tube of 5.6 mm OD. Continuous conical leaflets were made from the formaldehyde fixed porcine pericardium. First the computer model was created to determine the optimum dimensions and then the leaflets were cut to those dimensions. The leaflets were sutured to the frame and the valve was tested in a left heart simulator. The valve function and leaflet dynamics were recorded. Four prototype valves were made showing continuous improvements. Third prototype had excellent hemodynamics, however, the leaflets had asynchronous closure, asymmetric coaptation, and excessive wrinkles in open and closed configurations; the likely reasons for valve dysfunction. The fourth prototype was created with the commissure pillars and annulus diameter 20.25 mm, commissure diameter 15.25 mm, valve height 14 mm, and leaflet free edge 19 mm. The hemodynamic performance was excellent, no valvular pressure gradient and no leak. The dynamics of the leaflets were absolutely superb; the closure was symmetric, synchronous, and there were no wrinkles in the leaflets in closed or open positions. In conclusion, using the optimization criteria and incorporating the commissure pillars, we are able to produce TAV which has optimum design and function and should last longer in patients.

### Making the Optimum Transcatheter Aortic Valve

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A new technology is emerging to treat aortic valve stenosis in older high risk patients which uses catheter based implantation of a bioprosthetic valve. Our goal is to develop a transcatheter aortic valve (TAV) based on the optimum performance criteria developed by us for the natural aortic valve. The cylindrical valve frame...
from 72.1 ± 10.2° to 80.6 ± 5.7° in systole (p = 0.01) and from 74.0 ± 10.1° to 83.3 ± 5.5° in diastole (p = 0.007). In case of posterior muscle the angle did not change (p = 0.4). Sphericity index increased from 0.62 ± 0.06 to 0.72 ± 0.13 (p = 0.03). **Conclusions:** SVR relocates anterior and not the posterior papillary muscle resulting in changes of subvalvar apparatus and MV geometry that could not possibly improve mitral regurgitation.

**Insights on the Echocardiographically Normally Functioning Bicuspid Aortic Valve and Root from a Morphofunctional Magnetic Resonance Imaging Study**

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In order to investigate opening/closure mechanisms of congenital bicuspid aortic valve (BAV) without dysfunction at echocardiography, in comparison with tricuspid aortic valve (TAV), an original protocol of cine-magnetic resonance imaging measurements of the aortic valve-root complex was applied through a 1.5T system. For each individual leaflet/sinus, intercommissural distance (ICD), coaptation height (CH), root tilt angle (between ventriculo-aortic and sino-tubular junction planes), tilt angle of the leaflet to the outflow axis at fully open valve (leaflet tilt angle) were measured, comparing 22 BAV subjects (fusion of the coronary leaflets, no stenosis, no regurgitation) with 10 healthy volunteers. Aortic wall strains were computed from three longitudinal scan planes passing through each commissure and the midpoint of the opposite sinus, as 100(systolic diameter – diastolic diameter)/diastolic diameter. BAV showed significantly greater non-coronary leaflet ICD (p = 0.006). The non-coronary leaflet tilt angle in BAV was comparable to TAV (p = 0.38), showing normal opening of the non-fused leaflet, whereas the angle of the conjoint cusp was significantly wider (p < 0.001). A more eccentric systolic jet in the ascending aorta was visualized in all BAV cases, consistently. Aortic wall stretch rates in the three views were homogeneous in TAV, while in BAV the left coronary sinus had wider deformation and at the ascending level the area above the non-coronary sinus was significantly less elastic than the other two. Even when clinically normally functioning, BAV has abnormal opening mechanism, affecting both flow and aortic wall mechanics with asymmetry. Possible usefulness of these measurements in BAV follow-up, to predict valve dysfunction and/or aortopathy, may deserve prospective evaluation.

**Clinical Evaluation of the Biophysio Aortic Bioprosthesis**

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**Background:** The Biophysio (Edwards Lifesciences LLC, Irvine, Calif., USA) bioprosthesis was designed to further improve hemodynamic performance currently achieved by stented valves. A flexible nitinol stent that preserves aortic root dynamics, thus maximizing effective orifice area, is a key innovation of this prosthesis. Yet, it can be implanted with a single suture line. Clinical trials began December 2004 and being one of the first centres to implant this prosthesis in humans, we would like to present our experiences with this new device. **Methods:** Between December 2004 and August 2005, 50 Biophysio aortic bioprostheses were implanted at our institution. The mean age of patients was 75.9 ± 5.1 years. Clinical outcomes, effective orifice area, mean gradients and regression of left ventricular hypertrophy were evaluated by echocardiography at discharge, at 6 months and yearly thereafter. **Results:** 4-year follow-up was complete for all patients. Overall mortality was 14.3% (n = 6). There were no early deaths. Mortality at 12 months was 9.5% (n = 4) and 4.8% (n = 2) at 4 years. All deaths were non-valve related. One patient developed endocarditis 2 years after surgery and was reoperated. A further 2 patients were reoperated for progressive elevation of transvalvulat gradients. There were no cases of stroke or renal failure. The Biophysio prosthesis showed good hemodynamic performance with a significant drop of mean gradients to 15.1 ± 8.3 mm Hg, a mean effective orifice area of 1.5 ± 0.7 cm² and a mean ejection fraction of 60.7 ± 7.2%. There were no cases of aortic regurgitation. New York Heart Association functional class improved in all patients and there was a significant reduction of left ventricular mass index to 185.7 ± 49.6 g/m² at 24 months. **Conclusions:** The clinical performance of the new Biophysio aortic bioprosthesis is comparable to regular stentless aortic valves. Its unique design features make it easier and quicker to implant than conventional stentless valves.

**Pericardial Bioprosthetic Valve Implants in Sudan: Clinical Experience**

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**Objective:** Clinical experiences on Western series provided valuable information on the structural durability and complications of bioprostheses. In a young Sudan patient series social environment, poor feeding, hygienic conditions and lack of medical care are significant risk factors for structural and non-structural valve deterioration and can deeply affect the destiny of cardiac surgical patients. As this population is extremely different from occidental population, the devices were implanted outside the standard manufacture recommendations because of specific clin-
Rheumatic and Non-Rheumatic Mitral Valve Repair in a Young, Underdeveloped Sudanese Population

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Objective: Valve repair, especially in young rheumatic patients, still carries the worst results due to valve deformity and low surgical experience in western countries, and remains particularly difficult to treat with high failure rate, but it is the only rational alternative in a population in which anticoagulation is difficult. We present our early experience in a hospital for an underdeveloped population in Sudan. Methods: From April 2007 through February 2009, 141 patients (55% females, mean age 21.4 ± 11.33 years) out of 762 mitral surgeries performed underwent mitral valve conservative surgery (18.5%, in the last two months the percentage rose up to 50%). The aetiology was rheumatic in 100 patients (71%) and degenerative/infective in the others (stenosis in 37, regurgitation in 95 and both in 9 cases). Severe congestive heart failure was present in 62%. Reparative procedures included different techniques. Echocardiographic and clinical follow-up was performed at 1, 6, 12 and 24 months. Results: Operative mortality was 3.5% (5 patients). Follow-up was available for 85.9% the survived. The reoperation rate was 6.4%, 5 early and 4 late failures (mean 11.75 months) (8 in mitral regurgitation and 1 in mixed, 5 rheumatic valves). No late deaths occurred. Among the controlled survivors, 89% had no or trivial mitral regurgitation and were in NYHA functional class I. Conclusions: Mitral valve reconstruction in young patients should be performed when technically feasible providing satisfactory early results, to maximize survival and reduce morbidity. In rheumatic patients progression of disease is the most important risk factor for reoperation.

Transcatheter-Based Aortic Valve Implantation at Four Years: What Happened to Our Initial Patients?

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Background: Short-term results of transcatheter valve implantations, for aortic valve stenosis, have been encouraging, with potential for reducing perioperative risk and hospital length of stay. However, little is known about mid-term efficacy of this approach. This report analyses the mid-term results of a single institution's results, of the initial series of patients. Methods: The first 20 patients had transapical aortic valve implantations at our institution starting in January 2005. The mean age was 85 ± 6 years. All patients had a high perioperative risk for aortic valve replacement, with a mean logistic Euroscore of 36 ± 12. Clinical and echocardiographic variables were entered prospectively into a database. Follow up was complete for all patients. Results: After a mean follow up of 4.1 ± 2 years, overall mortality was 50% (n = 10/20). 30 day mortality was 12.5% and late mortality 37.5%. The causes of late mortality were cardiac failure, respiratory failure, renal failure and cancer. There were 2 perioperative rethoracotomies for bleeding, 2 intraoperative conversions, 1 prosthesis migration and 2 impairments of coronaries. There were 2 late conversions. One for aortic valve thrombosis and one for acute type A dissection. Valve thrombosis occurred after discontinuing Clopidogrel at 6 months. One patient developed late atrio-ventricular block and needed the implantation of a pacemaker. There were no cases of endocarditis or stroke in any of the patients. None of the valves showed structural valve degeneration. NYHA functional class at 4 years ranged between 1 and 3. Four patients did not improve their functional class. All others improved by one or two steps. Conclusion: Mid-term outcomes after transcatheter aortic valve implantation, in high risk patients at our institution, show an improvement in quality of life, but a progressive mortality. Valve degeneration is not an issue at mid-term.

Hemorheology after Transapical and Transfemoral Aortic Valve Implantations

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Objective: After initial scepticism, transcatheter valve implantations have found their way into clinical practice, in a selected patient cohort. The novel nature of these interventions necessitates the development of specific postoperative clinical reference ranges, to allow physicians to accurately assess clinical outcomes and procedural success. Methods: Starting in January 2006, a total of 100 patients receiving transcatheter aortic valve implantations were enrolled in this study. Depending on the size of iliac vessels, they had transfemoral (Corevalve n = 50) or transapical (Edwards Sapien n = 50) access. Hemorheology, hematology, coagulation, renalfunction, cardiac enzymes and clinical
chemistry were evaluated preoperatively, on the day of intervention, daily thereafter until discharge, at 6 months and 1 year postoperatively. Results: The maximum mean postoperative hematocrit was 36.6 ± 4.7% versus 39.1 ± 3.8%, C-reactive protein 20.7 ± 9.4 mg/dl versus 11.2 ± 7.2 mg/dl, leukocytes 14.6 ± 6.6/nl versus 14.1 ± 5.4/nl, creatinine kinase 1671.9 ± 3247.2 μg/l versus 164.6 ± 232.4 μg/l, CKMB 85.8 ± 118.8 μg/dl versus 30.1 ± 33 μg/dl, considering transapical versus transseceral access respectively. There were no significant differences between the groups regarding hemolysis, coagulation or renal function parameters. Conclusion: Due to the nature of transapical aortic valve implantations there is understandably a significant increase in inflammatory parameters and cardiac enzymes.

Relationship between Left Ventricular Mass and Aortic Valve Calcification: The Multi-Ethnic Study of Atherosclerosis

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Background: Aortic valve calcification (AVC) occurs during the early stages of valve remodeling, frequently before the development of hemodynamic valve obstruction. Data suggest that left ventricular hypertrophy, widely considered a compensatory mechanism of hemodynamic valve obstruction. Data suggest that left ventricular mass may precede CAVD.

Methods: The relationship of baseline left ventricular mass (%LVM; standardized for gender, height, and weight) to the prevalence, severity, and incidence of AVC was determined by regression modeling. Results: AVC was prevalent in 631 subjects at baseline. An additional 227 subjects developed incident AVC at follow-up (median 3.1 years later). After adjustment for age, gender, body mass index, demographics, study site, antihypertensive therapy, statin use, diabetes, smoking status, blood pressure, cholesterol levels, and renal function, %LVM was positively associated with AVC prevalence (prevalence ratio = 1.06 [95% CI 1.03, 1.10]; p < 0.0005; all results reported per 10% increase) and severity (risk difference = 1.14 [95% CI 1.09, 1.20]; p < 0.0001) at baseline. In those without AVC at baseline, %LVM was associated with the development of AVC (relative risk = 1.18 [95% CI 1.06, 1.31]; p < 0.0005). Conclusion: In the diverse MESA cohort, %LVM was associated with prevalence and severity of AVC. An association between baseline %LVM and incident AVC suggests that increased left ventricular mass may precede CAVD. Further study is needed to determine the mechanisms responsible for this association and evaluate its impact on patient outcomes.

Bisphosphonate Use and the Prevalence of Valvular Calcification in Women: The Multi-Ethnic Study of Atherosclerosis

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Background: Valvular calcification correlates with atherosclerotic disease burden. Experimental data suggest that nitrogen-containing bisphosphonates (NCBP) may limit cardiovascular calcification, which has implications for disease prevention.

Methods: The relationship of NCBP use to the prevalence of aortic valve, aortic valve ring, and mitral annulus calcification (AVC, AVRC, and MAC, respectively) detected by computed tomography was assessed in 3,636 women aged 45–84 years within the Multi-Ethnic Study of Atherosclerosis (MESA) using relative risk regression modeling. All subjects were free of clinically overt cardiovascular disease. This analysis was confined to women because the overwhelming majority of subjects (>93%) receiving NCBP therapy in MESA are women. Results: Analyses were age-stratified because of a significant interaction between age and NCBP use (interaction p-values: AVC p < 0.0001; AVRC p < 0.0001; MAC p < 0.005). After adjusting for age, body mass index, ethnicity, socioeconomic status, diabetes, smoking, blood pressure, cholesterol levels, and statin, hormone replacement, and renin-angiotensin inhibitor therapy, NCBP use was associated with a lower prevalence of valvular calcification in women ≥65 years old (prevalence ratio [95% confidence interval]: AVC 0.68 [0.41, 1.14]; AVRC 0.69 [0.51, 0.84]; MAC 0.54 [0.32, 0.92]), whereas calcification was more prevalent in NCBP users among the 2,181 women <65 years old (AVC 4.01 [2.33, 6.91]; AVRC 1.89 [1.40, 2.56]; MAC 2.35 [1.13, 4.88]). Conclusions: Among women in the diverse MESA cohort, NCBBs were associated with decreased prevalence of valvular calcification in older subjects, but more prevalent cardiovascular calcification in younger ones. Further study is warranted to clarify these age-dependent NCBP effects.

Association between Congenital Bicuspid Aortic Valve Anatomy and Valve Inflammation and Neovascularization

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Background: Patients with congenital bicuspid aortic valves (CBAV) develop aortic valve stenosis (AS) at a relatively young age compared to patients with tricuspid aortic valves. We hypothesize
that AS evolves from a more aggressive inflammatory process, with increased macrophage/T cell and neovessel content in CBAV when compared to tricuspid valves. **Methods:** Fifty-one severely stenotic aortic valves were obtained at the time of aortic valve replacement surgery. A total of 17 bicuspid and 34 tricuspid aortic valves were evaluated. Macrophage/T cell infiltration (CD-68+CD3) and neovessel density (CD-34) were evaluated using immunohistochemical staining. Leaflet calcification and ossification were also quantified. Real-time PCR was used to assess expression of chondromodulin-1 (ChM-1) and vascular endothelial growth factor (VEGF).

**Results:** The density of macrophage/T cells was greater in CBAV than in tricuspid ones (51 ± 31 vs. 23 ± 13 cells/mm²; p = 0.002). Neovascularization was more frequently noted in CBAV when compared to tricuspid valves (31 ± 10 vs. 21 ± 9 vessels/mm²; p = 0.0005), and calcification was more severe (p = 0.03). ChM-1 demonstrated a 6-fold down regulation (p = 0.0003) and VEGF a two-fold increase (p = 0.02) in CBAV compared to tricuspid valves. Multivariable analyses demonstrated significant associations between bicuspid aortic valve anatomy and increased inflammatory cell infiltration (β = 0.0007) and neovascularization (β = 0.001) despite adjusting for measured covariates. **Conclusion:** The pathogenesis of AS in CBAV is associated with a more aggressive inflammatory process and neovascularization when compared to tricuspid valves.

**Long-Term Outcome following the Bentall Procedure in Low-Risk Patients: A Benchmark for Valve SpARING Operations**


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**Objective:** Valve-sparing procedures have progressively been recommended for aortic valve and root/ascending aorta repair, especially in younger, low risk patients. The durability and long-term outcome of valve-sparing operations have, however, never been shown to be superior to the results with the Bentall procedure. **Methods:** We have followed a cohort of 142 consecutive, elective patients – all <65 years – who underwent a Bentall operation without concomitant procedures between 1989 and 2002 85% were men; median age was 46 (13–64) years. Degenerative disease of the aorta was the most common indication for operation (86%, including 46% with bicuspid aortic valve); 8% had chronic dissection, and 6% atherosclerotic aneurysms. The ascending aorta was replaced in 94 patients (66%); 45 patients (32%) underwent hemiarch replacement, and in 3 (2%) the entire arch was replaced. A mechanical valve was used in the conduit in 88%, and a biologic valve in 12%. **Results:** Follow up was 100% complete, with a median of 10.9 (6.4–19.5) years. Survival was 95% after five, 91% after ten and 88% after twelve years; the linearized death rate was 1.2% per patient-year. There was no significant difference in overall survival after the Bentall procedure compared to a sex- and age-matched normal population. Twenty patients (14%) experienced adverse events: all episodes of bleeding occurred in patients with a mechanical valve. One-third of all bleeding events occurred within the first postoperative year; the bleeding rate declined to 1.1% per patient-year during years 1–5, and thereafter to 0.5% per patient-year. The probability of suffering a thromboembolic stroke declined after the first year, from 1.4% per patient-year to <0.2% per patient-year thereafter. Endocarditis risk was 2.1% per patient year the first year, subsequently diminishing to 0.18%. The reoperation rate was <0.1% per patient-year. Freedom from adverse events was 87% after five, 86% after ten and 84% after twelve years. **Conclusions:** The Bentall procedure restored this young cohort of patients requiring operation for disease of the ascending aorta to a normal life expectancy. Stroke, bleeding and reoperation rates were low. These long-term results indicate that the Bentall procedure in young elective patients produces a low risk durable option that may compare very favorably with long term results of valve sparing procedures in comparable patients. The decline in prosthesis-related complications over time in Bentall patients contrasts favorably with the increasing rate over time of valve failure in patients with valve sparing procedures.

**Height of the Anterior Leaflet (A2) Measured by Echocardiography Predicts Accurately the Annuloplasty Ring Size Used during Mitral Valve Reconstruction Using Carpentier’s Techniques**

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**Rationale:** Remodeling concept annuloplasty is one of the golden rules of long term efficacy of mitral valve reconstruction using Carpentier’s techniques. Sizing is a key issue to avoid undersizing (risk of SAM) or oversizing (residual MR) in degener-
operative mitral regurgitation (MR). There are no studies who try to predict the accurate ring annuloplasty size based upon echocardiographic measurement of the height of anterior leaflet height (A2). **Aim:** To establish a correlation between height of the anterior leaflet height (A2) measured by intra-operative (IOE) transesophageal echocardiography (TEE) and annuloplasty ring size measured by surgeons in type II degenerative MR. **Method:** Prospective monocentric study. Measurement of the height of anterior leaflet (A2) in long axis view using multiplane IOE TEE (pre pump) and mitral annuloplasty ring size (Carpentier-Edwards Physio) measured systematically by surgeons with sizers. Intra Class Correlation test and Bland-Altman plot were done. **Results:** Fifty patients were included. The mitral ring diameter was 41.4 ± 3.7 mm. The anterior leaflet height was 32.7 ± 2.9 mm. Size of annuloplasty ring was 32.8 ± 2.9 mm. The anterior leaflet height was significantly correlated with the prosthetic ring used, $r = 0.869$ [0.780, 0.923], $p < 10^{-3}$. The mitral ring diameter was not concordant with the prosthetic ring used, $r = -0.432$ [-0.632, -0.178], $p = 0.39$. The Bland-Altman plot shows that there is a good correlation between the anterior leaflet height and the prosthetic ring used. **Conclusion:** The anterior leaflet height (A2) measured by echocardiography predicts accurately annuloplasty mitral ring size measured systematically by surgeons.

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**Is the Bentall Procedure Appropriate for Ascending Aortic Aneurysms Associated with Bicuspid Aortic Valve?**

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**Objectives:** The Bentall procedure is the standard treatment for patients presenting with an ascending aortic aneurysm (AAA) associated with aortic valve dysfunction, except in cases of insufficient aortic root dilatation. The extent to which its outcome is influenced by the valve morphology remains unknown. The present study was designed to address whether a more conservative intervention is appropriate in patients with bicuspid aortic valve (BAV). **Methods:** Between October 2005 and March 2009, aortic geometry was compared between 41 patients, operated for AAA, of whom 22 had a BAV (group A) and 19 a tricuspid aortic valve (TAV) (group B). Forty-two aged-matched subjects served as controls (group C). Measurements were made by using pre-operative ECG-gated thoracic 64 row multi-slice CT scan. Aortic diameters at 10 levels and the distances between the annulus and 5 points along the ascending aorta were measured at end diastole. **Results:** See table 1. **Conclusion:** CT analysis shows that patients with BAV usually develop AAA above STJ, whereas patients with TAV develop AAA starting at the aortic root level. Thus, supra-junctional aortic replacement might often be the sound operation for patients with BAV presenting with an AAA.

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**Reoperative Minimally Invasive AVR with Patent LIMA – Use of Continuous Retrograde Cardioplegia and a ‘No Touch’ Technique**

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**Background:** We sought to determine if we could improve outcomes in patients who needed aortic valve replacement (AVR) after CABG with a patent left internal mammary artery (LIMA). **Methods:** We performed reoperative minimally invasive (upper hemisternotomy) AVR using moderate hypothermia (25°C) with the addition of continuous retrograde cardioplegia. Coronary sinus catheters were placed pre-operatively by anesthesiologists. We cooled all patients to 25°C and allowed the patient to undergo cold fibrillation. To provide a cooling jacket for the heart, we used continuous low potassium cold blood cardioplegia intermixed every 20 min with high potassium cold blood cardioplegia. The aorta was cannulated directly in the chest, and femoral venous drainage was used with a 25 French multistage femoral venous cannula. The groin was exposed prior to sternotomy. The LIMA was left untouched. Hemisternotomy was performed into the 3rd–4th intercostal space. Aortotomy was performed as a ‘lazy S’ pattern and bovine pericardium was used to routinely close the aorta. **Results:** Ten patients had AVR after a CABG was per-

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**Table 1.**

<table>
<thead>
<tr>
<th>Distance (mm)</th>
<th>Group A</th>
<th>Group B</th>
<th>Group C</th>
<th>p</th>
<th>A versus B*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Annulus to maximal aneurysmal diameter</td>
<td>50.4 ± 16.5</td>
<td>38.4 ± 16.7</td>
<td>NA</td>
<td>&lt;0.0008</td>
<td>p = 0.034</td>
</tr>
<tr>
<td>Annulus to right coronary ostium</td>
<td>15.45 ± 5.40</td>
<td>19.95 ± 5.87</td>
<td>14.2 ± 2.3</td>
<td>&lt;0.0004</td>
<td>p = 0.17</td>
</tr>
<tr>
<td>Annulus to left coronary ostium</td>
<td>16.74 ± 2.67</td>
<td>16.84 ± 4.29</td>
<td>14.0 ± 2.4</td>
<td>&lt;0.0009</td>
<td>p = 0.91</td>
</tr>
<tr>
<td>Identified sino-tubular junction (STJ)</td>
<td>86.36%</td>
<td>47.36%</td>
<td>(100%)</td>
<td>0.007</td>
<td></td>
</tr>
<tr>
<td>Annulus to sino-tubular junction (when identified)</td>
<td>22.1 ± 4.1</td>
<td>23.4 ± 7.2</td>
<td>19.5 ± 2.9</td>
<td>&lt;0.0009</td>
<td>p = 0.17</td>
</tr>
</tbody>
</table>

* Pairwise comparisons following ANOVA.
formed, with a patent LIMA. All were performed by a single surgeon. The mean age was 72 years (55–88), 10% were women. Mean cross-clamp time was 118 min. Mean CPB time was 167 min. Length of stay averaged 17 days (from 6–39 days). No patients required mechanical assistance. 1 patient required a permanent pacemaker. There were (0) no deaths in the group. All are alive with one year of followup. STS risk was greater than 10% for the cohort. Conclusions: Reoperative AVR after CABG with a patent LIMA can be safely performed using continuous retrograde cardioplegia, moderate hypothermia, and a no touch technique for all grafts. The use of a smaller incision limits potentially dangerous dissection and vein graft atheroma formation. This may provide an alternative to percutaneous grafting in high-risk patients.

Improved Assessment of the Mitral Annulus Using Real-Time Three-Dimensional Transesophageal Echocardiography


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Background: Accurate quantification of the mitral annulus is important in mitral valve (MV) repair. Methods of annular quantification by transesophageal echocardiography (TEE) are inaccurate when standard 2D imaging planes do not represent the true annular diameters. We evaluated a simple and practical method of mitral annular quantification using a real-time three-dimensional (RT3D) matrix array TEE. Methods: Multiplane 2D and RT3D TEE images were obtained in 17 patients. Five patients had significant MV disease and 12 had no MV pathology. The anterior-posterior (AP) and the medial-lateral (ML) annular diameters were measured in standard 2D imaging planes (135 and 60°, respectively). From the RT3D images, the true AP and ML planes were determined and diameters measured. Elliptical annular areas were compared to the gold standard 3D projected annular area. Results: The mean ML diameter by 2D was similar to RT3D (4.3 ± 0.5 vs. 4.2 ± 0.3 cm, p = 0.18). However, the mean AP diameter by 2D was larger than RT3D (3.8 ± 0.6 vs. 3.5 ± 0.3 cm, p = 0.05), indicating the 2D plane cut obliquely through the annulus. The mean annular area was 13.1 ± 3.5 cm² with 2D planes and 11.6 ± 1.8 cm² using RT3D (p = 0.038). The projected annular area was 11.7 ± 1.9 cm² (p = 0.046 vs. 2D and p = 0.95 vs. RT3D). Furthermore, the degree of variance was significantly different between the projected area and 2D (p = 0.03), but not RT3D (p = 0.70). Conclusion: Mitral annular diameters and area by RT3D are more accurate and less variable than using standard 2D imaging.

How to Preserve Renal Function in Transcatheter Aortic Valve Therapies

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Background: Transcatheter aortic valve implantations (TAVI) are indicated in high risk patients requiring aortic valve replacement (AVR). However, CT-scans, coronary angiograms and intraoperative aortographies can induce contrast-related nephrotoxicity with a concrete risk of acute postoperative renal failure, especially in severely diseased patients. To prevent this complication, we routinely perform transapical (TA) TAVI guided by transesophageal echocardiogram and fluoroscopy without angiography. Material and Methods: From November 2008 to December 2009, 31 high-risk patients suffering from severe symptomatic aortic stenosis underwent TA-TAVI in our institution. The preoperative imaging assessment (cardiac CT-scan and coronary angiogram) was performed no less than 10 days before the TA-TAVI in all patients (to recover the renal function) with a low-dose protocol for injected contrast medium (equivalent to the patient’s weight for the CT-scan). During the TA-TAVI, the stent-valve positioning was performed without any contrast injection. Results: 32 consecutive stent-valve were successfully positioned in 31 patients (mean age 80.76 ± 8.3 years; mean EuroSCORE: 32.2 ± 12.9%) through a transapical access (1 patient required 2 valves for valve embolisation). The mean preoperative creatinine and urea blood levels were 102.6 ± 67.7 μg/dl (range 53–339 μg/dl) and 8.45 ± 4.9 mmol/l, respectively. A chronic renal insufficiency affected 12 patients (38.7%) with 1 patient in pre-dialysis. Postoperatively, no patient developed acute myocardial infarction, atrio-ventricular block or acute renal insufficiency (mean creatinine level: 89.7 ± 64.55 μg/dl; urea level: 7.11 ± 3.47 mmol/l) and the 30-days mortality was 9.67% (3 patients). Conclusion: Specific preoperative and intraoperative protocols that require low-doses or absence of contrast medium are useful to preserve the renal function in high risk patients operated for TAVI.

Quantitative Index of Aortic Stenosis Progression and Potential Predictive Measures

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Abstract: Managing patients diagnosed with heart valve disease is challenging due to the unpredictable rates at which the disease progresses. The objectives of this study were to (1) develop a quantitative index of AS severity to enable comparison of disease progression in patients, (2) establish patient subgroups with specific AS progression tendencies, and (3) identify factors that may predict progression rate. The index we developed is based on a combination of the three parameters currently used in AS diagnosis (aortic valve area, mean gradient, and peak velocity). Each were normalized to factor equally and then linearized to fall on a scale from 0 to 8. We validated this metric in a retrospective study of 50 patients followed for up to 15 years. We identified four sub-
groups of patients based on the initial severity (low/high) and rate of progression (slow/fast) using this AS Severity Index (ASSI): low-slow, low-rapid, high-slow, high-rapid. We then conducted a logistic regression analysis of the all measured parameters across all patients over the initial 2-year follow-up period, and found two factors that correlated with slow and rapid progression. We found that patients with a unit increase in right ventricular dimension in diastole (p = 0.026) over two years have a 35-fold increase in odds of rapidly progressing AS. However, a decrease in aortic root area (p = 0.01) was associated with a 40% increased probability of slow progression. These results suggest that the ASSI is a useful quantitative metric of AS progression that can support predictor identification.

**Effect of Patient-Prosthesis Mismatch on the Hemodynamics and Quality of Life after Aortic Valve Replacement**

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**Objective:** We determined the effect of patient-prosthesis mismatch (PPM) in patients who had undergone aortic valve replacement (AVR). **Method:** From June 1981 to December 2008, 325 patients who underwent isolated AVR using a 19-, 21-, or 23-mm prosthetic valve were analyzed. The St. Jude Medical valve was used in 149 patients, and the Carpentier-Edwards Perimount valve, in 174 patients. A 19-mm valve was used in 35 patients; 21-mm in 116 patients; and 23-mm in 174 patients. The early and late results were evaluated. At follow-up examination, echocardiography was performed, and a questionnaire based on the specific activity scale (SAS) was administered to the patients. **Results:** There were two early deaths (0.6%). Follow-up was performed in 97% of the operative survivors: the mean period of 7.9 years. There were 38 late deaths including 19 cardiac deaths. No statistical differences were observed among the 3 valve sizes with regard to survival and freedom from valve-related complications. According to the echocardiography results, 9 patients (2.8%) were defined as having severe PPM; 68 patients (21%), moderate PPM; and 246 patients (76.2%), no PPM. The survival, freedom from valve-related complications, and SAS scores did not differ among groups formed on the basis of the presence or severity PPM. The left ventricular mass index at follow-up was significantly higher in patients with severe PPM; however, it was still in the normal range. **Conclusion:** The results of AVR and the activities of the patients were found to be satisfactory even in the patients with severe PPM.

**Transcatheter Aortic Valve Implantation for Severe Symptomatic Aortic Stenosis in Inoperable Patients: A Single Italian Center Two-Year Experience**

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**Purpose:** Catheter-based aortic valve implantation (TAVI) is a rapidly evolving technique with potential to create a paradigm shift in the treatment of critical aortic stenosis in patients unsuitable for conventional open-heart surgery. Since 2002, over 10,000 transcatheter aortic valve implantations have been performed worldwide. We report procedural and follow-up results of our 2-year experience with TAVI in high-risk patients with severe symptomatic aortic stenosis. **Materials and Methods:** Transcatheter Edwards SAPIEN valve implantation was attempted in 150 patients (81 ± 6 years) in whom surgical risk was deemed excessive due to older age, poor left ventricular function and comorbidities (average logistic EuroSCORE 23.46 ± 12.43%). Either retrograde transarterial or transapical approach was used. All procedures were performed without cardiopulmonary bypass. Rapid ventricular pacing was used to reduce cardiac output while delivering balloon-expandable prosthesis. **Results:** Successfull valve replacement was 100%. It was associated with excellent hemodynamic function of the prostheses with a physiologic mean aortic gradient and an increase in trans-thoracic echocardiographic aortic root area from 0.6 ± 0.15 to 2.2 ± 0.4 cm². All causes 30-day mortality was less than 3% and incidence of acute myocardial infarction as well as stroke was 1%. Patients improved of one NYHA class at least at one-month follow-up. **Conclusions:** The present study confirms the excellent haemodynamic performances of transcatheter implanted aortic prostheses, with both transarterial and transapical approaches. Progressive improvement in patients selection, techniques, equipment and operator endovascular skills allowed to solve early problems and to obtain consistently reproducible success.

**Tissue-Guided Regenerated Valved Conduits: Long-Term Results of Porcine Decellularized α-Gal Negative Roots**

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The onset of calcification is still a major hurdle of structural valve deterioration of bioprosthetic valve. Durability, short- and long-term competency, host cell colonization leading to physiological ECM remodelling and growth potential are ideal requirements for any valve substitute. TRICOL decellularized
Impact of Coronary Disease on Aortic Valve Surgery: Trends and Predictors of Outcomes


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Objective: Compared to isolated aortic valve replacement (AVR), concomitant coronary bypass surgery (CABG) purports increased operative risk. This study describes current trends related to AVR +/- CABG (1998–2008) to determine patient, anatomic and operative factors that predict contemporary clinical outcomes. Methods: Descriptive analyses and multivariable regression modeling were performed using a prospectively collected database at a single academic institution. Results: AVR was performed in 2,710 patients (isolated AVR, n = 1,662; AVR+CABG, n = 1,048). Degenerative stenosis was the commonest etiology/pathology in both cohorts. The AVR+CABG cohort had more: cardiovascular co-morbidities, prior myocardial infarction (MI), left ventricular (LV) dysfunction and worse symptom class. They also had longer cross-clamp (146 ± 40 vs. 106 ± 39 min), cardiopulmonary bypass (180 ± 52 vs. 133 ± 51 min) and ICU durations (47 ± 9 vs. 39 ± 69 h) (all p < 0.05). Chest re-opening (11 vs. 7%), dialysis (4 vs. 2%) and perioperative MI (9 vs. 6%) were more common, as was 30-day mortality (9 vs. 6%), in the AVR+CABG cohort (all p < 0.05). Significant, independent predictors of poor outcomes (MI, stroke or death) were: older age, female gender, cardiopulmonary bypass time, preoperative renal or LV dysfunction, anemia and combined AVR+CABG. Conclusions: Contemporary operative risk for AVR+CABG exceeds that of isolated AVR. A valid, rigorous statistical model including coronary and aortic valve disease burden and preoperative co-morbidities, was devised to predict poor clinical outcomes. This may be useful in patient selection for presumably lower risk catheter-based valve/coronary interventions.

Circulating Endothelial Progenitor Cells Co-Expressing an Osteoblastic Phenotype Are Increased in Patients with Severe Calcific Aortic Valve Stenosis

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Objective: To investigate the numbers of circulating endothelial progenitor cells (EPC) co-expressing an osteogenic phenotype (EPC-OC) in patients with clinically severe calcific aortic valve stenosis (AoS). Background: AoS is one of the most common valvular heart diseases with increasing prevalence. Recent investigations have shifted the old paradigm of AoS being a passive, degenerative process to an active biological process associated with an osteoblast-like phenotype. We have recently identified circulating EPC-OC which are significantly increased in patients with severe coronary artery sclerosis (CAD). Methods and Results: We studied 38 patients, 14 of which underwent aortic valve replacement due to AoS with only mild angiographic CAD. Patients with normal aortic valves and normal coronary arteries (n = 12) and severe CAD without aortic valve disease (n = 12) served as controls (table 1). Peripheral blood mononuclear cells were analyzed using flow cytometry following staining for EPC markers (CD133, CD34, KDR) and the osteoblastic marker, osteo-

![Graph](image_url)

**Fig. 1.** *p < 0.03.
Table 1. Clinical data

<table>
<thead>
<tr>
<th></th>
<th>Normal (n = 12)</th>
<th>AoC (n = 14)</th>
<th>CAD (n = 12)</th>
<th>p value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age, years</td>
<td>53 ± 2</td>
<td>66 ± 3</td>
<td>64 ± 2</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Male, %</td>
<td>33</td>
<td>86</td>
<td>92</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>BP syst, mm Hg</td>
<td>131 ± 6</td>
<td>118 ± 6</td>
<td>124 ± 7</td>
<td>NS</td>
</tr>
<tr>
<td>BP diast, mm Hg</td>
<td>73 ± 3</td>
<td>66 ± 3</td>
<td>76 ± 3</td>
<td>NS</td>
</tr>
<tr>
<td>GFR (MDRD)</td>
<td>82 ± 4</td>
<td>69 ± 3</td>
<td>77 ± 6</td>
<td>NS</td>
</tr>
<tr>
<td>LDL, mg/dl</td>
<td>107 ± 10</td>
<td>82 ± 7</td>
<td>90 ± 15</td>
<td>NS</td>
</tr>
<tr>
<td>Statin use, %</td>
<td>50</td>
<td>71</td>
<td>75</td>
<td>NS</td>
</tr>
<tr>
<td>Diabetes, %</td>
<td>0</td>
<td>7</td>
<td>25</td>
<td>NS</td>
</tr>
</tbody>
</table>

Calcification (OC). Patients with AoC had significantly higher percentages of OC co-expression in three subtypes of EPC than normal patients, similar to patients with CAD (Fig. 1). 

Conclusions: Our preliminary results indicate that circulating EPC with an osteoblastic phenotype may play a role in an active process of aortic valve calcification. Future studies will have to show whether circulating EPC-OCN may serve as a biomarker facilitating the prognostication of the progression of aortic valve calcification and calcific aortic stenosis.

Rapid, Reliable Repair of Mitral Regurgitation Using ‘Z-Plasty’ Posterior Annular Suturing Technique for Implantation of the CG Future Band

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Insertion of posterior annuloplasty bands for the correction of mitral regurgitation and annular dilatation is accomplished with serial double armed suture placements placed parallel to or within the annulus. In older or ischemic dilated cardiomyopathy patients, tissue friability is common, and the need for rapid insertion to lessen clamp is crucial. Using techniques common to plastic surgery, we utilized placement of posterior annuloplasty sutures using a ‘Z-Plasty’ style. A single needle of a double armed 4–0 braided suture was sewn at a 45 degree angle away from the annulus into the posterior leaf atrial wall. The same needle was then reintroduced starting 5–8 mm further along the annulus, making a parallel 45-degree angle placement into the atrial wall, completing the second line of the ‘Z’. Suture placement continues until ‘Z’ sutures have been placed from fibrous trigone to fibrous trigone. A total of 8 sutures are needed, even in severely dilated annuli. Sutures are then brought through a CG Future Band (Medtronic, Minneapolis, Minn., USA) and the band tied into place. From 2002 to 2010, a total of 196 ‘Z-Plasty’ implantations have been performed, with echo follow-up on all implants. There have been no dehiscences; no peri-band leaks, no revisions, or subsequent mitral valve replacements. The majority of repairs have been graded none, trace, or mild regurgitation. Three patients (1%) have moderate MR, all of whom have severe ischemic dilated cardiomyopathy. We conclude that ‘Z-Plasty’ posterior annular suture technique and band implantation provides simple, reliable repair of mitral annular dilatation.

A Single-Center Prospective Study of Clinical Outcomes with the Sorin Mitroflow Pericardial Aortic Valve

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Objective: The aim of this study was to investigate the medium-term clinical and hemodynamic outcomes after aortic valve replacement at a single center with the Sorin Mitroflow pericardial aortic bioprosthesis. Methods: Data was reviewed from a single center as part of a larger prospective, non-randomized, multicenter study involving 25 sites and 699 patients from 2003–2007. Seventy-one patients at our center received the Sorin Mitroflow pericardial bioprosthesis with a mean age of 73.8 years (range 45–89), and a male/female ratio of 37:34. Before operation, 77.1% of patients were in New York Heart Association functional class III or IV, and 66 patients (93%) had stenosis or mixed valvular lesions. Associated surgical procedures included coronary bypass
grafting in 50 patients (70.4%), maze procedure in 9 patients (12.7%), and associated tricuspid or mitral valve repair in 9 patients (12.7%). Fifty-one patients (71.9%) received a 23 or 25 mm sized valve. Previous cardiac operations had been performed in 9 (12.4%) cases.

**Results:** The mean follow-up was 2.9 years (6 days-5.1 years), with cumulative of 206 patient-years. There was one early death and 16 late deaths for a total of 17 deaths at follow-up, 4 of which were valve related (2 endocarditis, 2 strokes). Half of our cohort (35 patients) are currently active and continue follow-up out to 5 years and beyond. Actuarial survival was 84.5 ± 4.3% at 1 year and 74.7 ± 5.4% at 5 years. Early adverse events included arrhythmia (15.5%), heart failure (7%), and anticoagulation-related bleeding (4.2%). Late adverse events included heart failure (10%), major bleeding (8.6%), and sepsis (7.1%). Peak and mean gradients at one year were 9.4–21.6 and 4.9–13.3 mm Hg for sizes 27 to 19, respectively, demonstrating excellent hemodynamics at mid-term follow-up. At two years, 86% of patients were in NYHA class I, and 89.5% of patients had none or trace valve regurgitation at one year. **Conclusion:** The Sorin Mitroflow provides excellent hemodynamics, and survival at early to midterm follow-up.

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**Human Macrophage Cytokine Profiles to Assess Inflammatory Potential of Metallic, Polymer and Tissue-Based Biomaterials for Cardiovascular Tissue Engineering of Aortic Valves**

R.A. Hopkins

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**Objective:** Cardiac valve bioprostheses have limited durability due to inflammation, fibrosis and calcification. Bioengineered decellularized valves have been proposed as ‘deantigenized’ biologic alternatives to cryopreserved valves. Inflammatory cytokines produced by human macrophages were quantitated during timed exposures to assess inflammatory potentials of candidate biomaterials. **Methods:** Xenograft and allograft Aortic Valves were compared to glutaraldehyde-treated manufactured valves and two theoretically ‘inert’ materials (nitinol and PTFE). Valves from three species (ovine, porcine, human) were either repetitively freeze-fractured (causes cell lysis increasing antigen exposure), cryopreserved native (containing donor cells), or decellularized (no cells, DNA or remnants). IL-2, IL-6, TNF-α, TGF-β1, IL-1-β, titers, were measured (picograms cytokine/milligram test material) by ELISA at 0, 6, 24, 48 h (differences p ≤ 0.05 = significant by ANOVA), and scaled by standardized expression profiles from low to high. **Results:** Glutaraldehyde, nitinol, PTFE, and human decellularized valves had the lowest expression of cytokines. Decellularization virtually eliminated stimulation by allogeneic but not the xenogeneic materials which remained pro-

**Fig. 1.**
inflammatory. **Conclusion:** Materials with intact cells or fragments were most provocative. Cytokine signaling responses to decellularized allogeneic aortic valve extracellular matrix scaffolds were brief and low. In contrast, even decellularized, xenografts were proinflammatory, and without masking (e.g. glutaraldehyde), are unlikely to be suitable as clinical scaffolds for tissue engineering viable valves. Decellularization of human aortic valves does appear to minimize innate human macrophage inflammatory signaling, with responses similar to materials traditionally considered ‘nonreactive’.

### Mitral Subvalvular Apparatus Changes after Restrictive Annuloplasty: MRI-Based Study


**2nd Department of Cardiac Surgery**, **Department of Radiology**, **2nd Department of Cardiology**, **Medical University of Silesia**, Katowice, Poland

**Objectives:** Restrictive mitral annuloplasty (MVA) in ischemic cardiomyopathy has a high failure rate. This study was performed to delineate the influence of MVA on the subvalvular apparatus and MV geometry. **Methods:** Eleven patients with severe ischemic mitral regurgitation and EF ≤35% treated with CABG and MVA (Duran Ring 25) were subjected to ECG-gated cine-MRI before operation and 4 months thereafter. Short axis, two-chamber and four-chamber views were used to measure distances, areas and angles describing MV apparatus geometry. LV volumes and global function were also assessed. **Results:** No mitral regurgitation was present 4 months postoperatively. MVA decreased MV area from 7.91 ± 1.64 cm² to 5.30 ± 0.82 cm² (p = 0.007) in systole and 9.42 ± 1.83 cm² to 5.60 ± 1.05 cm² (p = 0.005) in diastole. Similarly, annulus septo-lateral diameter decreased from 4.05 ± 0.37 cm to 2.75 ± 0.21 cm (p = 0.005). We observed decrease of tenting area by 0.88 ± 0.42 cm² (p = 0.005) and increased coaptation (4.8 ± 0.8 cm vs. 6.3 ± 1.1 cm; p = 0.007). Posterior papillary muscle (PM) tethering distance decreased by 6.9 ± 2.6 mm in systole (p = 0.005) and 6.3 ± 4.0 mm in diastole (p = 0.007). The posterior PM to saddlehorn distance decreased by 4.2 ± 5.9 mm (p = 0.047). This was accompanied by increased posterior leaflet-M Vannulus angle (37.5 ± 5.0° before and 55.6 ± 7.8° after MVA; p = 0.005). Tethering distance of anterior PM was also decreased by 2.8 ± 3.7 mm (p = 0.05). LV end-diastolic volume was reduced from 308 ± 132 ml before surgery to 218 ± 114 ml (p = 0.005) 4 months later. Similarly, end-systolic volume decreased from 239 ± 118 ml to 170 ± 105 ml (p = 0.005). The ejection fraction did not change (24.5 ± 6.1 vs. 24.5 ± 7.3; p = 0.6). End-systolic diameter decreased from 60.5 ± 12.6 mm to 55.6 ± 13.0 mm (p = 0.02) but the change of end-diastolic diameter failed to reach significance (69.4 ± 12.7 vs. 65.8 ± 11.9; p = 0.09). **Conclusions:** Restrictive MVA for mitral regurgitation in ischemic cardiomyopathy promotes reverse LV remodeling. It decreases PM tethering but significantly tethers posterior mitral leaflet.

**Fig. 1.** Two overlapped 0.1-mm meshed MV leaflet models demonstrate a high level of consistency between repeat analyses by independent observers.
Use of Speckle Myocardial Imaging for Detection of Diastolic Dysfunction in Patients with Chronic Severe Mitral Regurgitation

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Background and Aims: Although presenting normal or super-normal ejection fraction (EF), patients with chronic mitral regurgitation (MR) may have sub-clinical left ventricular (LV) dysfunction. Speckle myocardial imaging (SMI) has been proposed to be a sensitive technique to assess LV function, independently from loading conditions. The aim of this study was to test if diastolic SMI can be useful in depicting LV dysfunction in patient with MR and normal EF. Methods and Results: 44 patients with chronic, moderate (n = 8, 18%) to severe (n = 36, 82%) degenerative MR, and 45 age- and sex-comparable controls were enrolled. Severity of MR was graded by calculation of proximal isovelocity surface area. LV untorsion rate at early and late diastole was measured. EF was lower in patients as compared to controls, although within normal range. Longitudinal sS was not different among groups. dMVI-E mean of the 6 middle segments was higher in patients compared to controls. dSR-E mean of the 6 apical segments, as well as dSR-E global average was higher in patients compared to controls. LV untorsion rate both at early and late diastole was reduced in patients compared to healthy subjects. By ROC analysis, untorsion rate at late diastole was the most accurate to differentiate patients from controls (AUC 0.70, 95% CI 0.62, 0.79). Conclusions: Longitudinal systolic SMI is not abnormal in patients with severe chronic MR, while diastolic MV1 and SR are increased, likely secondary to the associated increase in pre-load. This demonstrates that diastolic SMI is indeed a pre-load dependent technique. However, LV untorsion rate is abnormally lower in these patients, and LV diastolic impairment was present in 7 (16%) patients despite normal LVEF and normal systolic strain. This suggests that, among measures currently available in clinical practice, decreased untorsion rate may be the earliest marker of LV dysfunction for patients with significant mitral regurgitation.

Table 1. Standard Echo and SMI measures

<table>
<thead>
<tr>
<th>Variable (mean ± SD)</th>
<th>Controls (n = 45)</th>
<th>Patients (n = 44)</th>
<th>p value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age, years</td>
<td>66 ± 11</td>
<td>66 ± 14</td>
<td>0.49</td>
</tr>
<tr>
<td>Females (%)</td>
<td>23 (51)</td>
<td>20 (46)</td>
<td>0.67</td>
</tr>
<tr>
<td>Regurgitant volume, ml</td>
<td>0</td>
<td>67 ± 28</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>NYHA III/IV (%)</td>
<td>0 (0)</td>
<td>6 (14)</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Atrial fibrillation (%)</td>
<td>0 (0)</td>
<td>5 (11)</td>
<td>0.03</td>
</tr>
<tr>
<td>PM/ICD (%)</td>
<td>0 (0)</td>
<td>4 (9)</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Left ventricular mass index, g/m²</td>
<td>66 ± 37</td>
<td>118 ± 29</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>LV end-diastolic diameter, mm</td>
<td>47 ± 6</td>
<td>55 ± 6</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>LV end-systolic diameter, mm</td>
<td>30 ± 5</td>
<td>33 ± 5</td>
<td>0.003</td>
</tr>
<tr>
<td>Left atrial volume index, ml/m²</td>
<td>30 ± 7</td>
<td>60 ± 35</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Ejection fraction (%)</td>
<td>64 ± 4</td>
<td>58 ± 11</td>
<td>0.003</td>
</tr>
<tr>
<td>Cardiac index, l/m²/min</td>
<td>3.1 ± 0.6</td>
<td>2.7 ± 0.07</td>
<td>0.003</td>
</tr>
<tr>
<td>Right ventricular systolic pressure, mm Hg</td>
<td>31 ± 5</td>
<td>35 ± 13</td>
<td>0.46</td>
</tr>
<tr>
<td>sMVI global average</td>
<td>4.6 ± 0.9</td>
<td>4.5 ± 0.9</td>
<td>0.93</td>
</tr>
<tr>
<td>sSR global average</td>
<td>-1.4 ± 0.2</td>
<td>-1.5 ± 0.3</td>
<td>0.19</td>
</tr>
<tr>
<td>sS global average</td>
<td>-22.0 ± 2.0</td>
<td>-21.6 ± 3.2</td>
<td>0.84</td>
</tr>
<tr>
<td>dMVI basal mean E</td>
<td>-6.5 ± 1.9</td>
<td>-6.7 ± 1.8</td>
<td>0.62</td>
</tr>
<tr>
<td>dMVI middle mean E</td>
<td>-4.5 ± 1.6</td>
<td>-5.3 ± 1.5</td>
<td>0.02</td>
</tr>
<tr>
<td>dMVI apex mean E</td>
<td>-3.0 ± 1.0</td>
<td>-3.6 ± 1.3</td>
<td>0.05</td>
</tr>
<tr>
<td>dMVI global average E</td>
<td>-4.7 ± 1.4</td>
<td>-5.2 ± 1.4</td>
<td>0.09</td>
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<tr>
<td>dSR basal mean E</td>
<td>1.8 ± 0.3</td>
<td>1.9 ± 0.7</td>
<td>0.52</td>
</tr>
<tr>
<td>dSR middle mean E</td>
<td>1.5 ± 0.3</td>
<td>1.7 ± 0.4</td>
<td>0.06</td>
</tr>
<tr>
<td>dSR apex mean E</td>
<td>1.6 ± 0.5</td>
<td>2.0 ± 0.5</td>
<td>0.0004</td>
</tr>
<tr>
<td>dSR global average E</td>
<td>1.6 ± 0.3</td>
<td>1.9 ± 0.5</td>
<td>0.02</td>
</tr>
<tr>
<td>Untorsion rate IVRT, degrees/s</td>
<td>171.4 ± 52.7</td>
<td>147.4 ± 69.7</td>
<td>0.18</td>
</tr>
<tr>
<td>Untorsion rate late, degrees/s</td>
<td>103.8 ± 51.3</td>
<td>67.9 ± 39.2</td>
<td>0.02</td>
</tr>
</tbody>
</table>

Mitral Valve Re-Repair – Simple Solutions for a Complex Problem

P. Kiefer, J. Seeburger, M.A. Borger, F.W. Mohr

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Objective: Repeat mitral valve (MV) repair is a surgical challenge. Despite the overall increasing number of MV repair operations, little is known about the operative strategy in those patients who require a redo-repair. We therefore reviewed our experience in MV re-repair. Methods: Out of 2.707 patients who underwent minimally invasive MV surgery between 1999 and 2009, a total of 17 patients (0.6%) underwent MV re-repair. Mean age of the patients was 57 ± 13.2 years, 10 patients were male, and the mean logistic EuroSCORE was 8.8 ± 5.4%. Results: All patients underwent successful MV re-repair using our standard minimal invasive approach. Preoperative pathology included: posterior mitral leaflet (PML) prolapse in 8 patients (47%), reduced PML mobility due to retraction in 1 (6%), anterior mitral leaflet (AML) prolapse in 2 (12%), bi-leaflet prolapse in 4 (23%), native chordae rupture in 5 (29%) and annuloplasty ring dehiscence in 4 (23%). Re-repair was achieved with neo-chordae implantation (n = 8; 47%), leaflet resection (n = 2; 12%), and ring annuloplasty (n = 13; 77%). Intra-operative course was uneventful. Pre-discharge echocardiography showed no mitral regurgitation (MR) in 9 patients (53%), trivial MR in 6 (35%) and mild to moderate MR in 2 (12%). Mean duration of follow-up was 3.6 ± 2.7 years and complete. During follow-up 2 patients underwent MV replacement due to recurrent MR at 1 and 4 years postoperatively. Conclusions: MV re-repair
can be successfully performed using the minimally invasive approach. Current major repair techniques as neochordae-replacement and annuloplasty are absolutely suitable for these sometimes very complex repairs.

**Does a Lower Therapy Range in Anticoagulation of Patients with Mechanical Heart Valve Replacement Reduce the Risk of Complications?**

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**Background:** INR self-management after mechanical heart valve replacement resulted in a higher compliance of therapy. INR self-management with low-dose anticoagulation reduces the risk for thromboembolic events without increasing the risk of bleeding. The aim of the present study is to investigate the effects of a very-low target range of INR value and to predefine a target value with more reduced complication rates. **Methods:** ESCAT III is a prospective controlled randomized multicenter study. Patients were randomly assigned into three groups: a low-dose group (n = 339) and a very-low-dose group with one measurement/week (n = 343) and a very-low-dose group with two measurements/week (n = 337). The low-dose group received low-dose anticoagulation with a target INR range of 1.8–2.8 for aortic valve replacement and 2.5–3.5 for mitral or double valve replacement. Two very-low-dose groups received a new very-low-dose anticoagulation (1.6–2.1 for aortic valve replacement/2.0–2.5 for mitral or double valve replacement). The very-low-dose groups (once a week/n = 293, twice a week/n = 298) transferred INR values to the medical service centre. Patients were followed up 24 month. **Results:** Grad III complications (bleeding and thromboembolic events) occurred 16 times (low-dose = 12; very-low-dose 2 measures/week = 3). There was a significant difference between low-dose group and both very-low-dose groups. **Conclusion:** Just INR self-management permitted very-low-dose anticoagulation after mechanical heart valve replacement. This management guaranteed further reduction of ‘out-of-range’ INR values. Besides the variability of INR values decreased. By this seriously complications because of Phenprocoumon were reduced highly significant.

**Sinus Valsalva Tissue Dimensions in Fresh Autopsy Specimens**

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**Background:** The native aortic root has a complex geometry with three individually bulging sinuses. Though the literature gives detailed information regarding semilunar leaflet dimensions and on overall aortic root/valve geometry, there is limited data on sinus Valsalva true tissue dimensions. This study was aimed at obtaining measurements from normal subjects. **Methods:** In fresh autopsy specimens with no aortic valve/root pathology (n = 30) the aortic root was dissected away from the heart. Inflow and outflow diameters were measured and the root was opened longitudinally at the commissural line between right and non-coronary sinuses. After excising valve leaflets, the bulging sinus wall segments were separated from the aortic annulus and flattened with small radial incisions infero-laterally. Macroscopic tissue dimensions (sinus wall length, width and intercommissural distance) were measured and various geometrical relational patterns were determined. **Results:** The functional geometry of the aortic root was slightly cone-shaped in younger individuals and reverse cone-shaped in older subjects. In most cases the sinus wall segments were typically flat (width > length) with variable geometrical patterns and the left coronary sinus dimensions were the smallest on average. In our series there was only one aortic root (3.3%) with three symmetrical sinuses. **Conclusions:** Our measurements indicate that the ‘normal’ aortic root is almost always asymmetric. We also suggest that there may be an age related ‘remodeling’ process leading to geometrical changes that does not seem to affect valvular competence. These data should serve as anatomical guidelines for valve sparing aortic root surgery.

**Durability of the Carpentier-Edwards Supra-Annular Porcine Bioprosthesis in Aortic Position: Results beyond 25 Years**


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The aim of the study was to evaluate the fate of Carpentier-Edwards supra-annular porcine valve (CE-SAV), used for aortic valve replacement (AVR), at 25 years, by actuarial analysis to determine the clinical performance of the bioprosthesis, and by actual method (cumulative events) to precise the right choice of bioprosthetic substitutes. Between 1983 and 1994, 1,002 AVR were performed; mean age was 74.2 ± 8.4 years (range 25–91). A complete request was established in July 2009 (minimal delay between AVR and request is 15 years). Total follow-up is 8,493 patients-years; 99.4% complete. Mean follow-up is 17.8 ± 4.2 years for the 78 survivors. Three groups of patients were defined according to age: A: >70; B: 61 to 70; C: <60 years. 20 years survival was respectively 2.9, 8.1 and 60.5%. Freedom from reoperation at 20 years was respectively 96.7, 78.5, 14.2% (actuarial method); 98, 90.2 and 41.6% (actual evaluation). Freedom from reoperation for structure valve deterioration (SVD) at 20 years was respectively 98, 81.1 and 24.8% (actuarial method); 99.2, 92.5 and 48.3% (actual evaluation). The CE-SAV in aortic position provides low rate of deterioration at 20 years with less than 1% of reoperation for patients older than 70 years and less than 10% for patients aged 61 to 70 years. The results confirm the right choice of a bioprosthesis after 70 years, the legitimacy of a large discussion for patients aged 61 to 70 years, and a right information for younger who want to avoid anticoagulation.
Immediate and Long-Term Results of Mitral Valve Surgery in Octogenarians: Incidence for a Rationale Surgical Decision
Cardiovascular and Thoracic Surgery Department, University Hospital, Rennes, France

Increasing numbers of elderly patients are referred nowadays for mitral valve surgery, but this surgery remains controversial as it is often unclear whether the results offset the surgical risk. Since 1995, 89 patients, 80 years and older, underwent either a mitral valve repair (n = 52) or a replacement (n = 37). All were symptomatic, 64 patients (72%) being in NYHA class III or IV. Twenty-eight of them (31%) had significant associated coronary lesions. Fourteen were operated in emergency and 7 were redo surgery. Overall operative mortality is 19% (17/89 patients), mainly cardiac related (11 patients). It is clearly different according to the surgery performed: 11.4% in case of valve repair compared to 24% in case of isolated valve replacement, up to 41.6% for combined surgery. Statistical analysis identified seven variables responsible for an increased operative mortality, i.e. NYHA IV, renal failure, respiratory insufficiency, associated coronary disease, concomitant coronary bypass grafting, left ventricular dysfunction, combined valve replacement and associated surgery. This leads to define levels of surgical risk. Clinical follow-up was 96% complete. Overall survival was 70.2 ± 6.1% and 41.2 ± 8.9% at 2 and 5 years, respectively. All operative survivors report a patent and durable functional improvement. Despite a significant operative mortality, mitral surgery in elderly is legitimate, especially if valve repair is feasible, for symptomatic selected patients as it may provide a substantial functional improvement and a good survival rate. But mitral valve surgery is deeply questionable in high-risk patients.

Identification of Protein Expressed by Severe Aortic Stenosis Valves in the Search for Novel Biomarkers: Intermediate Results

Background: Aortic stenosis (AS) has been considered as a passive process secondary to calcium deposit in the valves. However, some studies have demonstrated that degenerative AS shares histological findings with atherosclerotic plaques which have led to the suggestion that AS may be a chronic inflammatory process. The aim of this study is to apply novel proteomic techniques to obtain new data that may contribute to understanding this processes, together with the identification of new biomarkers. Methods: Aortic valves obtained from necropsies (control samples) or surgical valve replacement were homogenized in extraction protein buffer. Both samples were analyzed using bidimensional differential gel electrophoresis and liquid chromatography-mass spectrometry. Furthermore, AS and control leaflets were studied by immunohistochemical (IH) and Western blot (WB) analysis, using a panel of monoclonal antibodies specific for inflammatory and cytoskeletal/contractile proteins to confirm these results. Results: 50 patients underwent aortic valve replacement due to degenerative severe AS were compared with 20 control valves obtained by necropsies. There are at least 18 proteins altered in AS. These differentially expressed proteins were classified according to their functions: response to stress, inflammation, structural proteins, antioxidant enzymes and lipid transport; and include proteins such as transtiretin, haptoglobin, fibrinogen gamma chain OS and Apo A I. Analysis by WB and IH techniques demonstrated their presence in AS valves, confirming the proteomic results. Conclusions: The different expression of several proteins in AS suggested that we are faced with an active process. This proteomic approach can get an insight into AS and provide potentially biomarkers.

Hemodynamic Performance of the St. Jude Medical Epic™ Supra Aortic Stented Valve
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The study aim was to evaluate the hemodynamic performance of the St. Jude Medical Epic Supra bioprosthesis during the early follow-up period, as well as confirm the safety and efficacy of the valve by collecting adverse events and NYHA functional classification. A total of 57 patients undergoing aortic valve replacement (AVR) with the Epic Supra valve between September 2007 and March 2009 from three centers in Canada were evaluated. Subjects were evaluated preoperatively, at discharge, and at six months postoperatively. Echocardiographic data was collected at the six month follow-up period and is available for 50 subjects. To prevent observer variability, all echos were sent to an independent central core lab for interpretation of the data. The mean subject age was 74.5 years. 38.6% of the subjects were female. The average mean pressure gradient was 11.2, 10.8, 12.5, 10.8, 8.4, and 11.3 mm Hg for valves 19, 21, 23, 25, and 27 mm, respectively. The average effective orifice areas (EOAs) were 1.44, 1.57, 1.69, 1.93, and 1.81 cm² for valves 19, 21, 23, 25, and 27 mm, respectively. Six month echo follow-up indicates the Epic Supra valve offers excellent hemodynamic performance. Mean gradients and effective orifice areas were comparable to other supra-annular stented tissue valves. Average EOA index indicated no patient-prosthesis mismatch with all subjects at or near 0.85 cm²/m². The percentage of subjects with no aortic insufficiency at follow-up was 92% – four subjects showed trivial AI.
Tricuspid Valve Repair with Artificial Chordae in a 72-Year-Old Woman

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Introduction: Expanded polytetrafluoroethylene sutures (Gore-Tex®) have been used for replacement of chordae tendineae since 1985, especially for mitral valve prolapse. There are only a few reports of artificial chordae tendineae regarding tricuspid valve regurgitation. Background: We report a 72-year-old woman in preoperative NYHA class III, who underwent successful tricuspid valve repair. Preoperative echocardiography revealed tricuspid valve regurgitation grade IV, caused by prolapse of anterior leaflet (A1–A2) and annular dilatation. Tricuspid valve repair was performed using artificial chords consisting of two polytetrafluoroethylene (CV-5) sutures and a ring annuloplasty (Carpentier-classic-ring # 34 mm). Postoperative echocardiography revealed mild tricuspid valve regurgitation less than 1°. The patient is presently doing well 3 years after the repair. Conclusions: Gore-Tex® sutures are an excellent option for replacing chordae tendineae in tricuspid valve prolapse as used in mitral valve repair. This approach represents a safe and effective technique for tricuspid valve repair.
Mitral Valve Repair for Ischemic Mitral Regurgitation: Midterm Clinical and Echocardiographic Results after Restrictive Complete Annuloplasty

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Background: Our objective was to assess the early and midterm results of annuloplasty (MVr) in patients with IMR in terms of survival and MR recurrence. Methods: 88 patients underwent MVr for IMR over a 5-year period (2004–9) at our institution (14% of total MVr volume). All patients had ≥2+ mitral regurgitation preoperatively and 76% were NYHA class III or IV. All patients received a complete restrictive annuloplasty ring (IMR Etoligox: n = 72 (82%); Physio: n = 16 (18%); median ring size IMR: 28 mm; Physio: 26mm). Concomitant bypass grafting was performed in 90%. Results: Thirty-day mortality was 3.4% (n = 3). Overall survival by Kaplan-Meier analysis was 91% at 1 year and 87% at 3 years. Predischarge echocardiography showed 0 (76%) or 1+ (16%) MR in 92% of patients. With follow-up out to 4.6 years 10 patients (11.8%) (8 IMR, 2 Physio) developed ≥2+ MR. Conclusions: Ring annuloplasty with surgical revascularization can be performed with low operative mortality and is associated with near complete resolution of IMR in the early postoperative period. A minority of patients develop >2+ MR at follow-up. Overall intermediate term survival in the entire cohort was good. Compared to earlier IMR series we have reported, rates of recurrent MR are lower.

The Natural History of Bicuspid Aortic Valves: A Community-Based, Long-Term Follow-Up Study

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Background: Bicuspid aortic valve (BAV) is common. The natural history of BAV patients has not been studied in an entirely geographically-defined community population, free of referral bias, with long follow-up. Methods: Repeated ascertainment of the electronic echocardiographic database of the Mayo Clinic, Rochester, for Olmsted County Minnesota was performed for the 1980 to 1999 time-period. Follow-up was carried out by electronic chart revision, mailed surveys and telephone calls. Relevant outcomes were survival, aortic valve replacement (AVR), ascending aorta surgery (AAS), bacterial endocarditis (BE) and Aortic dissection (AD). Results: A total of 416 patients, 69% males, were identified. Age was 35 ± 21 years (y), 79% >18 y, 84% typical BAV. Mean follow-up was 14 ± 6 y, maximum 28 y. Mean aortic peak velocity was 2.2 ± 0.86 m/s (55% >2 m/s). Survival probability was 92 ± 2% and 82 ± 3% at 10 and 20 y, respectively (not different than age-sex matched general population, p = 0.99). 188 patients (29%) underwent AVR (61% stenosis, 30% regurgitation). Probability of AVR was 22 ± 3% and 38 ± 4% at 10 and 20 y, respectively. Survival was not different between AVR and non-AVR patients. AAS probability was 11 ± 2% at 20 y (related to atherosmal dilatation in 64%). BE occurred in 11 patients (2 died, 9 required AVR), BE occurred in 1.4% of typical and 8% of atypical BAVs (p = 0.003). There was no relation between BAV phenotype and aortic size, sex, AAS, AVR, stenosis or regurgitation. There were 2 aortic dissections (males, typical BAVs, 1 died, both had ascending aortic diameters >45 mm at baseline echo, both with prior AVR). Total cholesterol >200 mgs% predicted AVR univariately (HR 2.2 [1.4–3.5] p = 0.0004). On multivariate analysis age (HR 6.6 [1.4–31] p = 0.01) and peak velocity >2 m/s (HR 8.6 [3.9–23] p < 0.0001) predicted AVR. Conclusions: Patients with BAV have a normal overall survival at 20 y regardless of the degree of dysfunction of the aortic valve at baseline. There is almost a 40% 20-y risk of AVR related mostly to stenosis and predicted by base-line aortic peak velocity and age. AVR restores survival to that of the general population. BE is highly morbid and affects atypical BAVs more commonly. Aortic dissection is uncommon and may relate to BAV dysfunction and interval AVR. The role of cholesterol in BAV dysfunction needs further study.

Real Stentless Aortic Valve
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Background: The native aortic valve can be explained with rules of the equal side triangle. In pathologic condition, because of the flow influence there is a distortion on such a way that every aortic valve leaflet is different size. Mostly in the cases non coronaria leaflet is the biggest one because the spirals flow of the blood. With this study we evaluated clinical results of stentless 3 leaflets pericardial patch in patients undergoing aortic valve replacement. Methods: We created this stentless valve using bovine/ equine pericardium, replacing valve cusps on aortic fibrous ring of patient. This valve was made from same pericardium from which other biologic valve prosthesis are done. Our aortic valve is called really stentless, because the new created leaflets are directly sutured on the patient’s native aortic ring. The ring of patient’s aorta was used as guide for sizing this valve. Leaflets are implanted separately; using continuous sutures with 2 supported stitches at newly created commissures, without a stent or sowing ring. Patients with aortic valvular stenosis have been included. Excluding criteria were postenotic aneurysmatically changes of the ascending aorta as well as aortic anuly ring dilatation intraoperative and postoperative TEE was performed for every created valve. Results: 42 patients with aortic valvular disease had been included in study. 21 of them got bovine and 21 equine pericardium created leaflets. Middle aorta cross clamping time was 71.94 min, and bypass time 112.33 min. 4 patients got a aortocoronary bypass in combination (2.3 grafts per patients); 1 patient developed middle aortic regitation. Mortality rate was 9.5% (4 patients). Follow-up period 1–19 months. Conclusions: Real stentless aortic valve bio prosthesis ensures haemodynamic improvement with a small transvalvular gradient in patients. It can be implanted even in patients with small root or with bicuspid valve, with good clinical outcome.
The Perimount Magna Aortic Bioprostheses in Patients with Small Aortic Roots: Single-Center Experience in 128 Patients
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Introduction: Patients with small aortic roots and the need of aortic valve replacement (AVR), are a challenging group of patients. The influence on morbidity and mortality of procedure, prosthesis and even patient prosthesis mismatch (PPM) is discussed controversially. We report our experience in 128 patients (mean age 71.2 ± 9.3 years, female n = 88, additionally procedures 48%) who underwent AVR with 19 (n = 28) and 21 (n = 100) Magna aortic bioprosthesis. Results: Statistically significant differences in discharge echocardiographic evaluation between patients with 19 and 21 prosthesis are (mean): EOA: 1.12 vs. 1.42 cm² p = 0.001, EOA1: 0.61 vs. 0.76 cm²/m² p = 0.001, LVOT diameter: 1.84 vs. 1.97 cm p = 0.02, BSA: 1.77 vs. 1.88 m² p = 0.01. Only female patients received 19 prosthesis, 3 patients with 19 need aortic root enlargement vs. 2 patients with 21. There were no statistically significant differences between AV Vmax 2.87 vs. 2.71 m/s, AV v mean 2.15 vs. 2.0 m/s, AV PG max 34.0 vs. 30.0 mm Hg, AV PG max 1.18 vs. 1.23 m/s, AV v mean 2.15 vs. 2.0 m/s, AV PG max 34.0 vs. 30.0 mm Hg, AV PG max 1.18 vs. 1.23 m/s, LVOT Vmean 0.88 vs. 0.92 m/s, age 73.7 vs. 70.2 years, left ventricular function (LVFx) and perioperative mortality (7.14 vs. 5.2 in the mechanical valve group (p = 0.04). All-cause linearized mortality rates were 0.64%/patient-year versus 0.24%/patient-year in the Ross procedure versus the mechanical valve group (matched hazard ratio 2.76, 95% confidence interval 0.76 to 10.00, p = 0.12). Late survival was comparable to the general German population. Conclusions: In comparable patients there appears no late survival advantage for the Ross procedure over mechanical aortic valve implantation in the first postoperative decade. In contrast to older reports, relative survival in these selected young adult patients closely resembles the general population, possibly a result of better timing of surgery, improved patient selection, and highly specialized self-management anticoagulation treatment in more recent years.

Impact of Coronary Disease on Mitral Valve Surgery: Trends and Predictors of Outcomes
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Objective: Compared to isolated mitral valve surgery (MVR), concomitant coronary bypass (CABG) purports increased operative risk. This study describes current trends related to MVR +/- CABG (1998–2008) to determine patient, anatomic and operative factors that predict contemporary clinical outcomes. Methods: Descriptive analyses and multivariable regression modeling were performed using a prospectively collected database at a single academic institution. Results: MVR (repair or replacement) was performed in 1,158 patients (isolated MVR, n = 688 [34% repair]; combined MVR+CABG, n = 470 [55% repair]). Etiology was predominantly rheumatic or myxomatous in the isolated cohort, versus rheumatic, myxomatous and ischemic in the combined MVR+CABG cohort. The MVR+CABG cohort had more: cardiovascular co-morbidities, prior myocardial infarction (MI), left ventricular (LV) dysfunction, and worse symptom class. They required longer cardiopulmonary bypass (190 ± 61 vs. 144 ± 63 min), cross-clamp (155 ± 46 vs. 111 ± 49 min) and ICU durations (86 ± 104 vs. 45 ± 67 h) (all p<0.05). Perioperative MI (7 vs. 4%), stroke (9 vs. 5%) and reopening (14 vs. 11%) were more common in the MVR+CABG cohort. 30-day mortality (12 vs. 9%) was higher but not statistically significant. Independent predictors of poor outcome were: older age, female gender, renal or LV dysfunction, cardiopulmonary bypass time and combined CABG. Conclusions: Contemporary operative risk for combined MVR+ CABG exceeds MVR alone. A valid, rigorous statistical model including coronary and valve disease burden and preoperative co-

Does the Ross Procedure Carry a Survival Advantage in Young Adult Patients over Mechanical Valve Replacement with Optimal Anticoagulation Self-Management?
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aErasmus Medical Center, Department of Cardiothoracic Surgery, Rotterdam, The Netherlands; bHeart and Diabetes Center North Rhine-Westphalia, Department of Thoracic and Cardiovascular Surgery, Bad Oeynhausen, cUniversity of Luebeck, Department of Cardiac and Thoracic Vascular Surgery, Luebeck, Germany

Purpose: It is suggested that in young adults the Ross procedure results in a better late patient survival compared to mechanical prosthesis implantation. We performed a propensity score matched study that assessed late survival in young adult patients after a Ross operation versus mechanical aortic valve replacement with an optimal self-management anticoagulation regimen. Methods: We selected 1,326 Ross patients (German-Dutch Ross Registry) and 431 mechanical valve patients (ESCAT-II trial) aged 18–60 years without dissection or mitral valve replacement who survived an elective procedure between 1994 and 2008. Using propensity score matching we attempted to compare late survival between the 2 treatment groups. Results: Two-hundred-fifty-eight patients with a mechanical valve could be propensity matched to a Ross patient. Mean age of the matched cohort was 48 years in both treatment groups, M/F ratio was 2.8 in the Ross procedure group and 5.2 in the mechanical valve group (p = 0.04). All-cause linearized mortality rates were 0.64%/patient-year versus 0.24%/patient-year in the Ross procedure versus the mechanical valve group (matched hazard ratio 2.76, 95% confidence interval 0.76 to 10.00, p = 0.12). Late survival was comparable to the general German population. Conclusions: In comparable patients there appears no late survival advantage for the Ross procedure over mechanical aortic valve implantation in the first postoperative decade. In contrast to older reports, relative survival in these selected young adult patients closely resembles the general population, possibly a result of better timing of surgery, improved patient selection, and highly specialized self-management anticoagulation treatment in more recent years.
morbidities, was devised to predict poor clinical outcomes. This may be useful in case selection of CABG patient with concomitant MR for consideration of newer catheter based valvular and coronary interventions.

**Alpha-Gal Removal Tool for the Creation of Xenogenic Biocompatible Heart Valve**

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Xenotransplantation of decellularized heart valves might be the final solution to overcome the shortage of homograft donors, hence avoiding glutaraldehyde fixation used for heart valve bioprostheses. The use of xenogenic tissues triggers a hyperacute rejection, due to the presence of alpha-Gal epitope. Aim of this study is the development of an ELISA alpha-Gal tissue test for the evaluation of the epitopes amount both in native aortic and pulmonary leaflets, along with its residual amount after detergent-based (TriCol) cell removal. TriCol procedure was reported to be suitable for the preparation of acellular and biocompatible heart valve scaffolds without affecting the extracellular matrix. The amount of alpha-Gal epitope was compared with a standardized source: rabbit erythrocytes. Samples are subjected to enzymatic digestion preserving the carbohydrate components subsequently reacting with a specific primary alpha-Gal monoclonal antibody (M86). The determination of unbound primary antibodies is revealed by a secondary HRP-conjugate. Results confirmed a different epitope distribution in native aortic and pulmonary leaflets respectively: 4.33 \times 10^{11} to 6.78 \times 10^{11} each 10 mg of wet tissue. The leaflets were also divided in zones showing a different distribution of the alpha-Gal not overlapping with the previously reported vessel density pattern. This result was consistent with the outcome of the immunofluorescence analysis performed with M86. The decellularization completely removed the epitope providing materials suitable for human xenotransplantation, cell repopulation and tissue remodeling. In conclusion this novel ELISA test allows the quantitative determination of alpha-Gal epitopes in heart valve tissue scaffold, providing the community an easy to use method.

**Minimally Invasive Direct Mitral Valve Surgery without Peripheral Cannulation in 120 Cases**

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**Objectives:** To reduce the morbidity from Mitral valve operations a right antero lateral mini-thoracotomy without robotic assistance, under direct vision was introduced. We report our experience with the procedure. **Material and Methods:** From July 1999 to April 2006, 120 consecutive patients underwent direct minimally invasive mitral valve surgery through right antero lateral mini-thoracotomy. The 80 patients requiring replacement had evidence of rheumatic disease, whereas 40 repair patients had myxomatous changes (75 vs. 25%, respectively). TV repair was performed in 25% of replacement group as well as RF ablation in the last 27 patients. All cannulas were introduced through the thoracotomy incision, eliminating femoral cannulation. No new instruments, retractors, or ports were used. Pleural and pericardial drainage was accomplished through a single drain. **Results:** There was no hospital death. Conversion to sternotomy was performed in 1 patient because we were unable to obtain satisfactory arterial cannulation. 2 cases required reoperation, one for mitral insufficiency and the other for postoperative bleeding. Mean cross-clamp time was 45 min; mean cardiac-pulmonary bypass time was 62 min. Mean intubation time was 130 min; mean ICU stay was 29 h and mean hospital stay was 4.3 days. **Conclusions:** We conclude that this minimally invasive approach is safe, rapid, cost-effective, and more comfortable for the patients, in addition to the cosmetic benefits. It can be performed as an ideal approach in young female patients.

**Perioperative Management of Anticoagulation in Patients with Mechanical Valves Undergoing Noncardiac Surgery: A Pilot Study**

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**Background:** Prospective studies on management of anticoagulation in patients with mechanical heart valves undergoing noncardiac surgery are scarce. **Aims:** Aims were (1) assess strategy of anticoagulation perioperatively in patients with mechanical heart valves and (2) determine bleeding or clotting complications perioperatively. **Methods:** Adult patients (>18 years) with mechanical heart valves undergoing noncardiac surgery were prospectively identified via daily crossmatching of electronic surgical listing and the echocardiographic laboratory database by use of an automated patient recruitment system. **Results:** Fifty-three patients have been identified. Warfarin was stopped 5 ± 2 days preoperatively. 68% of the patients received preoperative heparin (32% IV heparin vs. 68% LMWH). There were no complications preoperatively. Postoperatively, 76% patients received heparin (35% IV heparin vs. 65% LMWH). Heparin started 1.1 ± 1.5 and warfarin 1 ± 1.7 days postoperative. Bleeding occurred in 3 patients (6%) 2.7 ± 2.3 days postoperative and 2 patients (4%) required transfusion (procedures were total prostatectomy (n = 1), gastric bypass (n = 1), and endoscopy for history of GI bleed (n = 1)) and mean APTT was 107 ± 38 and 98 ± 40 at days 1 and 2, respectively, postoperative compared to 40 ± 26 and 45 ± 25 for patients without postoperative bleeding. Postoperative TIA occurred in 1 patient (2%) following umbilical hernia repair who had received IV heparin perioperatively with similar APTTs to patients without complications. **Conclusions:** Majority of patients with mechanical heart valves undergoing noncardiac surgery receive bridging heparin perioperatively. LMWH is more commonly used. Postoperative bleeding complication is more common than embolic complication, but these complications are uncommon. APTTs in patients with postoperative bleeding were higher, but not different in patient with postoperative TIA.
Impact of Metabolic Syndrome on Left Ventricular Geometry and Function in Patients with Calcific Aortic Stenosis: A Substudy of the Astronomer Trial
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Background: Recent studies reveal that, among animals with sustained pressure overload, those with insulin resistance induced by a high-carbohydrate/high-fat diet develop more severe LV hypertrophy and dysfunction compared to animals fed with standard diet. The aim of this study was to examine the relationship between metabolic syndrome (MetS) and LV geometry and function in patients with asymptomatic aortic stenosis (AS).

Methods: Among the 272 patients who were recruited in the ASTRONOMER study, none had hypercholesterolemia, diabetes, or coronary artery disease (exclusion criteria) at baseline. However, 33% had systemic hypertension (HPT) and 27% had MetS as identified by NCEP-ATPIII clinical criteria.

Results: Patients with MetS had higher LV mass index (53 ± 14 vs. 47 ± 15 g/m²; p = 0.002), relative wall thickness ratio (0.47 ± 0.09 vs. 0.42 ± 0.09; p = 0.001), and prevalence of LV concentric hypertrophy (27 vs. 18%; p = 0.03), and systolic (p = 0.03) myocardial velocities. Conclusions: Notwithstanding AS severity and increase in hemodynamic load, MetS is independently associated with more pronounced LV concentric hypertrophy and worse myocardial function in patients with AS, which may, in turn, predispose to the occurrence of adverse events in this population.

Defining Local Renin-Angiotensin System in Human Aortic Valve Stenosis: Gene-Expression of ACE2 and Mas Receptor in Stenotic Aortic Valves
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Background: Calcified aortic valve disease represents a spectrum of disease spanning from mild aortic valve sclerosis to severe aortic valve stenosis (AS), being an actively regulated disease showing some hallmarks of atherosclerosis. Calcified aortic valve lesion develops endothelial injury and is characterized by inflammation, fibrosis, lipid accumulation and renin-angiotensin sys-

Table 1. Patients’ (n = 96) characteristics

<table>
<thead>
<tr>
<th></th>
<th>Control</th>
<th>AR</th>
<th>AR + fibrosis</th>
<th>AS</th>
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<tbody>
<tr>
<td>Patients, n</td>
<td>11</td>
<td>11</td>
<td>17</td>
<td>57</td>
</tr>
<tr>
<td>Male, n</td>
<td>9 (81%)</td>
<td>9</td>
<td>12 (71%)</td>
<td>41 (72%)</td>
</tr>
<tr>
<td>Bicuspid valve, n</td>
<td>2 (18%)</td>
<td>7</td>
<td>8 (47%)</td>
<td>24 (42%)</td>
</tr>
<tr>
<td>Age, years (range)</td>
<td>50.8 ± 17.4 (21–70)</td>
<td>44.1 ± 13.0 (29–67)</td>
<td>60.1 ± 14.1 (31–80)</td>
<td>66.5 ± 10.8 (38–86)</td>
</tr>
<tr>
<td>Left ventricular EF</td>
<td>55.0 ± 9.8</td>
<td>49.9 ± 9.5</td>
<td>55.5 ± 11.0</td>
<td>58.3 ± 13.0</td>
</tr>
<tr>
<td>HDL level, mmol/l</td>
<td>1.14 ± 0.34</td>
<td>1.45 ± 0.49</td>
<td>1.55 ± 0.63</td>
<td>1.34 ± 0.36</td>
</tr>
<tr>
<td>LDL level, mmol/l</td>
<td>3.17 ± 0.76</td>
<td>2.88 ± 0.79</td>
<td>2.91 ± 1.05</td>
<td>2.74 ± 0.81</td>
</tr>
<tr>
<td>Cholesterol level, mmol/l</td>
<td>4.85 ± 1.06</td>
<td>4.78 ± 1.00</td>
<td>4.87 ± 1.58</td>
<td>4.58 ± 1.00</td>
</tr>
<tr>
<td>DM, n</td>
<td>0</td>
<td>1</td>
<td>2 (12%)</td>
<td>11 (19%)</td>
</tr>
<tr>
<td>Coronary disease, n</td>
<td>0</td>
<td>3</td>
<td>7 (41%)</td>
<td>34 (60%)</td>
</tr>
<tr>
<td>COPD, n</td>
<td>0</td>
<td>0</td>
<td>1 (7%)</td>
<td>4 (7%)</td>
</tr>
<tr>
<td>Statins</td>
<td>3 (27%)</td>
<td>3</td>
<td>7 (41%)</td>
<td>39 (68%)</td>
</tr>
<tr>
<td>ACEI/ARB</td>
<td>2 (18%)</td>
<td>5</td>
<td>2 (12%)</td>
<td>23 (40%)</td>
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<tr>
<td>Marfan syndrome</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
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<tr>
<td>Paget’s disease</td>
<td>0</td>
<td>0</td>
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</table>

Values are mean and standard deviation (SD) unless otherwise stated.
AR = Aortic regurgitation; AS = aortic stenosis; EF = ejection fraction; DM = diabetes mellitus.
1 p < 0.01 (analysis of variance).
The role of RAS in terms of angiotensin converting enzyme (ACE), angiotensin II (Ang II) and its receptor AT$_1$ genes is well described in AS, but gene-expression of ACE2 and mas receptor is unknown. Methods and Results: We characterized and compared expression of ACE2, mas and AT$_2$ in aortic valves of patients ($n = 96$) with normal control valves ($n = 11$), aortic regurgitation ($n = 11$), regurgitation with fibrosis ($n = 17$) and AS ($n = 57$). By RT-PCR, gene expressions of ACE2, mas and AT$_2$ were down-regulated by 69% ($p < 0.001$), 58% ($p = 0.008$) and 75% ($p = 0.001$), respectively, when stenotic valves were compared to controls. By immunohistochemistry, ACE2 positivity was localized mainly to stromal area in lamina spongiosa in control valves, which did not exist in stenotic valves. AT$_2$ protein levels were undetectable in valves by immunohistochemistry. 

Conclusions: We show that ACE2 and mas are expressed in human aortic valves in 4 groups reflecting in continuum character of calcified aortic valve disease. AS is characterized by downregulation of beneficial effect mediating ACE2, known to cleave Ang II to Ang [1–7]. Furthermore, receptor mediated elimination of Ang II is attenuated via downregulation of AT$_2$-receptors. Downregulation of mas receptor, known to be the target receptor of beneficial effects mediating Ang [1–7]'s, is potentiating the imbalance of tissue RAS in stenotic aortic valves. Statin treatment does not have effect on valvular ACE2, mas or AT$_2$ gene-expression levels in AS group.

**Beating Heart Aortic Valve Surgery: Experimental Evaluation of a New Cannula**

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**Background:** Prolonged life span in a progressively ageing population is likely to increase the incidence of aortic valve disease and the demand for aortic valve replacement (AVR) in the future. The aim of this study is to evaluate a new left atrial cannula$^a$. This new cannula, introduced in to the left ventricle from the right superior pulmonary vein, occludes – by means of an inflatable balloon – the mitral valve, and drains the blood from the left atrium. This blood is pumped, with a bio pump, into the ascending aorta distal to the aortic clamp, permitting therefore a beating heart aortic valve surgery. Considering the new technology of aortic valve replacement, such as the suture-less valve, this technique of beating heart AVR avoids the use of a conventional extracorporeal circulation (CECC) with the associated complications and, in our ageing population with associated comorbidities, this could be of some benefit. Besides the advantages of beating heart myocardial revascularization have been widely recognized. Therefore if the safety of our technique is demonstrated, it may be safely used for AVR and for ascending aorta surgery. The first step is to test the safety and the efficacy of this new technique by means of laboratory and animal test. Later on it may be used in the clinical setting. Material and Method: This new left atrial cannula has an inflatable balloon and holes positioned proximally to the balloon. When the balloon is inflated, occludes the mitral valves. The holes, proximal to the balloon, allow the blood to be drained from the left atrium and pumped by a bio pump directly to the ascending aorta distal to the aortic clamp (fig. 1). In this way the left ventricle is bypassed, the ascending aorta can be opened and surgery performed on the aortic valve. Seven pigs were used; the mean pigs weight was 70.6 ± 16.3 kg. Considering the pig heart anatomy with very short ascending aorta and with the left superior vena cava draining in to the coronary sinus, we decided to perform left mammary anastomosis to the left anterior descending artery and right mammary anastomosis to the right coronary artery to achieve good coronary flow after cross-clamping the aorta. In the experimental model after positioning the left atrial cannula the aorta was cross-clamped for one hour, an aortotomy was made to expose the aortic valve, then the aortotomy was closed with a continuous 4–0 prolene suture, the cross clasp removed and the left heart assisted pump discontinued. At the end of the experiment the animals were sacrificed. Surgical Technique: A well-prepared 75 kg pig was anesthetized by means of a standard veterinary procedure, was intubated and connected to a mechanical ventilator. The EKG was monitored; an indwelling catheter was inserted into the carotid artery to monitor the arterial pressure. A Swan–Ganz catheter (through the internal jugular vein) checks the right atrial, pulmonary artery and wedge pressures. Cardiac output was assessed with the thermodilution technique. The urine output is monitored with a catheter inserted into the bladder through a small laparotomy incision. The iliac artery was isolated for the arterial cannulation. Body temperature is recorded with a rectal probe. Standard median sternotomy was carried out; the pericardium was opened and suspended. The ascending aorta, the right superior and inferior vena cava, as well...
the left superior vena cava were carefully exposed. The right and left internal mammary were harvested. Standard heparin dose was given (to obtain an ACT more than 250 s). The left internal mammary was anastomosed to the LAD on the beating heart and the right internal mammary was anastomosed to the right coronary artery on the beating heart using Medtronic Octopus to stabilize the heart. A 20 Fr cannula was introduced into the iliac aorta. The left atrial cannula was introduced through the left atrial appendage by means of double 3–0 prolene purse strings. In the pig the right and left pulmonary veins are too small to allow a safe cannulation. The exact positioning of this new left atrial cannula was checked with a transesophageal echocardiogram (TEE). The two cannulas (aortic and atrial) were then connected to the bio pump with 3/8 inches tubing set, carefully removing any air bubble. The circulation was started and hemodynamic stabilization was achieved. The right and left coronary arteries were then closed with an umbilical tape at the origin. The coronary flow was obtained from the left and right internal mammary previous anastomosed the LAD and right coronary artery. Then the aorta was clamped and the balloon in the left atrial cannula was inflated thus occluding the mitral valve. The aorta was transversally opened, the aortic valve was exposed. After 1 h of assisted circulation, the aortotomy was closed with 2 continuous 4–0 prolene sutures. Few moments before closing the aortotomy, the mitral balloon was deflated, the circulation was momentarily stopped and air was carefully evacuated through the aortotomy with the aortic clamp still in place. The aorta was then declamped; the circulation was resumed and later gradually interrupted. At the end of the procedure animals was sacrificed according to standard veterinary procedure and samples were sent for histological evaluation to ascertain ischemic myocardial, renal, pulmonary and cerebral damages. Results: Seven pigs were used for the experiment. The mean arterial blood pressure during the circulatory assistance was 86 ± 14 mm Hg, the flow with the bio pump was calculated by the body surface and similar to the cardiac output obtained by the thermodilution method, and ranged from 4 to 6 l/ min. The mean pulmonary pressure was in normal range (24 mm Hg), as well as the wedge pressure (11 mm Hg). The mix venous O2 saturation during the assistance did not decrease. There was hemodynamic stability throughout out the experiment. The histology after the experiment did not show any myocardial necrosis, with normal renal, pulmonary and cerebral tissue. Conclusion: Aortic valve replacement is the treatment of choice for advanced aortic valve disease and currently accounts for 10–15% of all adult cardiac surgery in many centers [1, 2]. During recent years the average age of the entire patient population has increased as a result of a higher proportion of elderly patients. Moreover this elderly population has associated co morbidities (COPD, renal insufficiency, peripheral vascular disease, diabetes, etc.), which can be aggravated by CECC leading to unfavourable results. It is for this group of patients, that beating heart AVR may be an alternative surgical procedure especially in consideration of the new aortic valve suture-less. With this technique the indications of AVR can be widened, while reducing the expenses and shortening the postoperative stay [3, 4]. We contend that beating heart AVR may deliver the advantages of both beating heart surgery and CECC, while reducing the drawbacks of either technique [5, 6]. Lung ventilation continues throughout the procedure. Right heart distension has not been observed and is likely the result of left ventricular decompression and low LV end-diastolic pressure permitting more favourable unloading conditions for the right heart. Moreover, the patient's own lung is perfused and ventilated, thus avoiding stasis and reperfusion injury [7]. A farther validation of this technique in the animal model may represent the first step for a subsequent clinical use.

* Designed by Dr. Paolo Pepino, and produced by Engineer Patrizia Pini from NGC Medical SpA, Italy.

References

Experience with the Aortic Root Replacement: Comparative Perioperative Risk of Valve-Sparing versus Composite Root Replacement

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Mayo Clinic, Rochester, Minn., USA

Objective: There is growing enthusiasm for performance of valve-sparing root replacement operations (VSRR) even for moderate dilatation of the aortic root, however the advisability of this approach depends upon the operative risk associated with these more technically complex procedures as compared with the gold-standard composite root replacement (CRR).

Methods: Between 09/2001 and 12/2009, 195 root replacements were performed on a single surgical service, of which 69 were VSRR (Yacoub 6, modified Yacoub 4, or David 59) and 126 were mechanical (86) or bioprosthetic (40) CRR.

Results: Groups were similar with respect to age (VSRR 47 years vs. CRR 53 years). More patients in the VSRR group had Marfan or Ehlers-Danlos syndrome (29 vs. 10%). Concomitant procedures were performed less often with VSRR (42 vs. 58%). More extensive aortic surgery was performed often, including hemi-arch replacement (17% vs. 26%) total arch replacement (3% in both groups) or combined total arch and descending thoracic aortic replacement (7 vs. 5%). Mean aortic cross-clamp time was longer for isolated VSRR (n = 40) compared with isolated CRR (n = 53) procedures (117 ± 24 vs. 90 ± 37 min) as was CPB time (136 ± 27 vs. 118 ± 52 min, p < 0.001). There were no peri-

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operative deaths among VSRR procedures and 3 (2%) among CRR patients. One VSRR patient suffered a stroke (1%), as did 4 CRR patients (3%). **Conclusions:** Valve sparing procedures can be performed with low perioperative risk despite the need for increased cross-clamp and CPB periods. These data support an aggressive approach to aortic root pathology.

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**Intra-Valve Hemorrhage in Severe Calcific Aortic Valve Stenosis Is Related to Increased Inflammation and Neovascularization**


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**Objective:** Severity of disease progression in calcified Aortic Stenosis (AS) may involve increased inflammation and neovascularization. These may lead to micro vascular leakage resulting in intra-valvular hemorrhage. We tested the hypothesis that intra-valvular hemorrhage in severe bicuspid aortic stenosis is related to increased inflammation and neovascularization.

**Methods:** A total of 94 aortic valves procured during valve replacement from severe calcific AS were analyzed by light microscopy using H&E stain. Intra-valve hemorrhage (IVH) is defined as the extravasations of RBCs admixed with fibrin in severe calcified areas of the valve (fig. 1). 10 specimens showed IVH. We compared with 44 control aortic valve stenosis with out IVH and performed double label immunohistochemistry to quantify macrophage/T cell infiltration (CD-68+CD-3), and neovessel content (CD-34).

**Results:** Demographic and clinical data shows that patients with IVH were younger (59 ± 12 vs. 69 ± 9; p < 0.05). Gender, risk factors, coronary artery disease, aortic valve area, gradient, and ejection fraction were similar in both groups. Macrophage/T cell content was increased in IVH when compared to controls (59 ± 22 vs. 28 ± 22; p < 0.05). Neovascularization was also increased in IVH when compared to controls (32 ± 6 vs. 23 ± 10; p < 0.05).

**Conclusions:** Intra valve hemorrhage in severe calcified aortic valve stenosis is related to increased inflammation and neovascularization. Furthermore there is a predilection of occurrence of IVH in younger age group. These results suggest that IVH may play a role in the pathobiology of severe AS by accelerating the process of inflammation, which may trigger symptoms at a younger age.

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**Numerical Simulation of an Ultrasound Imaging Model of Mitral Valve Regurgitation**


aDepartment of Mathematics, University of Houston, bDepartment of Cardiology, Methodist Hospital and the Echocardiography Laboratory of Methodist DeBakey Heart Center, cDepartment of Medicine, Baylor College of Medicine, Houston, Tex., USA

We developed and validated a computational fluid dynamics (CFD) model to simulate the hemodynamics conditions in an imaging heart chamber containing a divider plate with an orifice. The imaging heart chamber, connected to a pulsatile flow loop, was previously designed to model in vitro the hemodynamics conditions encountered in patients with mitral regurgitation. Hemodynamics conditions in the chamber were simulated using a 3D computational fluid dynamics model based on a finite element method approximation of the Navier-Stokes equations for an incompressible, viscous fluid. This model was then extended to include a simulation of the fluid-structure interaction (FSI) between fluid flow and an elastic (moving) orifice modeling a ‘leaky’ valve. The mathematical description of the moving orifice was performed by using the elastodynamics equations for an elastic solid which were then fully coupled to the fluid motion via a FSI algorithm. Two orifice shapes and several regurgitant volumes were considered. Measurements of the chamber pressures, fluid velocity at the orifice, and flow were compared with those obtained using CFD simulations. Excellent agreement was achieved. The replacement of the fixed divider plate by an elastic one represents a step forward in the computational and in vitro modeling of a leaky mitral valve. Several examples will be presented, including a discussion of the use 2D PISA Doppler method for the assessment of mitral regurgitation. Our examples indicate that the CFD model we developed provides a powerful tool for further refinement and reinforcement of emerging 3D echocardiographic applications.
Isolated Pulmonary Valve Endocarditis Caused by *Mycobacterium Tuberculosis*: A Case Report

M.B. Rabus a, N. Etiz b, I. Oztek c, M. Balkanay a

Departments of aCardiovascular Surgery and bInfectious Diseases, Kartal Kosuyolu Heart and Research Hospital, cPrivate Pathology Laboratory, Istanbul, Turkey

Pulmonary valve endocarditis in the native pulmonary valve is a rare condition accounting for about 1.5–2% of all endocarditis-related hospital admissions. Pulmonary valve endocarditis which is generally accompanied by tricuspid valve endocarditis, rarely manifests as an isolated entity. The major risk factors for pulmonary valve endocarditis are: congenital pulmonary valve anomalies, intravenous drugs abuse and catheter-related infections. We present a case of isolated pulmonary valve endocarditis caused by *Mycobacterium tuberculosis*. The patient was a 20-year-old male who was treated for pulmonary tuberculosis 6 months before his admission to our institution with the complaints of shortness of breath, fatigue and palpitations. His echocardiography revealed vegetation in pulmonary valve, pulmonary hypertension (PAP: 79 mm Hg) and minimal pericardial effusion. A patent ductus arteriosus was diagnosed and surgically closed during the cardiopulmonary bypass. The vegetation in the pulmonary valve and the leaflet was resected. The pathologic examination of the pulmonary valve revealed caseification, subsequent hyalinization and calcification concordant with tuberculosis.

Safety and Efficacy Comparison between Implanted and Non-Implanted Patients in the TITAN™ Trial Using the CARILLON® Mitral Contour System™ to Treat Functional Mitral Regurgitation

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Background: Functional mitral regurgitation (FMR) increases the morbidity and mortality of heart failure patients. The TITAN™ trial evaluated the safety and efficacy of percutaneous mitral annuloplasty with the CARILLON® XE2. Methods: Inclusion criteria: Dilated ischemic or non-ischemic cardiomyopathy, moderate to severe FMR, LVEF <40%, NYHA Class II–IV, and 6-min walk distance (mwd) 150–450 meters. Permanent implantation occurred in patients with a peri-procedural reduction in FMR (n = 36). Patients in whom implantation was not achieved served as a non-randomized control (n = 17). The primary safety endpoint was the MAEs rate at 1 month. Secondary endpoints at 1 and 6 months included echo core lab derived quantitative measures of FMR (EROA, Vena Contracta, Regurgitant Volume, Jet area/Left atrial area), NYHA Class, 6 mwd, and QOL measured by the Kansas City Cardiomyopathy Questionnaire (KCCQ). Results: At baseline, 94% of patients were NYHA III, EF was 28.4%, and LVEDD was 70 mm. The MAE rate at 30-days for all 53 attempted patients was 1.9%. Reductions in 4 quantitative FMR measures ranged from 32–43% at 6 months (n = 21) for implanted patients. LVESV was reduced from 164 ± 64 (baseline) to 142 ± 52 (6 months) (p < 0.01). Conclusion: Percutaneous treatment of FMR with the CARILLON® Mitral Contour System™ was associated with reduction in FMR and a corresponding improvement in functional parameters.

Table 1. Functional changes (mean ± SD)

<table>
<thead>
<tr>
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<th>6 mwd (m)</th>
<th>NYHA class</th>
<th>KCCQ</th>
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<tr>
<td></td>
<td>baseline</td>
<td>6 months</td>
<td>baseline</td>
</tr>
<tr>
<td>Implanted (n = 23)</td>
<td>323 ± 58</td>
<td>452 ± 217</td>
<td>3.1 ± 0.3</td>
</tr>
<tr>
<td>Non-implanted (n = 7)</td>
<td>348 ± 92</td>
<td>317 ± 117</td>
<td>2.9 ± 0.3</td>
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Complete interim results will be presented.
ditis was 3.8%. Structural valve deterioration was 1.5%. For the characteristic of this valve, especially due to the wide opening of the leaflets, we prefer implant this valve in patient with a small LVOT (mean 19 ± 0.15). Preoperative mean aortic gradient was 49.6 ± 18.6 versus an early postoperative mean aortic gradient 17.7 ± 5.6 and at long-term follow-up mean aortic gradient 22.3 ± 15.4. Advanced age, renal insufficiency and pulmonary disease were implicated in perioperative and postoperative comorbidity.

**Conclusions:** After a mean follow-up of 2 years, the Mitroflow pericardial aortic valve seem to be a valuable choice in patients over 70 years old with a low rate of valve-related events and thromboembolic complications.

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**Estimation of Efficiency of Decreasing Interpapillary Muscles Distance Using Polytetrafluoroethylene Loop in Patients with Heart Valve Disease and Dilated Left Ventricle**

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**Objectives:** This study to investigate the mid-term results of decreasing interpapillary muscles distance using PTFE loop in patients with severe dilated left ventricle.

**Methods:** From 2005 till June 2009 40 patients with the distance between papillary muscles over 40 mm were operated. Mean age 47 ± 5 years. All patient were in New York Heart Association (NYHA) class III–IV.

**Results:** Hospital mortality was 5%. The distance between papillary muscles was reduced to 17 ± 3 mm. In the mid-term period (48 ± 7 months) 35 patients are surveyed. An average of value EDD 67 ± 6.1 mm, ESD 52 ± 10 mm, EF LV made 45 ± 5.4%. Four-year survival rate has made 82.5%. The majority of patients are 1–2 class (NYHA).

**Conclusions:** The presented way of left ventricle remodeling by means of loop PTFE in terms till 4 years is safe. Positive dynamics dimensions of heart and improvement of a functional condition of patients is observed.

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**Surgery for Ischemic Mitral Regurgitation: Should the Valve Be Repaired?**


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**Introduction:** Patients with ischemic cardiomyopathy undergoing CABG often have concomitant mitral regurgitation (MR). Repairing the valve at the time of surgery is not universally accepted. We compared results of CABG with or without mitral valve annuloplasty in patients with reduced LV function and ischemic MR.

**Methods:** There were 195 patients with moderate or severe LV dysfunction and moderate or severe MR: 108 underwent isolated CABG, 87 underwent CABG with mitral annuloplasty. Endpoints included survival, degree of MR, and NYHA class.

**Results:** Patients in the repair group were younger: 63 ± 10 vs. 68 ± 9 (p < 0.001), however they had more severe cardiac pathology: severe LV dysfunction in 45 vs. 26% (p = 0.006) and severe MR in 82 vs. 14% (p < 0.001). Operative mortality was 9% and similar in both groups. Mean follow-up was 66 months and available in 97%. Overall, no improvement was seen in LV function. Symptomatic improvement was more pronounced in the repair group (p = 0.006). At follow-up, residual MR was present in 23% of the repair group and 64% in the CABG only group (p < 0.001). For the repair group and non-repair groups respectively, survival at 5 and 10 years was 66 and 47% vs. 73 and 40% (p = ns). By multivariate analysis, neither degree of MR nor LV function at follow-up had any impact on survival.

**Conclusions:** For patients with reduced LV function undergoing CABG, the addition of a mitral annuloplasty
The Reality of Triple Valve Disease
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Background: Patients with triple valve disease are empirically though to be more severely ill than those with double valve disease. In this study, we evaluated outcomes in matched double and triple valve cohorts to test the hypothesis that the additional valve pathology indicates a sicker patient and a worse prognosis. Methods: Patient records were extracted from our STS database for all patients undergoing triple or double valve procedures from 1/1986 to 10/2009. Patients with additional aortopathy were excluded; concomitant bypass surgery was included. Patients with triple valve disease were matched 1:2 with equivalent patients having double valve surgery. Late mortality was determined from a search of the Social Security Death Index. Cohorts were compared with chi-squared, t-test and Kaplan-Meier statistical procedures. Results: 55 patients who had undergone triple valve surgery were matched to 110 double valve cases. Mean follow up was 4.2 ± 4.0 years for triple valves and 4.6 ± 1.0 for double valves. Compared to the double valve group, triple valve patients were associated with more episodes of prolonged ventilation (43.6 vs. 26.4%, p = 0.025) and longer ICU stays 228 ± 413 (median 97 hours versus 178 ± 304 (median 70; p = 0.50). There was no significant difference in perioperative mortality and overall mortality 40% (22/55) in triple and 38.2% (42/110) in double valves (p = 0.82). All other morbidity measures were equivalent. Conclusion: Contrary to the hypothesis, mortality was equal between groups and should not dissuade surgeons from fixing the tricuspid valve when indicated. As predicted, the triple valve patients were sicker and required more ICU time and resources.

Electro-Mechanical Coupling between the Atria and Mitral Valve
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Objective: Anterior leaflet (AL) stiffening during isovolumic contraction (IVC) aids mitral valve closure. We tested the hypothesis that AL stiffening requires atrial depolarization. Methods: Ten sheep had radiopaque-marker arrays implanted in the LV, mitral annulus, AL, and papillary muscle tips. 4-D marker coordinates were obtained from biplane videofluoroscopy at baseline (CTL) and during basal interventricular-septal pacing (PACE, 109–116 min⁻¹) to generate ventricular depolarization not preceded by atrial depolarization. Circumferential and radial stiffness values, reflecting force generation in three leaflet regions (annular, belly, free-edge) were obtained from finite element analysis of AL displacements in response to trans-leaflet pressure changes during IVC and isovolumic relaxation (IVR). Results: In CTL, IVC circumferential and radial stiffness was 46 ± 6% greater than IVR in all regions (p < 0.001). In PACE, AL annular IVC stiffness decreased by 25% (p < 0.001) in the circumferential and 27% (p < 0.001) in the radial directions relative to CTL, without affecting edge stiffness. Conclusions: AL annular stiffening during IVC is abolished when atrial depolarization does not precede ventricular systole. The likely mechanism underlying AL annular stiffening during IVC is contraction of cardiac muscle that extends from the atrium into the leaflet, which requires atrial excitation. The AL edge has no cardiac muscle and thus IVC AL edge stiffness was not affected by the loss of atrial depolarization.

Aortic Valve Replacement Surgery in Octogenarians: Impact of Patient Prosthesis Mismatch on Survival
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Background: As aortic valve replacement (AVR) is being performed increasingly in octogenarians, the effect of patient prosthesis mismatch (PPM) in aged patients survival is controversial. Methods: The institutional database was reviewed for octogenarians undergoing AVR. Follow-up was done by telephone call interview and/or regional health statistics review. The effect on survival of several preoperative and intraoperative variables, including PPM, was analyzed in univariate and multivariate settings with Cox piecewise-constant time-varying coefficients survival model modified by Gray. Cumulative incidence of cardiovascular death was calculated considering death for other causes as competing event. Results: Between September 1998 and May 2007, 94 octogenarians (mean age 82.6 ± 1.7 years) had bioprostheses AVR (with 49 patients, 52.1%) or without associated CABG. Mean indexed Effective Orifice Area (iEOA) was 0.93 ± 0.13 cm²/m². PPM (iEOA ≤0.85 cm²/m²) was present in 30 patients (31.9%). Ten (10.6%) in-hospital deaths were observed. Median follow-up was 940 days (range 5–3097). At 3 years, survival was 75% and cumulative incidences of cardiovascular death and death for other causes were 21 and 4.5%, respectively. PPM was not significant for survival (p = 0.55) nor for cardiovascular death (p = 0.39). At multivariate analysis survival was affected by preoperative cancer (Hazard-ratio, HR = 2.75, 95% Confidence Interval, CI = 1.01–7.48, p = 0.04) and Logistic Euroscore (HR = 1.04, 95% CI = 1.00–1.08, p = 0.02). Others variables analyzed, including PPM, were not significant. Conclusions: In our experience, AVR in octogenarians gave acceptable short and mid term results. As PPM did not affect survival and cardiovascular mortality, attempts to avoid it by more complex surgical procedures may not be safe in such patients.
These findings suggest one reason why atrial dysrhythmias or ventricular pacing may be accompanied by mitral regurgitation or may worsen regurgitation when already present.

**Fluid Dynamics in Aortic Valve Bioprostheses: A Novel Approach**

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**Introduction:** Calcification limits the durability of aortic valve bioprostheses. Fluid dynamical phenomena are involved as well as biochemical and mechanical phenomena [1]. **Materials and Methods:** We chose an incremental constant-flow configuration (fig. 1) to study the intrinsic flow characteristics of several 23 mm bioprostheses. An electric pump generates a constant flow (0.5 to 90 l/min) with a 36.6% glycerine-water solution. The pressure drop over the valve is recorded and the cusps’ positions are captured with a high-speed camera (fig. 2). **Results:** In figure 3 pressure loss and opening area for the valves is plotted as a function of the flow rates. Figure 4 shows the pressure drop against maximum bulk flow velocity $u$, given by $u = Q/A$ of flow rate $Q$ and opening area $A$. The curves for bovine pericardial valves collapse to a single curve. For these valves, the pressure drop $\Delta p$ is only a function of the bulk velocity $u = Q/A$. **Discussion and Conclusions:** There appears to be a general relation between the pressure drop and the maximum bulk flow velocity for certain bovine pericardial bioprostheses. It suggests that the transvalvular pressure drop is mainly a function of the maximum bulk flow velocity and not of the flow rate. Valves should be designed to yield large opening areas already at low flow rates minimizing the bulk flow velocity.

**References**


![Fig. 1. Schematic of the experimental set-up.](image1)

![Fig. 2. Camera image of the partially (left) and fully (right) open Edwards Magna.](image2)

![Fig. 3. Pressure loss and opening area against flow rate (green dot = Edwards Perimount, new; black dot = Edwards Perimount, ~6 months old; red dot = Edwards Magna; blue dot = Medtronic Mosaic).](image3)

![Fig. 4. Pressure loss against the maximum bulk flow velocity.](image4)
**Longitudinal Data Analysis of Echocardiographic Allograft Valve Function**


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**Objective:** This study describes echocardiographic allograft valve function over time in a prospective cohort of patients who underwent allograft aortic valve or root replacement, illustrating the use of longitudinal data analysis for the assessment of valve function over time. **Methods:** Serial, standardized echocardiographic measurements of aortic regurgitation, aortic gradient, annulus diameter and aortic diameter in 286 hospital survivors (mean age 45 years; range 12–83) after allograft aortic valve (n = 78) or root replacement (n = 208) were analyzed using non-linear longitudinal models (SAS®PROCNLMIXED). The association between temporal allograft valve function patterns, patient age and surgical technique was studied. **Results:** Patient survival was 77% at 14 years (SE 3.2%). Freedom from reoperation was 67% (SE 4.5%) at 14 years. Aortic regurgitation increased over time (at 13 years 53% of patients had ≥2+ AR; fig. 1); younger patient age and subcoronary implantation technique were associated with increased aortic regurgitation. Aortic gradient increased over time (from 9 mm Hg at 6 months to 21 mm Hg at 13 years); both initial and increase in aortic gradient were greater in younger patients and subcoronary implantation technique were associated with increased aortic regurgitation. Aortic gradient increased over time (from 9 mm Hg at 6 months to 21 mm Hg at 13 years); both initial and increase in aortic gradient were greater in younger patients and subcoronary implantation technique were associated with increased aortic regurgitation. Both aortic regurgitation and stenosis increase over time after allograft aortic valve or root replacement, and are the most important cause for allograft failure. Younger patient age and use of the subcoronary implantation technique are associated with increased regurgitation and stenosis. The use of non-linear longitudinal models allows for adequate analysis of allograft valve function over time.

**Conclusions:** Both aortic regurgitation and stenosis increase over time after allograft aortic valve or root replacement, and are the most important cause for allograft failure. Younger patient age and use of the subcoronary implantation technique are associated with increased regurgitation and stenosis. The use of non-linear longitudinal models allows for adequate analysis of allograft valve function over time.

**Fig. 2.**

**A Comparison of the Outcome of Aortic Valve Replacement in Patients with and without Critical Aortic Stenosis**

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**Objectives:** The incidence of aortic stenosis (AS) increases with age and, with an ageing population, more patients are presenting with critical aortic stenosis, the clinical consequences of which are substantial. This study determines whether the severity of AS at operation influences the outcome of aortic valve replacement (AVR). **Methods:** A retrospective analysis of 100 consecutive patients, undergoing isolated first time AVR commencing January 2007 was carried out. These patients were divided into 2 groups: Group I with peak aortic valve (AV) gradients ≥90 mm Hg and Group II with AV gradients <90 mm Hg. Early clinical outcomes were examined. **Results:** There were 49 patients in Group I (26 female, median age 72 and median gradient of 103 (range 90 to 148 mm Hg) and 51 patients in Group II (24 female, median age 67 and median gradient of 74). 11% of patients in Group I had impaired left ventricular function vs. no patients in group II (p < 0.05) and post-operative inotropic support was greater in Group I. Median ITU and hospital stays were the same in both Groups. 20 (40%) patients in Group I developed post-operative atrial fibrillation vs. 10 (20%) in Group II (p < 0.05). There was 1 post-operative stroke in Group I. There were no overall in-hospital deaths. At a median follow-up of 29.5 months, there were 2 late deaths, one in each Group, of non-cardiac causes. Patients in both Groups experienced similar improvements in NYHA functional status. **Conclusion:** The short-term outcome of AVR appears to be independent of the severity of aortic stenosis.

**Fig. 1.**
Surgery of Chronic Functional Mitral Regurgitation: Postoperative Outcomes and Respective Results of Undersizing Annuloplasty and Valve Replacement

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Background: Adverse prognostic impact of functional-ischemic mitral regurgitation (FMR) is established. However, surgical indications and modalities (undersizing annuloplasty, UA, vs. mitral valve replacement, MVR) are controversial. Objectives: (1) Early and late postoperative outcome; (2) comparison of UA and overall, 88% in UA and 71% in MVR group (p < 9%). Primary endpoints: in-hospital and late mortality. Secondary endpoints: (1) evolution of LVEF and (2) recurrence of MR. Results: 33 patients, age = 65 ± 10, ischemic disease in 23 patients, mean LVEF = 36 ± 6%, mean ERO = 41 ± 17 mm². Surgical indications: severe symptomatic MR refractory to medical treatment. Surgical procedures: 11 UA and 22 MVR. MVR and UA groups were comparable for most variables except Euroscore higher in MVR group (p = 0.05). In-hospital mortality: 6%, 9% in UA, 4.5% in MVR group (p = NS). Three years survival: 77% overall, 88% in UA and 71% in MVR group (p > 0.99). By multivariable analysis, only age (1.3 [1.1–1.5], p = 0.001) and LV end systolic diameter (1.16 [1.05–1.29], p = 0.005) independently predicted late mortality; type of surgery did not (0.6 [0.1–3.9], p = 0.6). LVEF did not change after surgery in MVR group (36 ± 6% vs. 36 ± 7%, p = 0.1) but tended to decrease in UA group (36 ± 6% vs. 30 ± 12%, p = 0.06). No MVR patient had postoperative MR versus 80% of UA patients (mean ERO = 21 ± 6 mm²). Conclusions: Surgery can be performed in FMR with acceptable operative risk and mid-term result. MVR yields similar mid-term results than UA without exposing patients to MR recurrence, particularly frequent in our UA group.

Fig. 1. Survival by age group and CABG.

Short- and Long-Term Outcomes of Geriatric Patients Undergoing Aortic Valve Replacement following Prior Coronary Artery Bypass Grafting

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Background: An increasing number of elderly patients with prior CABG are presenting for aortic valve replacement (AVR). We compared the outcomes of patients <75 years of age requiring AVR±CABG following prior CABG. Methods: Retrospective analysis was performed on 280 patients who underwent AVR±CABG following isolated prior CABG from 1/1/1996 – 3/13/2009 at a single US academic institution. Patients were divided into those <75 years. Outcomes were compared using multivariable logistic regression and analysis of variance techniques adjusting for 13 covariates. Long-term survival between groups was compared using the Cox proportional hazards model. Kaplan-Meier plots were used to determine survival rates. Results: Mean age included: AVR ± CABG ≥75 (79.6 ± 3.5 years) vs. <75 (65.4 ± 7.6 years) (p < 0.001). EF was similar between groups: AVR±CABG ≥75 years (46.5 ± 14.8) vs. <75 years (47.0 ± 14.4) (p = 0.83). Patients ≥75 years had similar overall in-hospital mortality compared to those <75 years (7.0 vs. 10.9%, respectively, p = 0.36) (table 1 below). Within the ≥75 years patients, CABG significantly increases hospital mortality (1.4 vs. 15.9%, p = 0.009). The age groups were similar with respect to adjusted in-hospital mortality (p = 0.42) and hospital LOS (p = 0.59). Independent predictors for long-term survival included age (HR 1.52), female (HR 1.5) and chronic lung disease (HR 1.4). Age significantly impacted long-term survival (p = 0.03). The Kaplan-Meier estimates of survival are represented (p < 0.001).

Conclusion: Excellent outcomes can be achieved in elderly patients undergoing AVR following prior CABG. Concomitant AVR+CABG significantly increase the short- and long-term mortality in this geriatric population. Hybrid techniques (PCI prior to isolated AVR) in this population should be investigated to improve outcomes.
Etiology of Patient-Prosthesis Mismatch in Aortic Valve Surgery: Implications for Cardioplegia

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Etiology of patient-prosthesis mismatch was investigated in porcine hearts arrested by two different methods. In 94 pigs, killed by either a bullet shot and volume depletion (V) or electrocution (E), the hearts were weighed and aortic annulus (Ann) and sinotubular junction (STJ) measured. In 16 human aortic roots, Ann and STJ were measured. In porcine, in V group, heart weights were 250–1,100 gms, Ann 18–23 mm, and STJ 18–25 mm. STJ increased with heart weight in both groups, however, annulus increased in V group but not in E group. In V group, Ann was almost always greater than STJ (Ann–STJ = +2 to –3 mm). In humans, 13–55 years, Ann was either larger or equal but never smaller than STJ. In porcine, in volume depletion, the heart stops in late diastole producing a dilated annulus, whereas in electrocution, it stops randomly, producing a contracted or dilated annulus. In valve surgery, cardioplegia stops the heart randomly producing a contracted or dilated annulus. Thus, stopping the heart with contracted annulus is the most likely reason of patient-prosthesis mismatch.

Quantitative Determinants of the Outcome of Idiopathic Tricuspid Regurgitation

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Background: Tricuspid regurgitation (TR) is frequently observed but its impact on clinical outcome is controversial due to the frequency of confounding associated comorbid conditions and to difficulties in ascertaining regurgitation severity. Thus, we analyzed clinical outcome of patients with idiopathic TR (without pulmonary hypertension or other cardiac or non-cardiac causes), that was quantified at diagnosis. Methods and Results: We enrolled 353 patients (age 70 ± 14 years; ejection fraction, 64 ± 6 percent; pulmonary systolic pressure 34 ± 8) with idiopathic functional TR, quantified according to the proximal isovelocity surface area method. Patients were classified according to effective tricuspid regurgitant orifice as severe (≥40 mm²), mild/moderate (1–39 mm²) and trivial (0 mm²). Independent determinants of survival were increasing age, heart failure symptoms, and increasing effective regurgitant orifice (adjusted risk ratio per 10 mm² increment, 3.5 [2.2–5.2], p < 0.0001), the predictive power of which superseded all other qualitative and quantitative measures of regurgitation. Patients with an effective regurgitant orifice ≥40 mm² incurred excess mortality during follow-up compared to patients with trivial regurgitation (adjusted risk ratio, 3.1 [1.9–5.0]; p < 0.0001 for overall survival and 5.6 [2.6–12.7; p < 0.0001 for cardiac death). Mild/moderate TR was not associated with excess complications (all p > 0.05 vs. trivial regurgitation). Conclusion: TR, even in the absence of cardiac or non-cardiac causes, has profound implications for outcome if it reaches criteria for severe regurgitation based on quantitative measurements. Conversely, mild/moderate TR does not carry excess complication rates. Thus, TR, independently of any left sided disease or pulmonary hypertension, is a powerful predictor of clinical outcome warranting close monitoring and consideration for surgery.
First Clinical Results of Orthotopic Implantation of Decellularized Human Aortic Valve Conduits

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Objectives: We presented the successful clinical results of implantation of decellularized human pulmonary heart valves. Here we report about the generation and first clinical usage in orthotopic position of decellularized human aortic valve conduits.

Methods: Human aortic valve conduits (HAVC) harvested from non-beating heart donors were decellularized using two detergents (Hanover protocol) and washed during 5 days to remove cellular and detergent remnants. Decellularized cusps and wall were investigated to demonstrate the quality of decellularization, maintenance of scaffold composition, architectonic, toxicity. Three patients with a follow-up of one year were investigated clinically, by echocardiography and CT scan. Results: Detergent treatment of HAVC resulted in loss of cellularity after 48 h. DNA assay revealed reduction of DNA content for more then 96% as compared to native tissue. EM and immunohistostaining revealed effective preservation of scaffold components as well the basement membrane over the entire luminal surface. Mean transvalvular gradient did not significantly changed after one year 4.50,8 mm Hg compared to immediate after operation 3,20,4 mm Hg. HAVC regurgitation was trivial in all cases, and did not progress. No graft infections, signs of conduit dilatation, cus thicknes or reduction of mobility were observed in all patients. Conclusion: Decellularized HAVC is a feasible and safe graft for replacement in high systemic environment and provide good early postoperative results.

A New Generation Aortic Valve Device for Transcatheter Implantation

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Transcatheter aortic valve implantation (TAVI) eliminates some of the main risks associated with invasive surgical operations, hence representing a potential transformative step towards a more sustainable healthcare. It is, however, at an early stage of development and substantial procedural and design improvements are still required to enhance the safety and effectiveness of the treatment. A novel aortic valve suitable for TAVI is being developed at UCL, aimed at overcoming the main limitations experienced with currently available percutaneous devices. The valve consists of three polymeric leaflets attached to a self-expandable nitinol wire stent. The stent design provides a high expanded/collapsible diameter ratio and enhanced anchoring through sufficient radial and axial forces. The device is fully retrievable and repositionable. The material selected for the leaflets is a biocompatible polymeric nanocomposite recently developed and patented at UCL, which exhibits superior mechanical and surface properties and higher resistance to calcification compared to other polymers experimented in heart valve applications. Moreover, the use of synthetic materials enables the reduction of the leaflet thickness, the use of consistent manufacturing techniques and eliminates the problem of the tissue dehydration in the crimped state. Prototypes of the device have been produced and their hydrodynamical performance is being assessed in a specifically adapted hydro-mechanical cardiovascular pulse duplicator system, reproducing physiologically equivalent aortic pressures and flows. The preliminary in vitro tests confirm the indications obtained from the numerical analyses, suggesting that the proposed device could contribute to the transition towards the adoption of TAVI procedures.

What Caused the Up-Grade of Tricuspid Regurgitation after Mitral Valve Repair for Degenerative Mitral Regurgitation?

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Objective: We investigated the risk factors of up-grading of tricuspid regurgitation (TR) during postoperative follow-up after mitral valve repair (MVR) for degenerative mitral regurgitation (MR).

Patients and Methods: We retrospectively reviewed 212 MVR patients with the mean age of 62 ± 14 years and follow-up of 41 ± 32 months. The TR and MR on echocardiography were graded as follows: 0 = none, 1 = trace, 2 = mild, 3 = moderate, 4 = moderately severe, 5 = severe. Preoperative factors were age ≥60, grade 5 MR, TR grade ≥3, left atrial dimension ≥50 mm, right ventricular (RV) pressure ≥35 mm Hg, RV Tei index ≥0.45, left ventricular (LV) Tei index ≥0.45, and atrial fibrillation. Operative factors were tricuspid annuloplasty and Maze procedure. The factors at mid-term postope included RV Tei index ≥0.45, LV Tei index ≥0.45, and up-grade of MR during follow-up. Statistical analysis was made by a multiple logistic regression method.

Results: Preoperative MR and TR grades were 4.5 ± 0.8 and 1.9 ± 0.8. Their grades at mid-term postope were 1.3 ± 1.0 and 1.8 ± 0.8. The up-grade of MR at mid-term postope was an only significant risk factor of TR up-grade (odds ratio of 5.3, p = 0.002). Non-significant risk factors with odds ratio above 1.5 were tricuspid annuloplasty (odds ratio of 2.2, p = 0.41) and RV pressure ≥35 mm Hg (odds ratio of 1.74, p = 0.33).

Conclusion: Long-term durable MVR without MR recurrence for degenerative disease may play a key role in prevention of postoperative progression of TR. Preoperative RV and LV performance, and MR and TR grades had no significant impact on it.
Systemic Metabolic Stress and Myocardial Injury in Patients Undergoing Mitral Valve Surgery: A Prospective Study

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**Objective:** To investigate the occurrence of myocardial injury, systemic metabolic stress, and their relationship in patients undergoing mitral valve surgery. **Methods:** Thirty-six consecutive patients (average age 60 years, range 35–83) undergoing mitral valve surgery with either Custodiol or Cold blood St. Thomas cardioplegia were recruited for this study. Left and right ventricular biopsies were collected before and after cardioplegic arrest to determine myocardial metabolic stress whilst myocardial injury was determined by CK-MB postoperative release. Systemic metabolic stress was assessed by serial measurements of blood lactate. **Results:** Following cardioplegic arrest and reperfusion, the myocardial concentration of ATP and ADP was lower than baseline for right but not left ventricle \((p < 0.05)\). A significant increase in blood lactate was observed on reperfusion after releasing the aortic cross-clamp and remained high for 1 h in both groups. However, a marked second phase of blood lactate release that peaked at 12 h was observed only when using Custodiol cardioplegia (fig. 1). Surgery was associated with significant cardiac injury which did not correlate with systemic blood lactate levels. **Conclusions:** During mitral valve surgery there is poor metabolic preservation of the right ventricle. Concomitantly, there is significant and sustained systemic metabolic stress, which appears to be particularly prominent when using Custodiol cardioplegia. This degree of systemic stress does not seem to correlate with the level of cardiac injury suggesting a genuine peripheral ischemic insult, which warrants further investigation.

![Lactate levels](image)

Fig. 1. \(* p < 0.05\) vs. pre-CPB values (Panel A) or vs. 1 h reperfusion (Panel B). \(** p < 0.05\) vs. all other values.

A Rapidly Exchangeable Bioprosthetic Valve

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While the trend towards using bioprosthetic valves, instead of mechanical, in younger patients has improved their quality of life considerably, it will lead to increased tissue valve failure later, necessitating redo surgery. Revailing failed bioprostheses with transcatheter valves cannot be used routinely because of diminished EOA and concerns for their durability beyond 5 years. To address these issues, a rapidly exchangeable tissue valve has been developed. The design of the valve is based on the off-patent features of the Edwards Perimount, incorporating (i) flexible stent posts, (ii) well controlled central gap, and (iii) precise stent circularity and 120 degree leaflet symmetry – the three tenets of durable tissue valve design demonstrated clinically. It is a two-component valve consisting of a permanent ‘docking station’ and an ‘exchangeable leaflet set’. The docking station can be implanted either surgically or transapically, and the leaflets exchanged via open or transapical access, off-pump. To date, we have implanted 18 such valves into adolescent sheep, exchanged 7 sheep after implant periods ranging from 2–4 months, and currently have 2 sheep living with an exchanged leaflet set. Fibrotic overgrowth was observed to be far greater in the sheep than in humans, as expected, but all leaflet sets were successfully surgically exchanged without any subsequent perivalvular leaks. An off-pump, rapidly exchangeable valve can thus bring tissue valve quality-of-life to younger valve patients. A fully transapically implantable version of this valve is currently in development so that patients of all ages can avoid even the first open heart surgery.