

Circulation Editors' Picks

Most Read Articles in Cardiovascular Surgery and Transplantation

The Editors

The following articles are being highlighted as part of *Circulation's* Topic Review series. This series will summarize the most important manuscripts, as selected by the editors, published in *Circulation* and the *Circulation* subspecialty journals. The studies included in this article represent the most read manuscripts published on the topic of cardiovascular surgery and transplantation in 2009 and 2010. (*Circulation*. 2011;124:e283-e295.)

Comparison of Early Surgery Versus Conventional Treatment in Asymptomatic Severe Mitral Regurgitation

Summary: The optimal timing of surgical intervention in patients with asymptomatic severe mitral regurgitation remains controversial, because the potential benefits of early surgery need to be balanced against the operative risks. As prediction of mitral valve repair has become clinically feasible, and mitral valve repair has shown excellent long-term results, there is an increasing need for direct comparison between watchful waiting and early mitral valve repair. We prospectively evaluated 447 consecutive asymptomatic patients with severe degenerative mitral regurgitation and preserved left ventricular function to compare clinical outcomes of early surgery with those of the conventional treatment strategy. Early surgery was performed on 161 patients and the conventional treatment strategy on 286 patients. In the early surgery group, mitral valve repair and replacement were performed successfully in 151 (94%) and 10 (6%) patients, respectively, without operative mortality. This study demonstrates that in asymptomatic patients with severe degenerative mitral regurgitation and preserved left ventricular function, early surgery is associated with improved long-term clinical outcomes compared with the conventional treatment strategy by decreasing cardiac mortality and hospitalization due to congestive heart failure. We therefore suggest that early surgery may further improve clinical outcomes in asymptomatic severe mitral regurgitation with a high likelihood of mitral valve repair. Further prospective, randomized studies are needed to confirm the efficacy of early surgery.

Conclusions: Compared with conservative management, the strategy of early surgery was associated with an improved long-term event rate by decreasing cardiac mortality and congestive heart failure hospitalization more effectively in patients with severe degenerative mitral regurgitation. Early surgery may therefore further improve clinical outcomes in asymptomatic severe mitral regurgitation with preserved left ventricular systolic function and a high likelihood of mitral valve repair.¹

Ten-Year Follow-Up Survival of the Medicine, Angioplasty, or Surgery Study (MASS II): A Randomized Controlled Clinical Trial of 3 Therapeutic Strategies for Multivessel Coronary Artery Disease

Summary: Patients who are symptomatic because of coronary artery disease can be managed with medical therapy (MT), percutaneous

coronary interventions (PCI), bypass surgery (CABG), or a combination of these strategies. It is unknown which treatment approach is best for specific patient subgroups. Here, we report 10-year follow-up of the second Medicine, Angioplasty, or Surgery Study (MASS II), a study that evaluated MT alone, PCI, or CABG among stable coronary patients with multivessel disease. No differences were observed in overall mortality in patients treated with CABG, PCI, or MT. Nevertheless, compared with CABG, MT was associated with a significantly higher incidence of cardiac death, subsequent myocardial infarction, and additional revascularization. Overall, compared with CABG, MT was associated with a 2.29-fold increased risk of combined events. Event rates for PCI patients were intermediate between MT and CABG. Indeed, by finding the lowest rate of further interventions in the CABG group, our results support a strategy of revascularization, and in particular CABG, in addition to MT for selected stable coronary patients with multivessel disease.

Conclusions: Compared with CABG, MT was associated with a significantly higher incidence of subsequent myocardial infarction, a higher rate of additional revascularization, a higher incidence of cardiac death, and consequently a 2.29-fold increased risk of combined events. PCI was associated with an increased need for further revascularization, a higher incidence of myocardial infarction, and a 1.46-fold increased risk of combined events compared with CABG. Additionally, CABG was better than MT at eliminating anginal symptoms.²

Randomized Comparison of Strategies for Type B Aortic Dissection: The INVESTIGATION of STent Grafts in Aortic Dissection (INSTEAD) Trial

Summary: INSTEAD, the first randomized comparison between elective endovascular stent grafting and best medical treatment, justifies medical management for uncomplicated type B aortic dissection and corroborates excellent survival rate with tight blood pressure control and close surveillance. For patients with complications such as progressive expansion or late malperfusion who fail to respond to medical management, deferred endovascular therapy is feasible and safe. The results of INSTEAD do not challenge the endovascular treatment alternative to open surgery and confirm the potential of endovascular therapy to successfully deal with late expansion and distal malperfusion. Nevertheless, primary endovascular therapy in stable type B dissection failed to improve the 2-year survival rate and was associated with spinal injury in 2.9% of cases. Although low death and complication rates in both groups suggest a need for a reappraisal of standardized medical management with monitored blood pressure control, TEVAR is an appropriate crossover strategy in cases of emerging complications. Interestingly, all crossover patients survived

elective TEVAR with uneventful follow-up and remodeling despite rather late intervention. INSTEAD supports the notion of a complication-specific approach instead of TEVAR for all type B dissections; patients who survive type B dissection and are given best medical management with surveillance show an excellent 2-year survival rate, with progression to crossover/conversion in only 21%. Surveillance can be used to identify patients with evidence of progression who qualify for safe crossover or conversion. Finally, INSTEAD confirmed that stent-graft scaffolding enhances false-lumen thrombosis and aortic remodeling in type B dissection not only in the early phase of dissections but also in the chronic phase after false-lumen expansion, a notion that may translate to prognostic benefits that could potentially be seen at longer (5-year) follow-up.

Conclusions: In the first randomized study on elective stent-graft placement in survivors of uncomplicated type B aortic dissection, TEVAR failed to improve 2-year survival and adverse event rates despite favorable aortic remodeling.³

Acute Kidney Injury After Cardiac Surgery: Focus on Modifiable Risk Factors

Summary: Acute kidney injury (AKI) after cardiac surgery is a serious complication that is closely associated with postoperative death. In previous studies that evaluated risk factors for AKI, most of the identified risk factors were not modifiable (eg, diabetes mellitus, preexisting kidney disease). In the present multicenter study of 3500 adult patients undergoing cardiac surgery in 2004, we focused on identifying potentially modifiable risk factors for postoperative AKI. We found that AKI, as defined by consensus-based criteria (>25%, >50%, and >75% decrease in estimated glomerular filtration rate or need for dialysis within 1 week of surgery), was independently associated with a >4-fold increase in death rates. Three common and potentially modifiable variables (preoperative anemia, red blood cell transfusions, and surgical reexploration) were highly associated with AKI, even after adjustment for other perioperative risk factors (eg, preoperative intra-aortic balloon pump, cardiopulmonary bypass duration). Given these results, we propose that randomized trials are now needed to determine whether interventions that modify these risk factors might also prevent AKI after cardiac surgery.

Conclusions: AKI after cardiac surgery is highly prevalent and prognostically important. Therapies aimed at mitigating preoperative anemia, perioperative red blood cell transfusions, and surgical reexploration may offer protection against this complication.⁴

The Ross Procedure: A Systematic Review and Meta-Analysis

Summary: When pediatric and young adult patients require aortic valve replacement, the choice for a particular valve prosthesis has a major impact on their lives. A mechanical prosthesis comes with lifelong anticoagulation and increased risk of bleeding and thromboembolic complications. The choice for a biological valve substitute, on the other hand, implies 1 or more reoperations during the remainder of life because of limited durability. The concept of the Ross procedure provides the patient with a living aortic valve substitute that does not require anticoagulation and is potentially more durable than other biological (nonviable) prostheses. On the downside, it is a double valve operation, and the valve substitute implanted in pulmonary position is also subject to degeneration. Durability of the autograft valve is in some centers clearly superior to other biological valve conduits, whereas other centers report worrisome autograft reoperation rates, causing a continuing discussion on the value of this operation. By systematically compiling and weighing evidence on outcome from multiple small reports, this systematic review and meta-analysis gives an objective overview of outcome after the Ross procedure, in particular the variable durability results. It allows the clinician to appreciate factors that may affect durability, such as patient factors, histological aspects, and surgical technique details. In addition, the potential measures to optimize durability of this operation that are discussed in this article provide

important information for those clinicians who treat patients undergoing a Ross procedure.

Conclusions: The Ross procedure provides satisfactory results for both children and young adults. Durability limitations become apparent by the end of the first postoperative decade, in particular in younger patients.⁵

Open Heart Surgery in Patients With Sickle Cell Hemoglobinopathy

Summary: Sickle cell disorders are associated with increased risk of sickling, resulting in vasoocclusive complications. The information available for patients with sickle cell hemoglobinopathies undergoing any cardiac operations using cardiopulmonary bypass is sparse. In this study, a retrospective review of 47 patients with sickle cell disease or sickle cell trait undergoing open heart surgery at a single institution over an 11-year time period demonstrated that these patients should not be denied the needed cardiac surgical treatment. Intraoperative monitoring of venous and arterial oxygen content, pH, and body temperature is critical for a successful operation. These data support the view that heart valve surgery and surgery for congenital heart diseases can be performed safely and with acceptable outcomes in patients with sickle cell disease or sickle cell trait.

Conclusion: Heart valve surgery and surgery for congenital heart diseases can be performed safely in patients with sickle cell disease or sickle cell trait with acceptable outcome and survival rates.⁶

Comparison of Drug-Eluting Stents and Coronary Artery Bypass Surgery for the Treatment of Multivessel Coronary Disease: Three-Year Follow-Up Results From a Single Institution

Summary: Numerous studies have compared the outcomes of 2 competing interventions for multivessel coronary artery disease: coronary artery bypass grafting and coronary stenting. However, little information has become available since the introduction of drug-eluting stents. In the present study, we identified 3720 consecutive patients with multivessel disease who received drug-eluting stents or underwent coronary artery bypass grafting to compare safety (death, myocardial infarction, or stroke) and efficacy (target-vessel revascularization) during a 3-year follow-up after adjustment for differences in baseline risk factors. Patients receiving drug-eluting stents had considerably higher 3-year rates of target-vessel revascularization. Drug-eluting stents were also associated with higher rates of death (adjusted hazard ratio, 1.62; 95% confidence interval, 1.07 to 2.47) and myocardial infarction (adjusted hazard ratio, 1.65; 95% confidence interval, 1.15 to 2.44). The risk-adjusted rate of stroke was similar in the 2 groups (hazard ratio, 0.92; 95% confidence interval, 0.69 to 1.51). Our findings need to be ascertained or refuted in ongoing, large randomized clinical trials, which may provide the answer to treatment effects between the 2 primary interventions.

Conclusions: In a cohort of patients with multivessel disease, CABG was associated with lower rates of death, myocardial infarction, and target-vessel revascularization than drug-eluting stents.⁷

Preoperative Hemoglobin Level as a Predictor of Survival After Coronary Artery Bypass Grafting: A Comparison With the Matched General Population

Summary: This single-center observational study investigated the association between preoperative hemoglobin level and both early and late mortality in >10 000 coronary surgery patients. To the best of our knowledge, no data are available on preoperative hemoglobin level as a predictor of long-term outcome of patients undergoing coronary artery bypass grafting. The predictive value of preoperative hemoglobin level indicates the importance of better investigation and management of

preoperative anemia in coronary surgery patients. An important finding of this study is that patients with a normal preoperative hemoglobin level had a better long-term survival than age- and sex-matched groups of the general Dutch population. Although this information has no significance in preoperative assessment and decision making, it gives patients a rough idea of their long-term prognosis.

Conclusions: A lower preoperative hemoglobin level is an independent predictor of late mortality in patients undergoing CABG, whereas anemia is a risk factor for early and late mortality. Compared with the general population, anemic patients had worse survival than expected, whereas nonanemic patients had better survival than expected.⁸

Aspirin Plus Clopidogrel Versus Aspirin Alone After Coronary Artery Bypass Grafting: The Clopidogrel After Surgery for Coronary Artery Disease (CASCADE) Trial

Summary: Coronary artery bypass grafting (CABG) is an effective treatment for ischemic heart disease, but its long-term results are compromised by the development of saphenous vein graft (SVG) disease. After surgery, a platelet-mediated thickening of the SVG wall occurs, with smooth muscle cell proliferation and extracellular matrix protein synthesis. This process, termed intimal hyperplasia, forms a template for the development of SVG atherosclerosis and eventual occlusion. Clopidogrel has been shown to inhibit intimal hyperplasia in animal studies and therefore may reduce SVG intimal hyperplasia after coronary artery bypass grafting. In the Clopidogrel After Surgery for Coronary Artery Disease (CASCADE) study, we conducted a double-blind, placebo-controlled trial to evaluate whether the addition of clopidogrel to aspirin inhibits the development of SVG disease. A total of 113 patients undergoing coronary artery bypass grafting with SVGs were randomized to receive either aspirin 162 mg plus clopidogrel 75 mg daily or aspirin 162 mg plus placebo daily for 1 year, followed by SVG intravascular ultrasound and coronary angiography. The primary outcome, SVG intimal area at 1 year, did not differ significantly between the 2 groups (4.1 ± 2.0 versus 4.5 ± 2.1 mm², aspirin-clopidogrel versus aspirin-placebo, $P=0.44$). Graft patency and freedom from major adverse cardiovascular events also did not significantly differ between the 2 groups. In summary, CASCADE indicated that compared with aspirin monotherapy, the combination of aspirin plus clopidogrel did not significantly reduce SVG intimal hyperplasia 1 year after coronary artery bypass grafting. Newer antiplatelet agents with purported advantages over clopidogrel may constitute important areas for future research to target the inhibition of SVG disease after CABG.

Conclusions: Compared with aspirin monotherapy, the combination of aspirin plus clopidogrel did not significantly reduce the process of SVG intimal hyperplasia 1 year after coronary artery bypass grafting.⁹

Shortage of Cardiothoracic Surgeons Is Likely by 2020

Summary: Even as the burden of cardiovascular disease in the United States is increasing as the population grows and ages, the number of active cardiothoracic surgeons has fallen for the first time in 20 years. This study evaluates current and future requirements for cardiothoracic surgeons in light of decreasing rates of coronary artery bypass grafting procedures. By 2025, the demand for cardiothoracic surgeons could increase by 46% on the basis of population growth and aging if current healthcare use and service delivery patterns continue. Even with complete elimination of coronary artery bypass grafting, there is a projected shortfall of cardiothoracic surgeons because the active supply is projected to decrease 21% over the same time period as a result of retirement and declining entrants. This shortage of cardiothoracic surgeons within the next 10 years could diminish quality of care if non-board-certified physicians

expand their role in cardiothoracic surgery or if patients must delay appropriate care because of a shortage of well-trained surgeons.

Conclusion: The United States is facing a shortage of cardiothoracic surgeons within the next 10 years, which could diminish quality of care if non-board-certified physicians expand their role in cardiothoracic surgery or if patients must delay appropriate care because of a shortage of well-trained surgeons.¹⁰

Benefits and Risks of Corticosteroid Prophylaxis in Adult Cardiac Surgery: A Dose-Response Meta-Analysis

Summary: Corticosteroid prophylaxis in cardiac surgery has been studied extensively for >30 years, but its potential benefits and risks remain inconclusive. Small sample sizes and a wide range of doses of corticosteroid used in different studies are the major confounders affecting the interpretation of these studies. We assessed the dose-response relationship of corticosteroid in adult on-pump cardiac surgery by meta-analyzing a total of 3323 patients from 50 randomized controlled trials. Corticosteroid prophylaxis was effective in reducing serum inflammatory markers, atrial fibrillation, and length of stay in the intensive care unit and hospital compared with placebo. The number of patients needed to treat to prevent 1 atrial fibrillation was estimated to be 10. No additional benefits were found on all outcomes beyond a total dose of 1000 mg hydrocortisone or equivalent. The use of corticosteroid prophylaxis was not associated with a change in hospital mortality or an increased risk of all-cause infection. The sample size of this meta-analysis has a power of 80% to exclude a 3.5% increase in infection risk if the infection rate of the control group is 5%. Hyperglycemia requiring insulin infusion, however, was common after corticosteroid prophylaxis, and very high doses of corticosteroid (>10 000 mg hydrocortisone or equivalent) were associated with prolonged mechanical ventilation. The current evidence suggests that low-dose corticosteroid, <1000 mg hydrocortisone, is safe and effective in reducing the risk of atrial fibrillation after on-pump adult cardiac surgery. Large randomized controlled studies are needed to confirm the cost-effectiveness of corticosteroid in adult cardiac surgery.

Conclusions: Evidence suggests that low-dose corticosteroid is as effective as high-dose corticosteroid in reducing the risk of atrial fibrillation and duration of mechanical ventilation but with fewer potential side effects in adult cardiac surgery.¹¹

Risk of Assessing Mortality Risk in Elective Cardiac Operations: Age, Creatinine, Ejection Fraction, and the Law of Parsimony

Summary: Risk stratification in cardiac surgery is a relevant issue. Many mortality risk models are currently available for clinicians and institutions. They are used to assign a specific operative mortality risk to individuals, to provide internal comparisons between surgeons, and to contrast the hospital performance with external benchmarks. Internal models accounting for specific risk profiles of the patient population may perform better than externally developed models. However, whereas external models are generally developed using very large series, often including up to 10 000 patients, internal models often rely on a more limited patient population. When addressing elective patients, the mortality rate is low, and the number of events is limited, allowing few predictors to be included in the model. In this retrospective, observational study, we have developed and validated an operative mortality risk score based on only 3 predictors: age, creatinine value, and left ventricular ejection fraction. This score provided a level of accuracy similar to or better than the EuroSCORE and other mortality risk scores with a better clinical performance. The limited number of predictors included in the model allows its use in relatively limited patient series, with the possibility of an annual recalibration, therefore accounting for possible local changes in clinical practice and risk profile of the patient population.

Conclusion: A risk model limited to 3 independent predictors has similar or better accuracy and calibration compared with more complex risk scores if applied to elective cardiac operations.¹²

Acute Kidney Injury Is Associated With Increased Long-Term Mortality After Cardiothoracic Surgery

Summary: In a single-center cohort of 2973 patients with no previous history of kidney disease who were discharged from the hospital after cardiothoracic surgery, acute kidney injury (AKI) with even small changes in serum creatinine level during hospitalization was associated with an independent long-term risk of death. Most importantly, even patients with complete renal recovery had an increased risk of death for up to 10 years compared with patients without AKI. Although AKI may be a marker of severe systemic illness in some patients, it is becoming clear that severe kidney injury can exhibit important independent effects on outcome that may extend well beyond discharge from the hospital. The effect of less severe AKI on long-term outcomes is less well understood, and in fact, the finding that patients with complete recovery after AKI had long-term outcomes comparable to those patients with only partial recovery may point toward some still unknown independent effect of mild AKI on long-term longevity. The findings of the present study promote efforts to identify and minimize renal-injurious interventions before surgery. Perhaps more important is follow-up for patients who sustain mild to moderate postoperative AKI, which is almost nonexistent in current clinical practice. This study may prompt closer monitoring of the patient who sustains postoperative AKI, as well as more aggressive attempts to protect this patient from any further injury to the kidney. This is especially important given that even mild chronic kidney disease is a significant risk factor for cardiovascular disease and death.

Conclusions: The risk of death associated with AKI after cardiothoracic surgery remains high for 10 years regardless of other risk factors, even for those patients with complete renal recovery. Improved renal protection and closer postdischarge follow-up of renal function may be warranted.¹³

Safety and Efficacy of Recombinant Activated Factor VII: A Randomized Placebo-Controlled Trial in the Setting of Bleeding After Cardiac Surgery

Summary: Activated recombinant factor VII (rFVIIa) has been widely reported in the management of patients bleeding after cardiac surgery. Given its widespread off-label use, physicians must be comfortable with its efficacy in stopping bleeding and reducing transfusion. However, no prospective information has been collected on the safety profile of this agent in patients undergoing cardiac surgical operations. We have looked at the potential risks and possible benefits of rFVIIa in patients who bleed after cardiac surgery. We randomized patients actively bleeding after cardiac surgery in an intensive care unit to either placebo or rFVIIa. Our results show a small numeric non-dose-dependent increase in the number of critical serious adverse events suffered by patients receiving rFVIIa. In an underpowered study, this was not statistically significant. Fifty percent fewer patients underwent reoperation for bleeding when treated with rFVIIa. Those patients who received 80 $\mu\text{g}/\text{kg}$ received considerably fewer transfusions of allogeneic blood or blood products. Our results imply that caution must be used if rFVIIa is given to patients without congenital coagulopathic disorders in whom its use is licensed.

Conclusions: On the basis of this preliminary evidence, rFVIIa may be beneficial for treating bleeding after cardiac surgery, but caution should be applied and further clinical trials are required because there is an increase in the number of critical serious adverse events, including stroke, in those patients randomized to receive rFVIIa.¹⁴

Derivation and Validation of a Preoperative Prediction Rule for Delirium After Cardiac Surgery

Summary: Delirium is a common, morbid, and costly condition after cardiac surgery. This study developed and validated a prediction rule for postoperative delirium using 4 independent risk factors for delirium assessed before surgery: prior stroke or transient ischemic attack, impaired cognition, abnormal serum albumin, and depression. A risk stratification system assigned points to each risk factor. Compared with no points, the presence of 1 point more than doubles the delirium risk, the presence of 2 points more than triples the delirium risk, and the presence of ≥ 3 points more than quadruples delirium risk. This prediction rule provides clinicians a method to identify delirium risk before cardiac surgery. Clinically, patients who are stratified into moderate and high risk for delirium categories would benefit from frequent delirium screening and implementation of delirium prevention strategies. Importantly, this cardiac surgery delirium prediction rule provides a method to stratify at-risk older patients preoperatively for such interventions to ultimately reduce the morbidity, mortality, and cost of postoperative delirium.

Conclusions: Delirium occurs frequently after cardiac surgery. Using 4 preoperative characteristics, clinicians can determine cardiac surgery patients' risk for delirium. Patients at higher delirium risk could be candidates for close postoperative monitoring and interventions to prevent delirium.¹⁵

Previous Coronary Stent Implantation and Cardiac Events in Patients Undergoing Noncardiac Surgery

Summary: Patients treated with coronary stent implantation before undergoing noncardiac surgery seem to be at increased risk for adverse perioperative cardiac events. The period of risk and the influence of stent type on outcome remain to be determined in a large-scale multicenter study. To specifically address these issues, we performed a systematic, large-scale retrospective cohort study in Scotland linking the national angioplasty registry with hospital admission data to examine outcomes in all patients treated with coronary stenting over a 4-year period who subsequently underwent noncardiac surgery ($n=1953$). Approximately 5% of patients underwent noncardiac surgery within 1 year of coronary stent implantation. Perioperative death and ischemic cardiac events were more common when surgery was performed within 6 weeks of stent implantation, especially where revascularization was performed after an acute coronary syndrome. For at least 2 years after coronary stent implantation, no difference in cardiac outcomes after noncardiac surgery was evident according to whether the initial stent was drug eluting or bare metal. Our findings support current guideline recommendations that noncardiac surgery should be deferred for at least 4 to 6 weeks after implantation of a bare-metal coronary stent. Although our findings suggest similar perioperative outcomes for patients treated with drug-eluting stents, further prospective large-scale studies are required before any change to the current guideline recommendations that noncardiac surgery be deferred for 6 to 12 months after drug-eluting stent implantation can be supported.

Conclusions: Patients undergoing noncardiac surgery after recent coronary stent implantation are at increased risk of perioperative myocardial ischemia, myocardial infarction, and death, particularly after an acute coronary syndrome. For at least 2 years after percutaneous coronary intervention, cardiac outcomes after noncardiac surgery are similar for both drug-eluting and bare-metal stents.¹⁶

Perioperative Complications After Vascular Surgery Are Predicted by the Revised Cardiac Risk Index But Are Not Reduced in High-Risk Subsets With Preoperative Revascularization

Summary: It is unclear whether preoperative coronary revascularization reduces postoperative cardiac complications in high-risk

patients undergoing vascular surgery as defined by the Revised Cardiac Risk Index (RCRI). Using preoperative baseline characteristics to determine the RCRI, we validated the RCRI in patients undergoing vascular surgery and evaluated the benefit of preoperative revascularization on death and nonfatal myocardial infarction among patients with varying risk. The postoperative risk of death and nonfatal myocardial infarction after surgery increased according to the RCRI (odds ratio, 1.73; 95% CI, 1.26 to 2.38; $P < 0.001$), with a rate of 1.6% in patients with no risk that increased to 23.4% in patients with ≥ 3 risks. However, preoperative revascularization was not associated with the incidence of complications in any risk subset (odds ratio, 0.86; 95% CI, 0.50 to 1.49; $P = 0.60$). Therefore, we conclude that the risk of death and nonfatal myocardial infarction is accurately predicted by the RCRI in patients undergoing vascular surgery but is not reduced by preoperative coronary artery revascularization among any RCRI risk subset.

Conclusions: The risk of death and nonfatal myocardial infarction is accurately predicted by the RCRI in patients undergoing vascular surgery but is not reduced in any high-risk subset of the RCRI with preoperative coronary artery revascularization.¹⁷

Tricuspid Valve Surgery in Adults With a Dysfunctional Systemic Right Ventricle: Repair or Replace?

Summary: Tricuspid regurgitation is a frequent finding in patients with atrially corrected or congenitally corrected transposition of the great arteries and, consequently, a systemic right ventricle. When important tricuspid regurgitation occurs, it is usually associated with rapid deterioration of right ventricular function and functional status. Selection of adequate therapy is a challenging issue, specifically in those patients beyond the second decade of life. Several surgical approaches are possible in cases of important tricuspid regurgitation, and in the present study, tricuspid valvuloplasty or tricuspid valve replacement was investigated in a cohort of 16 adult patients with symptomatic important tricuspid regurgitation and relatively mild right ventricular dysfunction. Mortality was rather low, but the rate of complications was high. All complications were manageable, which makes this a safe operation. The results of this study indicate that tricuspid valve replacement may be superior to tricuspid valvuloplasty. Although the short-term results were equal in terms of right ventricular function and improvement in functional class, a high incidence of recurrent moderate tricuspid regurgitation was observed within 1 year after valvuloplasty. It is concluded that tricuspid valve surgery is safe in patients with transposition of the great arteries and a systemic right ventricle, provided it is performed in specialized centers. Furthermore, tricuspid valve replacement is probably superior to tricuspid valvuloplasty in adult patients with important tricuspid regurgitation and a systemic right ventricle.

Conclusions: Mortality is rather low after tricuspid surgery in adult patients with mild to moderate right ventricular dysfunction. In general, tricuspid valve function and functional class improve significantly after surgery, and systemic right ventricular function is preserved. Tricuspid valvuloplasty, however, is associated with a high rate of recurrence of regurgitation.¹⁸

New-Onset Postoperative Atrial Fibrillation After Isolated Coronary Artery Bypass Graft Surgery and Long-Term Survival

Summary: New-onset postcoronary artery bypass graft surgery atrial fibrillation (AFIB) affects 11% to 40% of patients and is believed to have little impact on patients' long-term outcome. The findings in this study provide evidence that new-onset postcoronary artery bypass graft surgery AFIB has a significant effect on long-term mortality. The findings encourage implementation of the recommendations within the American College of Cardiology/American Heart Association/European Society of Cardiology guidelines regarding

the management of new-onset AFIB. Further research should focus on the development of more effective preventive therapeutic strategies and should identify high-risk patients for new-onset postoperative AFIB so that they can be targeted for potential prophylaxis.

Conclusions: This study provides evidence that new-onset post-CABG AFIB is significantly associated with increased long-term risk of mortality independent of patient preoperative severity. After controlling for a comprehensive array of risk factors associated with post-CABG adverse outcomes, risk of long-term mortality in patients that developed new-onset post-CABG AFIB was 29% higher than in patients without it.¹⁹

Improved Long-Term Survival After Abdominal Aortic Aneurysm Repair

Summary: Abdominal aortic aneurysm (AAA) is a common and potentially lethal disease if the AAA ruptures. The disease is preferably treated with prophylactic repair in selected patients. The treatment of AAA has developed substantially over the past 2 decades with the introduction of endovascular aneurysm repair, the timing of intervention established by randomized trials, and improved postoperative care. These developments have made it possible to treat AAA among older patients with more comorbidities while improving short-term outcome. The observed changes in patient demography may, however, affect long-term survival after AAA repair. Long-term survival is fundamental for surgical decision making and has important health economic implications when the cost-effectiveness of a new treatment (eg, endovascular aneurysm repair) or health intervention (eg, screening for AAA) is evaluated. In this population-based nationwide study, long-term survival after AAA repair in Sweden over an 18-year period was analyzed on the basis of 12 834 primary operations performed from 1987 to 2005. Both short- and long-term outcome after intact AAA repair improved over time. Long-term relative survival among those surviving the operation compared with a general population (adjusted for age, sex, and calendar year) was superior for octogenarians and male patients compared with younger patients and women. Although short-term survival after ruptured AAA repair increased over time, long-term outcome was unaffected. Changes in patient demography and case mix toward older patients, a higher proportion of patients with comorbidities, and the increasing use of endovascular aneurysm repair thus have not had any negative effects on long-term outcome after operation.

Conclusions: Long-term survival improved over time after intact AAA repair despite a change in case mix toward older patients with more comorbidities. Long-term survival was stable after ruptured AAA repair.²⁰

Determinants of Surgical Outcome in Patients With Isolated Tricuspid Regurgitation

Summary: Although the impact of tricuspid regurgitation on long-term prognosis has been well demonstrated, determining the optimal time for corrective surgery remains a difficult clinical problem. Therefore, it is of paramount importance to provide objective measures to predict clinical outcomes after surgery and thus to determine surgical timing in tricuspid regurgitation. We prospectively enrolled 61 patients with isolated severe tricuspid regurgitation to identify preoperative predictors of clinical outcomes after surgery. Operative mortality was 10%, and event-free survival rate was 75% during mean follow-up duration after surgery of 35 ± 16 months. In the 54 patients who underwent 6-month clinical and echocardiographic follow-up, right ventricular end-diastolic area decreased by 29%, and 33 patients (61%) showed improved functional capacity after surgery. Preoperative hemoglobin level and right-ventricular end-systolic area measured by echocardiography emerged as independent determinants of clinical outcomes. On receiver operating characteristic curve analysis, we found that preoperative right ventricular end-systolic area $< 20 \text{ cm}^2$ and preoperative hemoglobin level $> 11.3 \text{ g/dL}$ predicted event-free survival most effectively. Our data

suggest that timely correction of severe tricuspid regurgitation carries an acceptable risk and improves functional capacity. Surgery should be considered before the development of advanced right ventricular systolic dysfunction and before the development of anemia.

Conclusions: Timely correction of severe tricuspid regurgitation carries an acceptable risk and improves functional capacity. Surgery should be considered before the development of advanced right ventricular systolic dysfunction and before the development of anemia.²¹

Vernakalant Hydrochloride for the Rapid Conversion of Atrial Fibrillation After Cardiac Surgery: A Randomized, Double-Blind, Placebo-Controlled Trial

Summary: Atrial fibrillation (AF) occurring after cardiac surgery is common and is associated with considerable morbidity. Early restoration of sinus rhythm is usually desirable, and pharmacological conversion is generally preferable to electric cardioversion in these early postoperative patients. Intravenous vernakalant, a new antiarrhythmic agent with atrial selective properties, has been shown to be effective in rapidly and safely converting approximately 50% of patients with new-onset AF. In this study, vernakalant demonstrated successful conversion of AF to sinus rhythm in 47% of patients with new-onset AF after cardiac surgery. Responders converted rapidly (median time, 12 minutes). Vernakalant was ineffective at converting a small number of patients (n=6) with new-onset atrial flutter. Two serious adverse events occurred during the initial 10-minute vernakalant infusion. One event of hypotension responded to discontinuation of the infusion, intravenous fluids and norepinephrine, resolving in 3 minutes. The other event was complete heart block that responded to discontinuation of the infusion and pacing through an epicardial wire (placed at the time of surgery), resolving in 12 minutes. Vernakalant does not appear to promote ventricular arrhythmia. Episodes of asymptomatic, nonsustained ventricular runs were captured on Holter monitoring in all patients given vernakalant or placebo. There were no episodes of torsades de pointes, ventricular fibrillation, or death. Vernakalant is potentially a safe and effective pharmacological alternative for the conversion of AF to sinus rhythm in patients after cardiac surgery.

Conclusions: Vernakalant was safe and effective in the rapid conversion of AF to sinus rhythm in patients who had AF after cardiac surgery.²²

Prediction Models for Prolonged Intensive Care Unit Stay After Cardiac Surgery: Systematic Review and Validation Study

Summary: Prolonged intensive care unit (ICU) stay after cardiac surgery leads to potential reduction in quality of life and incremental use of resources. For efficient use of ICU resources and to schedule patients with a low risk of postoperative complications before patients with a higher risk, preoperative estimation of the risk of prolonged ICU stay is necessary. Various prediction models have been developed to preoperatively identify patients with an increased risk for prolonged ICU stay. It is widely accepted that no prediction model should be applied in practice before being formally validated in new patients. In the domain of prolonged ICU stay after cardiac surgery, however, no study has thus far conducted such a formal validation and comparison study. The present analysis is the first extensive quantitative validation of existing models for prolonged ICU stay after cardiac surgery in a large data set of 11 395 patients. The results show that the Parsonnet model and the European system for cardiac operative risk evaluation (EuroSCORE) have the overall best performance. Although both models were originally developed to predict mortality, they are also superior in identifying patients with an increased risk of prolonged ICU stay. Because in current daily practice both models are widely implemented for the estimation

of mortality risk, this allows for a relatively straightforward application of our findings in clinical practice. The risk stratification for mortality based on these models can also be used to identify patients with an increased risk of prolonged ICU stay, which is useful for timely planning of postoperative care and ICU management.

Conclusions: In this validation of prediction models for prolonged ICU length of stay, 2 widely implemented models (Parsonnet, EuroSCORE), although originally designed for prediction of mortality, were superior in identifying patients with prolonged ICU length of stay.²³

Predictors of Improvement of Unrepaired Moderate Ischemic Mitral Regurgitation in Patients Undergoing Elective Isolated Coronary Artery Bypass Graft Surgery

Summary: In this study, we sought to investigate preoperative predictors of moderate ischemic mitral regurgitation (IMR) improvement after elective isolated coronary artery bypass graft (CABG) surgery. The persistence of moderate IMR after isolated CABG surgery is an important independent predictor of long-term mortality. However, mitral valve repair at the time of CABG surgery does not appear to improve survival. In contrast, concomitant mitral valve repair is associated with increased perioperative risks compared with CABG alone. Hence, the optimal surgical management of patients with moderate IMR undergoing CABG surgery is unclear. In the present study, the presence of significant myocardial viability and the absence of dyssynchrony between papillary muscles were major independent predictors of long-term IMR improvement after isolated CABG surgery. Moreover, patients with IMR improvement also showed improved survival compared with patients who failed to improve. IMR is caused by disease of the left ventricle with a secondary distortion of mitral valve geometry. This suggests that recovery of left ventricular function by revascularization of viable myocardium or resynchronization of contractions between the papillary muscles through biventricular pacing may be the optimal therapy addressing the underlying IMR mechanism, ie, disease of the left ventricle. Thus, assessment of myocardial viability and dyssynchrony may provide a basis for clinical decision making as to whether to perform mitral valve repair at the time of surgical revascularization in patients with moderate IMR referred for elective CABG surgery.

Conclusion: Reliable improvement in moderate IMR by isolated coronary artery bypass graft surgery was observed only in patients with concomitant presence of viable myocardium and absence of dyssynchrony between papillary muscles.²⁴

No Major Differences in 30-Day Outcomes in High-Risk Patients Randomized to Off-Pump Versus On-Pump Coronary Bypass Surgery: The Best Bypass Surgery Trial

Summary: Observational studies comparing off-pump with on-pump coronary artery bypass grafting (CABG) have indicated that high-risk patients will benefit the most from avoiding cardiopulmonary bypass; however, this has not been assessed previously in a randomized trial. In the Best Bypass Surgery trial (n=341), off-pump compared with on-pump CABG in patients with 3-vessel disease and a EuroSCORE ≥ 5 did not result in a significant difference in the 30-day composite outcome including all-cause mortality, acute myocardial infarction, cardiac arrest with successful resuscitation, low cardiac output syndrome/cardiogenic shock, stroke, and coronary reintervention, nor were any of the individual components of the composite outcome significantly different. Off-pump CABG resulted in fewer grafts to the lateral territory of the left ventricle, although the overall number of grafts did not differ significantly between the 2 groups. The Best Bypass Surgery trial found that both off-pump and on-pump CABG can be performed in high-risk patients with low 30-day mortality and morbidity. Off-pump CABG

seems to carry a risk of incomplete revascularization, and this may affect long-term mortality and morbidity.

Conclusions: Both off- and on-pump coronary artery bypass grafting can be performed in high-risk patients with low short-term complications.²⁵

Extensive Primary Repair of the Thoracic Aorta in Acute Type A Aortic Dissection by Means of Ascending Aorta Replacement Combined With Open Placement of Triple-Branched Stent Graft: Early Results

Summary: In surgical extensive primary repair of the thoracic aorta for acute type A aortic dissection, careful manipulation of the arch and elaborate anastomoses to the distal arch and 3 arch vessels are time-consuming and could induce phrenic and recurrent laryngeal nerve injury. Our results suggest that extensive primary repair of the thoracic aorta for acute type A aortic dissection can be performed simply by both open placement of the triple-branched stent graft into the proximal descending aorta, arch, and 3 arch vessels and graft replacement of the ascending aorta, which can reduce the risk and technical difficulties of extensive thoracic aorta repair to close to those of the conventional ascending graft replacement with open distal anastomosis. Therefore, with open placement of triple-branched stent graft, extensive primary repair of the thoracic aorta may become easier and safer for acute type A aortic dissection. Careful long-term follow-up and further extensive clinical use are necessary to completely evaluate the efficacy of this new technique.

Conclusions: Open triple-branched stent graft placement is an effective technique with satisfactory early results. With this technique, extensive primary repair of the thoracic aorta may become easier and safer for acute type A aortic dissection.²⁶

Early On–Cardiopulmonary Bypass Hypotension and Other Factors Associated With Vasoplegic Syndrome

Summary: Vasoplegic syndrome is a well-described clinical entity that can occur after separation from cardiopulmonary bypass and is associated with a poor prognosis. The goal of this retrospective review was to explore the relationship of early arterial hypotension after cardiopulmonary bypass is begun and the subsequent development of vasoplegic syndrome after separation from cardiopulmonary bypass. Additionally, we were able to identify other factors that were associated with vasoplegic syndrome and build a model that could predict the likelihood of an individual patient becoming vasoplegic. By adequately stratifying patients according to their risk, we hope that future studies can be designed to test the effectiveness of therapeutic measures aimed at reducing the incidence of vasoplegic syndrome.

Conclusions: The results of this investigation suggest that it is possible to predict vasoplegia intraoperatively before separation from CPB and that the presence of a clinically significant area above the mean arterial blood pressure curve serves as a predictor of poor clinical outcome.²⁷

Outcomes of Patients With Acute Type A Aortic Intramural Hematoma

Summary: Aortic intramural hematoma (IMH) is increasingly recognized as a unique disease entity with pathological and clinical features differing from those of classic aortic dissection. However, the best treatment of IMH, especially in cases involving the ascending aorta, remains uncertain. We assessed the outcomes of our institutional policy of urgent surgery for unstable type A IMH patients and initial medical treatment for stable patients with surgery for subsequent complications. Type A IMH occurred in 101 patients (28%) admitted with a type A acute aortic syndrome. IMH patients were older than those with aortic dissection and, according to our

institutional policy, had less urgent surgery than those with aortic dissection (15.8% versus 87.5%; $P < 0.001$). The hospital mortality rate and subsequent longer-term mortality for type A IMH was similar to that for patients with aortic dissection treated with surgery. However, adverse clinical events, such as early sudden death or later progression to aortic dissection, were not uncommon with medical treatment alone. An initial aortic diameter >55 mm and hematoma thickness >16 mm were associated with these adverse events and may identify patients with IMH who would benefit from early elective surgery. Type A IMH is a unique disease entity with more favorable response to medical treatment than classic aortic dissection. Risk stratification of IMH based on aortic diameter and hematoma thickness to determine those who should have early surgery requires further testing.

Conclusions: The clinical outcome of IMH patients receiving treatment by our policy was comparable to that of surgically treated aortic dissection patients. However, adverse clinical events were not uncommon with medical treatment alone, and initial aorta diameter and hematoma thickness may identify patients who might benefit from urgent surgery.²⁸

Prospective, Comprehensive Assessment of Cardiac Troponin T Testing After Coronary Artery Bypass Graft Surgery

Summary: The role of serum troponin measurement is well defined in the diagnosis and risk stratification of acute coronary syndromes. However, the situation is less clear for the use of troponin measurement after cardiac surgery because troponin is released in essentially all such patients. Therefore, we undertook a prospective study of 847 patients to comprehensively evaluate and validate the use of troponin T testing for risk assessment in this setting. In addition, we studied patients within the context of recent consensus guidelines for the detection of postcoronary artery bypass grafting (CABG) myocardial infarction. Only 2% of subjects had a post-CABG myocardial infarction; however, we found that troponin T concentrations were elevated in essentially all patients and were determined by several relevant preoperative, intraoperative, and postoperative factors. Importantly, very elevated troponin T concentrations were correlated with more resource use and poorer outcomes and were additive to the Society for Thoracic Surgery risk score for prognostication after CABG. Whereas the consensus-endorsed cutpoint for troponin T (0.15 ng/mL) was overly sensitive and less clinically useful for either post-CABG diagnosis of myocardial infarction or risk assessment, a higher troponin T of <1.60 ng/mL provided excellent negative predictive value for excluding relevant complications in post-CABG setting. Troponin testing after CABG is therefore valuable for postoperative risk assessment, particularly when applied at the correct cut points.

Conclusions: cTnT concentrations after coronary artery bypass graft surgery are nearly universally elevated, are determined by numerous factors, and are independently prognostic for impending postoperative complications when used at appropriate cut points.²⁹

Outcomes for Patients With ST-Elevation Myocardial Infarction in Hospitals With and Without Onsite Coronary Artery Bypass Graft Surgery: The New York State Experience

Summary: The benefit of primary percutaneous coronary interventions (P-PCI) for patients with ST-elevation myocardial infarction (STEMI) has been well documented. However, controversy still exists as to whether PCI should be expanded to hospitals without coronary artery bypass graft surgery. In this study, patients who were discharged after PCI for STEMI between January 1, 2003, and December 12, 2006, in P-PCI centers (hospitals with no coronary artery bypass graft surgery and PCI only for patients with STEMI) were propensity matched with patients in full service centers, and mortality and subsequent revascularization rates were compared.

There were no differences for in-hospital/30-day mortality (2.3% for P-PCI centers versus 1.9% for full service centers [$P=0.40$]), emergency coronary artery bypass graft surgery (0.06% versus 0.35%, $P=0.06$), in 3-year mortality (7.1% versus 5.9%, $P=0.07$) or subsequent revascularization (23.8% versus 21.5%, $P=0.52$). P-PCI centers had a lower same/next day coronary artery bypass graft rate (0.23% versus 0.69%, $P=0.046$) and higher repeat target vessel PCI rates (12.1% versus 9.0%, $P=0.003$). For patients with STEMI who did not undergo PCI, P-PCI centers had higher in-hospital mortality (28.5% versus 22.3%; adjusted odds ratio, 1.38; 95% CI, 1.08 to 1.75). In conclusion, no differences between P-PCI centers and full service centers were found in in-hospital/30-day mortality, the need for emergency surgery, 3-year mortality or subsequent revascularization, but P-PCI centers had higher repeat target vessel PCI rates and higher mortality rates for patients who did not undergo PCI. P-PCI centers should be monitored very closely, including the monitoring of patients with STEMI who did not undergo PCI.

Conclusions: No differences between P-PCI centers and full service centers were found in in-hospital/30-day mortality, the need for emergency surgery, 3-year mortality or subsequent revascularization, but P-PCI centers had higher repeat target vessel PCI rates and higher mortality rates for patients who did not undergo PCI. P-PCI centers should be monitored closely, including the monitoring of patients with STEMI who did not undergo PCI.³⁰

Frail Patients Are at Increased Risk for Mortality and Prolonged Institutional Care After Cardiac Surgery

Summary: Frailty is an emerging concept in clinical medicine, most extensively investigated in community dwelling geriatric populations where it has been demonstrated that frail patients are predisposed to falls, hospitalization, institutionalization, and mortality. Frailty has been less thoroughly investigated as a risk factor for patients undergoing procedural interventions. Its role as a risk factor for cardiac surgical intervention has not been investigated previously. We have prospectively examined our cardiac patient population for frailty as measured by The Katz Index of Activities of Daily Living, an internationally validated measure of dependency in elderly patients, as well as for deficits in independent ambulation and for documented history of dementia. Patients having any defect in these measures were defined as frail. We demonstrated that frailty was an independent predictor of in-hospital mortality, reduced medium term survival, as well as discharge to institutional care rather than home. Although age was also a predictor of these outcomes, after adjusting for age, frailty remained an independent predictor of these outcomes. Our data have implications for frail patients who have cardiac disease amenable to surgical repair. As a result of our work, both patients and surgeons can be better informed about potential adverse outcomes before arriving at a decision to go ahead with cardiac surgical intervention. Additionally, frail patients would potentially benefit from altered approaches to care that could mitigate the risks these patients face, for example, in improving mobilization and nutrition prior to a planned intervention.

Conclusions: Frailty is a risk for postoperative complications and an independent predictor of in-hospital mortality, institutional discharge, and reduced midterm survival. Frailty screening improves risk assessment in cardiac surgery patients and may identify a subgroup of patients who may benefit from innovative processes of care.³¹

Vascular Reactivity and Flow Characteristics of Radial Artery and Long Saphenous Vein Coronary Bypass Grafts: A 5-Year Follow-Up

Summary: We have demonstrated, in a randomized clinical trial (the Radial Artery versus Saphenous Vein Patency [RSVP] trial), that radial artery (RA) aortocoronary bypass grafts anastomosed to a

branch of the circumflex coronary artery have significantly better patency rates than saphenous vein (SV) grafts at 5 years. The reasons for this are relatively unexplored. In a substudy from this trial, we now report preserved vascular function in RA but not SV grafts 5 years after surgery, which may at least in part explain the patency results of the RSVP trial. The primary finding from this study is that RA aortocoronary bypass grafts are living conduits at 5 years, with the ability to autoregulate their diameter in response to changes in myocardial flow physiology, similar to that which has been observed and reported for the pedicle left internal mammary artery graft. The SV grafts, devoid of their vascular autoregulatory function, are merely passive conduits at 5 years. This may result in the SV grafts being subjected to extreme flow stresses, resulting in repeated cycles of injury and repair, and this may be one of the mechanisms that may contribute to the less favorable patency rate in SV compared with RA aortocoronary conduits in the longer term. Our clinical trial results, with the use of excellent surgical technique, support the use of the RA in aortocoronary bypass graft surgery, which we hope will result in the more widespread and acceptable use of the RA as an aortocoronary conduit.

Conclusions: Five years after surgery, RA coronary bypass conduits grafted to a single coronary territory demonstrated preserved flow-mediated vasodilatation, whereas SV grafts did not. Our results may provide insight into the more favorable patency of RA grafts over SV grafts.³²

Tobacco Smoke Exposure in Either the Donor or Recipient Before Transplantation Accelerates Cardiac Allograft Rejection, Vascular Inflammation, and Graft Loss

Summary: Tobacco exposure in cardiac transplant recipients, before and after transplantation, may increase the risk of cardiac allograft vasculopathy and allograft loss. In this experimental study, we provide the first direct evidence that pretransplantation cigarette smoke exposure in the donor, recipient, or both accelerates the demise of the cardiac allograft. Importantly, our series of experiments reveal that the chain of deleterious events begins with inflammation and oxidative stress in the pretransplantation period of smoking exposure, which results in activation of molecular alloimmune pathways after transplantation, subsequently leading to accelerated cellular rejection, vascular inflammation, and graft loss with shortened allograft survival. Thus, it is possible to speculate that this cascade of events can be interrupted at the time of transplantation with focused pharmacological intervention in the antiinflammatory and antioxidant pathways. Thus, in addition to cessation of tobacco exposure, use of pharmacological agents such as n-acetyl cysteine (an antioxidant) or statin drugs (antiinflammatory drugs) could prove useful in inhibiting these adverse responses. These require independent study and verification and should be considered only hypothesis generating. Our studies also uniquely demonstrate that the adverse effects of cigarette smoking stem not only from the smoke exposure to the recipient smoker but also from donor smoke exposure to the organ transplanted, which maybe equally harmful to eventual allograft survival.

Conclusions: These sentinel findings confirm that tobacco smoke exposure in either donors or recipients leads to accelerated allograft rejection, vascular inflammation, and graft loss. Molecular pathways that intersect as arbiters in this phenomenon include instigation of alloimmune activation associated with tobacco smoke-induced inflammation.³³

Omega-3 Fatty Acid Supplementation Does Not Reduce Risk of Atrial Fibrillation After Coronary Artery Bypass Surgery: A Randomized, Double-Blind, Placebo-Controlled Clinical Trial

Summary: Omega-3 poly unsaturated fatty acids (n-3 PUFA) of marine origin (fish oils) have been shown to reduce the risk of

sudden cardiac death after myocardial infarction. This has evoked considerable interest in the possible antiarrhythmic effects of n-3 PUFA. Animal experiments have shown several potential antiarrhythmic properties of n-3 PUFA; however, clinical studies on ventricular arrhythmias have shown mixed results. Atrial fibrillation (AF) is a common arrhythmia and is associated with increased morbidity and mortality. Drug therapy of AF is limited, mainly because of the proarrhythmic properties of most antiarrhythmic agents, and there is a need to identify safe and effective drugs. Epidemiological studies evaluating the benefit of dietary fish intake on the risk of developing AF have shown conflicting results, but 1 clinical trial with open-label n-3 PUFA supplementation for a short duration has reported considerable reduction in the incidence of AF after coronary artery bypass surgery. This, if supported by further studies, would open a new therapeutic option in the management of AF. Hence, we addressed this question in the same subset of patients with a more stringent trial design and robust monitoring of primary outcome of postoperative AF. In our study, we have shown that there is no benefit with n-3 PUFA supplementation and that there may be a trend toward increased AF in the n-3 PUFA-treated group. Hence, we believe that larger clinical trials are needed to assess the risk and benefit of n-3 PUFA therapy in various forms of AF seen in clinical practice.

Conclusions: Omega-3 PUFA do not reduce the risk of AF after coronary artery bypass graft surgery.³⁴

Noncardiac Surgery and Bleeding After Percutaneous Coronary Intervention

Summary: The clinical decision on whether to implant a bare-metal or drug-eluting stent during percutaneous coronary intervention is influenced by the perceived likelihood of the patient developing stent thrombosis and is increased in patients having noncardiac surgery or developing bleeding. Using hospital discharge coding, we found that one quarter of patients will undergo noncardiac surgery, and almost one tenth will have significant bleeding during the next 5 years. Half of the bleeding was gastrointestinal and represents the rate in patients taking aspirin alone rather than aspirin and clopidogrel. Increasing age was a strong predictor of both noncardiac surgery and of bleeding. Other predictors of noncardiac surgery and bleeding were a previous history of these events, respectively. Patients with renal failure also had an increased likelihood of both events. Knowledge of these predictors should help clinicians better match the stent to the patient.

Conclusions: Noncardiac surgery is required frequently after PCI, whereas bleeding is less common. Before implanting a drug-eluting or bare-metal stent, individual patient risk stratification by the interventional cardiologist should include assessment of whether there is an increased likelihood of needing noncardiac surgery or developing bleeding.³⁵

Operative and Middle-Term Results of Cardiac Surgery in Nonagenarians: A Bridge Toward Routine Practice

Summary: Extending life expectancy in the population is expected to determine an increase in the number of elderly patients affected by heart disease; therefore, nonagenarians with heart disease susceptible to surgical treatment will represent an expanding clinical and ethical problem. A large series (127 cases) of very elderly individuals (mean age, 92 years) who underwent cardiac operation (either coronary, valvular, or combined surgery) is reported, including a mean 3.6-year follow-up period (maximum, 5 years). Operative mortality was 13.4%, the postoperative course was complicated in 54 cases, and 5-year survival was 51.2%. Nonelective timing predicted both operative mortality and occurrence of complications in the immediate postoperative period. Functional status was improved among follow-up survivors in comparison with the preoperative period. Data indicate that very elderly patients should not be prejudicially denied surgery on the basis of chronological age itself. The practice of cardiac operations among these candidates is supported, provided

that they are strictly selected and that the operation is conducted electively. All of the following factors must be taken into account: functional status at the time of operation; general physiological condition (the Duke Activity Status Index is a reliable tool, in our experience); careful evaluation of comorbidities; familial environment; and personal motivation to undergo surgery. Patients expected to undergo combined coronary and valvular surgery should not be considered to have a significantly increased surgical risk.

Conclusions: Although the rate of postoperative complications remains high, cardiac surgery in nonagenarians can achieve functional improvement at the price of considerable operative and follow-up mortality rates. Cardiac operations in these very elderly subjects are supported if appropriate selection is made and if the operation is performed earlier and electively. Our results should contribute to the development of guidelines for cardiac operations in nonagenarians.³⁶

Increasing Long-Term Major Vascular Events and Resource Consumption in Patients Receiving Off-Pump Coronary Artery Bypass: A Single-Center Prospective Observational Study

Summary: Worldwide, ≈1 million patients undergo coronary artery bypass grafting procedures each year. Off-pump procedures, which involve performing anastomoses on a beating heart, have gained in popularity over the last decade. A rising trend in off-pump surgery volume is seen in developing countries such as China and India. In sharp contrast to the experience in the United States, where off-pump surgery accounts for ≈20% of all coronary artery bypass grafting procedures, two thirds are performed with this technique in China. Unfortunately, substantial uncertainties remain about the long-term outcomes. A number of studies have addressed this issue, but several inadequacies exist in the currently available literature. First, besides mortality, long-term adverse events that are important from a healthcare point of view are less frequently documented. Second, studies with long-term follow up are needed. Finally, analyses of resource use are still lacking. Therefore, more evidence is needed to guide surgeons in making decisions for patients undergoing coronary artery bypass graft.

Conclusions: Compared with conventional CABG, off-pump coronary artery bypass is associated with small short-term gain but increased long-term risks of repeat revascularization and major vascular events, especially among high-risk patients. Moreover, OPCAB consumes more resources and is less cost-effective in the long run.³⁷

Outcomes of Endovascular Repair of Ruptured Descending Thoracic Aortic Aneurysms

Summary: Thoracic endovascular aortic repair has recently offered a less invasive approach, compared with traditional open surgical repair, for the management of ruptured descending thoracic aortic aneurysms. Due to the low incidence, the exact outcome of endovascular management of this emergency is not well known. In the present multicenter study, we found that endovascular repair of ruptured descending thoracic aortic aneurysms was associated with encouraging results, which appeared to be superior to the historic results of open repair. An increased mortality was observed after endovascular management of patients with hypovolemic shock and/or hemothorax at presentation. During follow-up, the incidence of endograft-related complications such as endoleak was considerable, and several patients died as a result of an infected endograft. The findings of the current study suggest that a preferential endovascular approach for the management of ruptured descending thoracic aortic aneurysms may be appropriate; however, it emphasizes the need for continued surveillance during follow-up and perhaps improvement of current endovascular devices.

Conclusion: Endovascular repair of ruptured descending thoracic aortic aneurysms is associated with encouraging results. The endovascular approach was associated with considerable rates of neuro-

logical complications and procedure-related complications such as endoleak.³⁸

Prevalence and Variability of Internal Mammary Artery Graft Use in Contemporary Multivessel Coronary Artery Bypass Graft Surgery: Analysis of the Society of Thoracic Surgeons National Cardiac Database

Summary: Use of an internal mammary artery (IMA) is a well-recognized, nationally endorsed quality indicator for evaluating the process of operative care for coronary artery bypass graft surgery. This study assesses the current status of IMA use, the association of hospital volume and IMA use, and disparities in IMA use by patient gender and race and by region of hospital location. These findings highlight the variability of IMA graft use by hospitals, the infrequent use of bilateral IMA, and the disparity of IMA use by gender and race. Frequency of IMA use in coronary artery bypass graft surgery is increasing; however, many patients still do not receive the benefits of IMA grafts, and some hospitals have a very low IMA use rate. Hospital volume is not associated with IMA use in coronary artery bypass graft surgery. Analysis of this critical performance measure also reveals significant gender and race disparities.

Conclusions: Frequency of IMA use in coronary artery bypass graft surgery is increasing; however, many patients still do not receive the benefits of IMA grafts, and some hospitals have a very low IMA use rate. Hospital volume is not associated with IMA use in coronary artery bypass graft surgery. Analysis of this critical performance measure reveals significant gender and race disparities.³⁹

Corticosteroids and Outcome in Children Undergoing Congenital Heart Surgery: Analysis of the Pediatric Health Information Systems Database

Summary: Children undergoing congenital heart surgery often receive corticosteroids with the aim of reducing the inflammatory response after cardiopulmonary bypass; however, the value of this approach is unclear. Using the Pediatric Health Information Systems Database, we evaluated outcomes associated with corticosteroids in a multicenter cohort of >40 000 children undergoing congenital heart surgery from 2003 to 2008. We were unable to demonstrate a significant benefit associated with corticosteroids and found that corticosteroids may be associated with increased morbidity, particularly in lower-risk patients. These data indicate the need for an adequately powered clinical trial in high-risk patients to evaluate the efficacy and safety of corticosteroids in this population. Further analysis focusing on the potential impact of different dosing regimens and timing of corticosteroid administration relative to surgery may help to inform the design of a future trial.

Conclusion: In this observational analysis of children undergoing congenital heart surgery, we were unable to demonstrate a significant benefit associated with corticosteroids and found that corticosteroids may be associated with increased morbidity, particularly in lower-risk patients.⁴⁰

Development and Evaluation of a Novel Solution, Somah, for the Procurement and Preservation of Beating and Nonbeating Donor Hearts for Transplantation

Summary: Organ donation is limited by the number of organs available for transplantation, with organs being derived largely from brain-dead, beating heart donors. In addition, the length of storage continues to be a limiting factor with currently available solutions and devices, and the viability of stored organs and their cellular

substructures, even within currently accepted storage timeframes, may be compromised. In the case of heart transplantation, hearts must be transplanted within 4 to 6 hours of harvesting, thereby severely restricting the number of organs harvested for transplantation. A new capability to harvest organs from nonbeating heart donors could open up a new paradigm in transplant medicine. Use of Somah solution should enable the resuscitation of an arrested heart within 60 minutes of the arrest. Thus, it will make available a much larger donor pool, considering that patients dying in the emergency room as a result of noncardiac trauma can become potential heart donors. By increasing the number of available organs, one can increase the number of hearts for candidates on the waiting list and offer hearts to patients who are not currently considered for transplantation. Besides the extension of storage times beyond current conventions, hearts stored in Somah solution show complete preservation of coronary endothelial cells. Considering that 40% to 50% of late rejection of the donor heart occurs in the presence of new and accelerated arteriosclerosis, it is likely that Somah solution will have a significant impact on prolonging the life of patients after cardiac transplantation.

Conclusions: The Celsior preservation solution in clinical use today has led to a profound decline in cardiomyocyte and endothelial cell viability, whereas the newly designed Somah solution has safeguarded myocyte and endothelial integrity and function during organ storage. Use of Somah as a storage medium may lead to optimized graft function and long-term patient survival after transplantation.⁴¹

Importance of Refractory Pain and Hypertension in Acute Type B Aortic Dissection: Insights From the International Registry of Acute Aortic Dissection (IRAD)

Summary: Medical management is generally recommended for patients with uncomplicated acute type B aortic dissection (ABAD), whereas invasive treatment such as surgical or endovascular approaches is typically recommended for ABAD patients with complications such as malperfusion syndromes, extending dissection, or aortic rupture, who are defined as high risk. The optimal approach for uncomplicated ABAD patients who develop recurrent/refractory pain or refractory hypertension is still being debated. We used data from the International Registry of Acute Aortic Dissection to better define the importance of refractory pain and/or refractory hypertension in ABAD. We found that in uncomplicated ABAD patients, medical therapy was associated with excellent outcomes, whereas the in-hospital mortality was considerably increased in those ABAD patients with refractory pain and/or refractory hypertension, especially when these patients underwent medical management. These observations suggest that ABAD patients presenting with refractory hypertension and/or pain symptoms in the absence of other complications are at intermediate risk for an adverse in-hospital outcome but still have a better outcome than the high-risk group. More invasive treatment, such as an endovascular approach, may be indicated in this intermediate-risk group.

Conclusions: Recurrent pain and refractory hypertension appeared as clinical signs associated with increased in-hospital mortality, particularly when managed medically. These observations suggest that aortic intervention, such as via an endovascular approach, may be indicated in this intermediate-risk group.⁴²

Novel Small Interfering RNA-Containing Solution Protecting Donor Organs in Heart Transplantation

Summary: The present study provides a framework for development of a clinically applicable ex vivo method of modifying organ grafts to decrease immunogenicity. These findings support further investigation into the feasibility of large-organ manipulation through the perfusion method. Current organ storage solutions have the limitation of providing physical protection from hypothermia-associated

changes but do nothing to inhibit ischemia/reperfusion injury or the ensuing rise in immunogenicity. By demonstrating that gene silencing can be induced in the context of this clinically applicable scenario, we can develop new targets and approaches to improve graft quality before replantation, which would expand the use of marginal donors and increase organ transportation time.

Conclusion: Incorporation of siRNA into organ storage solution is a feasible and effective method of attenuating ischemia/reperfusion injury, protecting cardiac function, and prolonging graft survival.⁴³

Spectrum and Outcome of Reoperations After the Ross Procedure

Summary: Although this manuscript deals with a topic that is surgical in nature, it also provides valuable information to cardiologists, because they are involved in the preoperative consultation and the long-term follow-up of patients being considered for the Ross procedure. The Ross procedure is performed for aortic valve disease and is offered to patients in all age groups: infants, children, and adults. The operation is palliative, and the need for reintervention (percutaneous or surgical) over a lifetime is inevitable for the majority of patients. This study represents the largest reported series of patients undergoing reoperation after the Ross procedure to date. Although literature is available that quantifies the incidence of reoperation after the Ross procedure, there are no published reports that address the qualitative nature and risks associated with reoperation when it is required. This manuscript provides that “missing” information so the clinician can properly counsel patients not only about the potential need for reoperation but also about the nature of the reoperation when it is necessary.

Conclusions: A broad spectrum of complex reoperations may be required after the Ross procedure. Patients and family members considering the procedure should be informed of the potential for associated morbidity should reoperation be necessary.⁴⁴

Model for End-Stage Liver Disease Score Predicts Left Ventricular Assist Device Operative Transfusion Requirements, Morbidity, and Mortality

Summary: Bleeding after implantation of a left ventricular assist device (LVAD) is associated with increased mortality and an increased risk for several morbidities that can affect a patient's quality of life on LVAD therapy and candidacy for future cardiac transplantation. Causes for perioperative bleeding in LVAD patients are often multifactorial. Identifying patients at high risk for perioperative LVAD bleeding would assist with LVAD candidate risk stratification and may offer the potential for improving LVAD outcomes by triggering clinicians to institute therapies in the preoperative period directed at reducing bleeding risk. The present study uses the Model for End-Stage Liver Disease in the LVAD preoperative period to assess patient risk for perioperative bleeding, morbidity, and mortality.

Conclusion: The MELD score identified left ventricular assist device candidates at high risk for perioperative bleeding and mortality.⁴⁵

A Prospective 1-Year Study of Changes in Neuropsychological Functioning After Implantable Cardioverter-Defibrillator Surgery

Summary: Acute neuropsychological impairments have been established after implantable cardioverter-defibrillator implantation and are related to length of cerebral arrest during ventricular fibrillation testing. Until now, deficits have not been previously shown in the longer term; however, our study demonstrated significant cognitive deficits in auditory and visual memory recall, attention, and executive frontal lobe functions (planning, organizing, and reasoning) in a

varied pattern up to 12 months after surgery. Up to 40% of patients had deficits from 6 weeks to 12 months after surgery, with 10% developing late-onset deficits only at 12 months. Deficits were not related to cardiac diagnoses, postoperative shock frequency, mood, and quality of life. Follow-up care should reflect on the impact of subtle cognitive deficits and their implications to both clinical care and patient adjustment. Memory and attention deficits will impair retention, recall, and application of medical consultations, which may lead to nonintentional nonadherence to necessary lifestyle changes and medication management with possible consequential effects on clinical deterioration. A decline in executive functions requiring planning and organization of thinking and problem-solving skills will lead patients to become avoidant and less proactive in their coping of overcoming the challenges of living with an implantable cardioverter-defibrillator, resulting in a decline in their psychological adjustment. Preparing patients for possible deficits after surgery (which happens with other cardiac populations), is useful to normalize patients' rehabilitation and reduce anxieties about changes. Screening patients and referring them on for further testing will help to facilitate treatment interventions to maximize outcomes after surgery.

Conclusions: ICD implantation is associated with neuropsychological impairment that dissipates for the majority of recipients after 12 months. Short-term memory function and attention are particularly vulnerable to changes in oxygen during ICD testing. Although anxiety and depression are prevalent, there is little evidence for the direct impact of mood on cognition, and deficits appear not to be associated with reduced quality of life. These results provide evidence for longitudinal outcomes of ICD surgery and have implications for patient rehabilitation and adjustment.⁴⁶

Variation in the 4q25 Chromosomal Locus Predicts Atrial Fibrillation After Coronary Artery Bypass Graft Surgery

Summary: Atrial fibrillation (AF) is the most frequently occurring arrhythmia both in ambulatory and postcardiac surgical patients and is associated with significant morbidity. There is strong evidence for the heritability of ambulatory AF and variation in potassium and sodium channel genes has been associated with AF in ambulatory populations. However, these mutations are rare and predominantly limited to family kindreds. Recently, common variants in the 4q25 chromosomal locus have been strongly associated with AF in Caucasian and Chinese ambulatory cohorts. The association of the 4q25 variants with postoperative AF has yet to be elucidated. We found that genetic variants in the 4q25 locus are also independently associated with postoperative AF after cardiac surgery. The addition of genotype information to a clinical model that derives risk class for development of postoperative AF improves overall prediction by correctly reclassifying 7.3% of patients, although at the cost of incorrectly reclassifying 5.4% of patients. The commonality of variants associated with both ambulatory and postoperative AF argue strongly for a common biological mechanism. These findings delineate an important genetic role in the etiology of postoperative AF.

Conclusions: In 2 independently collected cardiac surgery cohorts, noncoding SNPs within the chromosome 4q25 region are independently associated with postoperative AF after coronary artery bypass graft surgery after adjusting for clinical covariates and multiple comparisons.⁴⁷

Anterior Mitral Leaflet Curvature During the Cardiac Cycle in the Normal Ovine Heart

Summary: Anterior mitral leaflet (AML) curvature dynamic changes are of primary importance for optimal left ventricular filling and emptying. Mitral leaflet curvature has been described in the closed position; however, dynamic leaflet curvature has not been characterized. With the increasing use of mitral valve repair techniques that substantially perturb the mitral leaflets (surgical or percutaneous

edge-to-edge repair techniques), data describing the 3-dimensional geometry and curvature of the mitral leaflets throughout the cardiac cycle are needed. This in vivo ovine experiment used 4-dimensional tracking of a dense AML marker array coupled with a novel method of surface subdivision to quantify the changes in AML curvature. The septal-lateral curvature of the AML along the septal-lateral meridian was similar across the belly region at midsystole and early diastole; however, the commissure-commissure curvature of the commissure-commissure meridian changes, with the belly being convex to the left atrium at midsystole and concave at maximal valve opening. These findings suggest that the strut chordae may serve not only as anchors to preserve systolic and diastolic AML shape but also as hinge points for AML shape changes along the commissure-commissure meridian. Alteration of the shape of the leaflet could affect diastolic left ventricular filling and theoretically increase leaflet stresses during systole. These data suggest that the natural curvature of the AML produces optimal inflow and outflow shapes of the AML and should be preserved during catheter or surgical repair interventions.

Conclusions: While the septal-lateral curvature of the AML along the SL AML meridian is similar across the belly region at midsystole and early diastole, the commissure-commissure curvature of the AML along the M_{CC} flips, with the belly being convex to the left atrium at midsystole and concave at maximal valve opening. These curvature orientations suggest optimal left ventricular inflow and outflow shapes of the AML and should be preserved during catheter or surgical interventions.⁴⁸

Effects of Mitral Valve Surgery on Myocardial Energetics in Patients With Severe Mitral Regurgitation

Summary: Hemodynamically significant mitral regurgitation (MR) may alter left ventricular (LV) myocardial energy requirements. The effects of MR and subsequent corrective mitral valve (MV) surgery on myocardial energetics are not well understood. A better understanding of myocardial energetics and the LV responses to changes in preload and afterload may assist with the understanding of MR and its effect on the LV. We sought to determine the effects of MV surgery on forward stroke work, myocardial oxidative metabolism, and myocardial efficiency. Prospectively enrolled patients with chronic, severe, nonischemic MR underwent echocardiography, radionuclide angiography, and C-11 acetate positron emission tomography to measure LV volumes, ejection fraction, oxidative metabolism, and work metabolic index before and 1 year after MV surgery. One year after MV surgery, there was a reduction in LV end-diastolic and end-systolic volumes, preservation of LV ejection fraction, and a conservation of total work metabolic index.

Conclusions: MV surgery has a beneficial effect on forward stroke volume and forward work metabolic index without adverse effects on oxidative metabolism or total work metabolic index.⁴⁹

Increasing Healthcare Resource Utilization After Coronary Artery Bypass Graft Surgery in the United States

Summary: Using a large national database, we found that there was a decrease in hospital stay after CABG surgery with a concurrent increase in discharges with extended healthcare facility requirements. This trend was consistent across the entire period of our study, from 1988 to 2005. Despite improving in-hospital indicators of morbidity and mortality, postdischarge resource utilization continues to increase after CABG surgery. Because nonroutine discharges are now common after CABG surgery, our study highlights the need to consider discharge disposition in any investigation of resource utilization after CABG surgery.

Conclusions: We found a significant increase in nonroutine discharges after CABG surgery across the United States from 1988 to

2005. The significant shortening of length of stay during CABG may be counterbalanced by the increased requirement for additional postoperative healthcare services. Nonacute care institutions are playing an increasingly significant role in providing CABG patients with postdischarge healthcare and should be considered in investigations of postoperative healthcare resource utilization. The impact of these changes on long-term outcomes and net resource utilization remain unknown.⁵⁰

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