EXPERT REVIEW

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Recent Advances in Perioperative Medicine: Highlights From the Literature for the Cardiothoracic and Vascular Anesthesiologist

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There have been major advances in perioperative cardiothoracic and vascular medicine. Because of promising data, steroids, statins, and endothelin antagonists are being clinically tested in randomized trials with adult cardiac surgical patients. In vascular surgical patients, recent meta-analysis has revealed that interventions such as β-blockade or endovascular stenting for peripheral vascular lesions may not improve outcome overall. Furthermore, a landmark trial has shown that anesthetic technique does not affect outcome after carotid endarterectomy. The surgical Apgar score may become part of routine clinical care of the vascular surgical patient because it predicts outcome and can be calculated at the bedside. Recent studies confirm that the serious perioperative risks of hyperglycemia also apply to nondiabetic and pediatric cardiac surgical patients. This has been highlighted in the new guidelines from the Society of Thoracic Surgeons. Perioperative myocardial protection is possible with ischemic preconditioning and omega-3 fatty acids. Pneumonia after lung resection may be reduced significantly by broadening antibiotic prophylaxis. Transfusion-related acute lung injury has immediate and delayed presentations that highlight the dangers of blood transfusion. Perioperative renal dysfunction after adult cardiac surgery is significantly reduced by the infusion of sodium bicarbonate. Although promising, further trials are required. Taken together, these recent advances will have significant influence on the future practice of cardiovascular and thoracic anesthesia as the ongoing search for perioperative outcome improvement achieves results.

KEY WORDS: steroids, statins, endothelins, insulin, β-blockers, surgical Apgar score, pneumonia, sodium bicarbonate, renal dysfunction, transfusion

THERE HAS BEEN SIGNIFICANT recent progress in perioperative medicine related to cardiothoracic and vascular disease. Based on recent meta-analysis, steroids and statins are ready for evaluation by randomized controlled trials in adult cardiac surgery designed to detect effects on important clinical outcomes. Furthermore, because of crosstalk with proinflammatory cytokines such as tumor necrosis factor (TNF), endothelins recently have been targeted for pharmacologic blockade to improve cardiac surgical outcomes.

In vascular surgical patients, recent meta-analysis has revealed that perioperative β-blockade may not improve outcome overall. A landmark multicenter randomized controlled trial (RCT) documented that local anesthesia, as compared with general anesthesia, made no difference in outcome after carotid endarterectomy. In peripheral vascular disease, endovascular stenting may not offer a major advantage over simple balloon angioplasty. For all vascular surgical patients, perioperative risk now can be readily estimated by the surgical Apgar score, a simple scoring system that can be calculated at the bedside.

There has been ongoing discovery related to the morbidity and mortality associated with perioperative hyperglycemia in cardiac surgical patients. Recent observational studies confirm that these risks apply to nondiabetics and pediatric patients. The importance of perioperative glucose control in cardiac surgical patients has been highlighted in the new guidelines from the Society of Thoracic Surgeons.

There have been multiple advances in perioperative organ protection. Perioperative myocardial protection is possible not only with ischemic preconditioning but also omega-3 fatty acids. Pneumonia after lung resection may be reduced significantly by targeting bacterial colonizers of the bronchial tree with appropriate perioperative antibiotic prophylaxis. The definition of transfusion-related acute lung injury has been revised to recognize acute and delayed presentations; this highlights the dangers of blood component transfusion. Furthermore, pilot RCTs show that perioperative renal dysfunction after adult cardiac surgery is significantly reduced by the infusion of sodium bicarbonate.

These studies, taken together, offer major advances in cardiothoracic and vascular anesthesiology with respect to patient care, future research, and education at all levels within the specialty. The selected studies for this update on perioperative cardiovascular medicine are now reviewed in detail to highlight the advances summarized in this introduction.

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MODIFICATION OF THE PERIOPERATIVE INFLAMMATORY RESPONSE IN CARDIAC SURGERY

Perioperative Steroids

Cardiopulmonary bypass (CPB) uniformly induces a systemic inflammatory response syndrome (SIRS) because of antigen exposure, nonpulsatile blood flow, and ischemia-reperfusion.[1] Although steroid therapy attenuates the SIRS secondary to CPB, it has not gained widespread clinical acceptance because of multiple limitations with the evidence to date including surrogate endpoints, limited safety data, and insufficient statistical power.[2,3] Consequently, a systematic review and meta-analysis was recently performed to determine the efficacy and safety of steroids in cardiac surgery with CPB.[4] The authors included 44 RCTs (cumulative N = 3,205: 1997-2007).[4] The selected trials all examined steroids in adults undergoing cardiac surgery with CPB; they all had a control group design and a priori specified clinical endpoints. Trial quality was quantified by 2 independent examiners with the Jadad score for RCTs.[4,5] The Jadad score is a validated 5-point scale (0-2: poor quality; 3-4: good quality; and 5: excellent quality) that grades RCT design features such as randomization, blinding, and dropout reporting.[5] Publication bias within the selected trials was evaluated with funnel plot analysis. The median sample size for each RCT was 51 (range, 13-295). The RCTs included patients undergoing coronary artery bypass and/or valve procedures. The steroid protocols varied in duration and drug type. Steroid exposure significantly reduced atrial fibrillation (relative risk = 0.71; 95% confidence interval, 0.59-0.87), postoperative bleeding (weighted mean difference = 99.6 mL; 95% confidence interval, −149.8 to −49.3), intensive care unit stay (weighted mean difference = −0.23 days; 95% confidence interval, −0.40 to −0.07), and hospital stay (weighted mean difference = −0.59 days; 95% confidence interval, −1.17 to −0.02). There was also a trend toward a reduction in mortality (relative risk = 0.73; 95% confidence interval, 0.45-1.18). No major adverse clinical outcomes because of steroids were evident in this meta-analysis.

The authors concluded that the current evidence still does not exclude adverse effects of steroids in adult cardiac surgery with CPB, especially because these effects may be dose-dependent.[5] Furthermore, the optimal steroid protocol in terms of steroid type, dosing regimen, and duration still remains to be defined. Because this meta-analysis has identified major clinical benefits from attenuating the SIRS response to CPB with steroids, adequately powered RCTs are now indicated.

There are currently at least 2 registered steroid RCTs in adult cardiac surgery with CPB. The SIRS RCT (Steroids In CaRdiac Surgery Study) is evaluating methylprednisolone in adult cardiac surgery with CPB (details available at www.clinicaltrials.gov with study number NCT00427388). The second RCT is testing dexamethasone in adult cardiac surgery with CPB (details available at www.clinicaltrials.gov with study number NCT00293592). These 2 RCTs are currently in progress and plan to enroll more than 14,000 subjects. Their endpoints are important clinical outcomes such as mortality and major organ-based complications. They will most likely determine the future of prophylactic steroids in adult cardiac surgery with CPB.

Perioperative Statins

Therapy with inhibitors of 3-hydroxyl-3-methylglutaryl-coenzyme A reductase (statins) has been shown to prevent the progression of coronary artery disease.[6] Furthermore, statins have multiple pleiotropic effects that may improve perioperative outcome after cardiac surgery, including attenuation of SIRS.[7] These beneficial effects may benefit adult cardiac surgical patients with and without coronary artery disease.[8-10] A meta-analysis of statin trials in cardiac surgery was recently undertaken to assess the type and magnitude of outcome effects caused by statin exposure in adult cardiac surgery.[11]

In this meta-analysis, a systematic review of the literature identified 19 suitable studies (cumulative N = 31,725: 3 RCTs and 16 non-RCTs: 1999-2007).[13] Pooling of all the datasets yielded 2 study groups: 54% (N = 17,201) with preoperative statin exposure and 46% (N = 14,524) without preoperative statin exposure. The selected outcome measures were early all-cause mortality, stroke, myocardial infarction, atrial fibrillation, and renal failure. Because this meta-analysis is of an extremely high quality and shows the very best features of this study type, its methodology will be discussed in detail.

The quality of the selected studies was assessed by 2 independent investigators using the Jadad score for RCTs and the Downs and Black checklist for both RCTs and non-RCTs.[4,12] The Jadad score has been explained previously. The Downs and Black tool examines trial features such as reporting (total score = 11), external validity (total score = 3), internal validity bias (total score = 7), internal validity confounding (total score = 6), and power (total score = 2). The highest score of 29 indicates the highest possible methodologic quality.[14]

Publication bias in the selected studies was assessed with funnel plot analysis and Egger regression analysis.[13] For the funnel plot analysis, the treatment effects of each study (expressed as odds ratios) were plotted against a measure of precision for each study (expressed as inverse standard errors). In the absence of publication bias, this plot resembles an inverted symmetric funnel with the less precise studies scattered at the bottom of the plot. Egger regression analysis generates a weighted regression statistic with a p value < 0.05 considered as significant publication bias among the included studies. In the case of this statin meta-analysis, the funnel plot was symmetric, and the Egger statistic had a p value of 0.60. Therefore, according to both methods, there was no significant publication bias. Furthermore, the conduct of this statin meta-analysis was compliant with the guidelines according to the QUOROM (Quality of Reporting of Meta-Analyses) group for RCTs and the MOOSE (Meta-Analysis of Observational Studies in Epidemiology) group for non-RCTs.[13,14]

The main findings of this high-quality meta-analysis are important. Preoperative statin therapy was associated with significant reductions ($p < 0.05$) in mortality (odds ratio = 0.57; 95% confidence interval, 0.49-0.67), stroke (odds ratio = 0.74; 95% confidence interval, 0.60-0.91), and atrial fibrillation (odds ratio = 0.67; 95% confidence interval, 0.51-0.88). Preoperative statins were not protective against myocardial infarction or renal failure after adult cardiac surgery.

The authors concluded that preoperative statins significantly improve multiple clinical outcomes after cardiac surgery. Al-

though their data are compelling, the authors cautioned against empiric statin therapy for all patients scheduled for cardiac surgery until supported by evidence from adequately powered future RCTs. The widespread clinical outcome benefits from the pleiotropic effects of stains might not only revolutionize the practice of anesthesiology with respect to cardiac surgery but also with respect to the intensive care unit where their role in improving outcome in SIRS associated with sepsis is already evident.[15] Indeed, a survey of the National Institutes of Health clinical trials registry revealed at least 7 statin trials in sepsis and at least 16 statin trials in cardiothoracic and vascular surgery (details available at www.clinicaltrials.gov with search terms statins, surgery, and sepsis).

Perioperative Endothelin Blockade

The humoral response to CPB includes the release of endothelins and proinflammatory cytokines, including TNF.[16,17] These bioactive molecules have been linked to adverse perioperative outcome.[18,19] Because endothelins have diverse cardiovascular effects mediated through α-receptors (vasoconstriction) and β-receptors (negative inotropy), endothelin blockers (the "suntans") have been developed for cardiovascular intervention (eg, nonselective blocker bosentan and α-blockers sitaxsentan and ambrisentan for the management of pulmonary arterial hypertension).[20] Since cross-talk occurs between the endothelin-α-receptors and TNF, a recent clinical study tested the biologically important hypothesis that endothelin-α-receptor blockade would affect the TNF response elicited by exposure to CPB during adult cardiac surgery.[21] If this hypothesis is correct, then the possibility exists that perioperative outcome benefits from endothelin blockade may be amplified through TNF inhibition. In this RCT, adult cardiac surgical patients were randomized (N = 44) to placebo or endothelin-α-receptor blockade with sitaxsentan on separation from CPB.[21] The major finding was that in the presence of endothelin-α-blockade, TNF activation was significantly suppressed at 24 hours. Furthermore, this suppression of TNF was dose-dependent with higher doses of sitaxsentan associated with greater TNF suppression. This RCT has shown a potentially important clinical interaction between endothelin and cytokine pathways after CPB. Further trials should be adequately powered to determine whether endothelin blockers such as sitaxsentan significantly improve outcomes after cardiac surgery with CPB.

Interestingly, endothelin-α-receptor activity is significantly upregulated in patients with aortic stenosis, promoting inflammation and fibrosis of aortic valve leaflets.[22] Just as is the case with statins, endothelin blockade should be evaluated as a medical intervention to prevent or slow the progression of aortic valve stenosis.[22,23]

PERIOPERATIVE PRACTICE IN VASCULAR SURGICAL PATIENTS

According to recent guidelines by the American College of Cardiology and American Heart Association, perioperative β-blockade is recommended for vascular surgery, even though several recent RCTs do not support this guideline.[24-26] For example, in the recently published landmark POISE (PeriOperative ISchemic Evaluation) RCT, perioperative metoprolol was associated with a 30% drop in nonfatal myocardial infarction but at the expense of a 33% rise in perioperative mortality and a 117% rise in stroke.[26] In an effort to understand the cumulative evidence from multiple RCTs of β-blockade in noncardiac surgery including vascular surgery, a recent systematic review and meta-analysis was performed and published.[27]

The authors performed a systematic literature review and identified 33 suitable RCTs (N = 12,306).[27] Their pooled analysis showed that β-blockade did not significantly decrease perioperative mortality, cardiovascular mortality, or heart failure. Although β-blockade significantly decreased myocardial infarction (odds ratio = 0.65; 95% confidence interval, 0.54-0.79) and myocardial ischemia (odds ratio = 0.36; 95% confidence interval, 0.26-0.50), it significantly increased perioperative stroke (odds ratio = 2.01; 95% confidence interval, 1.27-3.68). They showed that the perioperative benefits of β-blockade were mostly derived from trials with a high risk of bias. They also showed significant harm from hypotension and bradycardia secondary to β-blockade. The authors of this meta-analysis concluded that the cumulative evidence to date does not support perioperative β-blockade for outcome enhancement in noncardiac surgery, including vascular surgical patients.

Besides perioperative blockade, another controversy in vascular surgery has been whether perioperative outcome after carotid endarterectomy depends on anesthetic technique. The landmark GALA (General Anesthesia versus Local Anesthesia) RCT randomized 3,526 patients for carotid endarterectomy (95 medical centers in 24 countries: 1999-2007) to local (n = 1,773) versus general (n = 1,753) anesthesia.[28] The defined primary outcome was the percentage of patients with stroke, myocardial infarction, or death up to 30 days after surgery. This clinical composite endpoint was not significantly different between patients exposed to general versus local anesthesia (4.8% *v* 4.5%, $p > 0.05$). The authors concluded that because anesthetic technique did not affect clinical outcome, the choice of anesthetic technique should be based on a discussion among the patient, surgeon, and anesthesia team.

In most vascular beds, including the carotid and coronary systems, endovascular stenting is recommended above angioplasty alone for optimal endovascular revascularization. However, in the femoropopliteal arterial system, it is still not clear whether routine stenting is superior to angioplasty alone, despite multiple RCTs. To clarify this important question, a meta-analysis of all relevant RCTS was undertaken.[29] The authors included 10 RCTs (724 stenting and 718 angioplasty only) with follow-up periods in the range of 9 to 24 months. They found that angioplasty alone was associated with a higher immediate technical failure (17.1% *v* 5.9%; relative risk = 0.28; 95% confidence interval, 0.15-0.54; $p < 0.001$); 10.3% of angioplasty patients underwent stenting to improve the technical success of immediate revascularization. Although there was a trend for a lower rate of stenosis associated with stenting (37.6% *v* 45.3%; relative risk = 0.85; 95% confidence interval, 0.69-1.06; $p = 0.15$), there was no difference in target vessel revascularization (20% *v* 20.2%; relative risk = 0.98; 95% confidence interval, 0.78-1.23; $p = 0.89$). The authors concluded that although stenting had a higher immediate technical success, they could not recommend it as a routine alternative to angioplasty alone based on the evidence from RCTs to date.

The research with β-blockade, the anesthesia technique, and the type of endovascular intervention in vascular surgical patients are all aimed at improving perioperative outcomes in this high-risk surgical population. Although complex risk models such as the Acute Physiology and Chronic Health Evaluation Score adequately predicts risk of perioperative complications, they are not in routine clinical practice because they are not easily determined at the bedside and often require data elements that are not routinely collected.[30] Recently, a surgical Apgar score was developed to provide a simple and valid outcome score applicable throughout noncardiac surgery, including vascular surgery.[31] This score is calculated at the end of the surgical operation from the following 3 criteria: estimated blood loss in milliliters (0 = >1,000, 1 = 601-1,000, 2 = 101-600, and 3 ≤100), lowest intraoperative mean arterial pressure in millimeters of mercury (0 = <40, 1 = 40-54, 2 = 55-69, and 3 = ≥70), and lowest intraoperative heart rate in beats per minute (0 = >85 or pathologic bradyarrhythmia, 1 = 76-85, 2 = 66-75, 3 = 56-65, and 4 = ≤55). The final score is the sum of the points from each category.

The surgical Apgar score was recently validated in 4,119 general and vascular surgical patients.[32] There were 1,441 patients with scores of 9 to 10; 5.0% of this group developed major complications, including a 0.1% death rate. There were 128 patients with scores ≤4; 56.3% of this group developed major complications (relative risk = 11.3; 95% confidence interval, 8.6-14.8; $p < 0.001$), including a 19.5% mortality rate (relative risk = 140.7; 95% confidence interval, 33.7-587.4; $p < 0.001$). The surgical Apgar score based on these 3 criteria had a C statistic of 0.73 for major complications and 0.81 for mortality. The authors conclude that this scoring system is a user-friendly, immediate, and objective method for measuring and communicating perioperative outcomes in noncardiac surgery. Because the surgical Apgar score identifies high-risk patients, it may be useful for evaluating perioperative interventions to improve outcomes. Future clinical trials should evaluate interventions in general surgical populations stratified as high risk by the surgical Apgar score.

PERIOPERATIVE HYPERGLYCEMIA AND CLINICAL OUTCOME IN CARDIAC SURGERY

Diabetes mellitus is a known risk factor for adverse clinical outcomes after cardiac surgery.[33] Perioperative diabetes, however, is not limited to known diabetics; the majority of nondiabetics will be hyperglycemic after cardiac surgery in part because of SIRS from surgery and CPB.[34] A recent large single-center observational study investigated the effect of different degrees of hyperglycemia on clinical outcomes in adult cardiac surgical patients whether they were known diabetics or not.[35] The investigators studied 8,727 adult cardiac surgical patients (1996-2004). Based on the highest blood glucose level recorded in the first 60 postoperative hours, glucose control was defined as follows: good (<200 mg/dL), moderate (200-250 mg/dL), and poor (>250 mg/dL). Inadequate blood glucose control was defined as moderate and poor control together. In this large cohort, glucose control was as follows: good in 85%, moderate in 11%, and poor in 4%. The incidence of diabetes in the 3 glucose control categories was as follows: 8% in the good cohort, 31% in the moderate cohort, and 52% in the poor cohort.

Inadequate blood glucose control was significantly associated with in-hospital mortality, myocardial infarction, and pulmonary and renal complications. With respect to mortality, the incidence was as follows: 1.8% in the good group, 4.2% in the moderate group (moderate *v* good control: odds ratio = 1.68; 95% confidence interval, 1.25-2.25), and 9.6% in the poor group (poor *v* good control: odds ratio = 3.90; 95% confidence interval, 2.47-6.15). The investigators concluded that 50% of patients with inadequate blood glucose control perioperatively were not known diabetics. This observation is critical because inadequate glucose control is an independent predictor of in-hospital mortality and morbidity.

The impact of tight glucose control in adult cardiac surgical patients was again highlighted by a recent trial (N = 1,050: control = 305 and insulin therapy = 745) showing that this intervention significantly decreased renal impairment ($p = 0.01$) and renal failure ($p = 0.02$).[36] Postoperative dialysis (3.9% to 0.7%, $p < 0.01$) and mortality (3.6% to 1.2%, $p = 0.02$: a 70% decrease for nondiabetics) decreased significantly.

This powerful outcome association of perioperative hyperglycemia in cardiac surgery also has been established in congenital heart surgery as well (N = 378).[37] This association mandates RCTs of strict glucose control in pediatric heart surgery powered to detect important outcome differences caused by this intervention.

The need for RCTs is important because intensive insulin therapy is not always associated with improved outcomes in critical care medicine.[38] However, a recent RCT showed that intensive insulin therapy reduced mortality (3% *v* 6%, $p = 0.038$) and the incidence of prolonged stay (38% *v* 47%, $p = 0.013$) in the pediatric intensive care unit.[39]

Finally, the Society of Thoracic Surgeons published a guideline on blood glucose management during adult cardiac surgery.[40] This guideline recommends that blood glucose be maintained <180 mg/dL whether patients are known diabetics or not. The full recommendations are presented in a graded format as per the American College of Cardiology and American Heart Association criteria (Classes of Recommendations I, IIa, IIb, and III; Levels of Evidence A, B, and, C: full details of this guideline available at www.sts.org in guidelines section).

ADVANCES IN PERIOPERATIVE ORGAN PROTECTION

Myocardial Protection

Although ischemic preconditioning induces myocardial protection, its effects on clinical outcomes after cardiac surgery remain unresolved because of multiple small clinical trials. A recent meta-analysis was completed to clarify the clinical benefit from intervention.[41] The authors included 22 trials (cumulative N = 933). Ischemic preconditioning was performed after the initiation of CPB before additional myocardial protection such as cardioplegia. Overall, preconditioning significantly reduced ventricular arrhythmias (odds ratio = 0.11; 95% confidence interval, 0.04-0.29; $p = 0.001$) and inotrope requirements (odds ratio = 0.34; 95% confidence interval, 0.17-0.68; $p = 0.002$). These beneficial clinical effects require validation in a large RCT in cardiac

surgery before ischemic preconditioning can be routinely recommended.

Omega-3 fatty acids increasingly have been highlighted for their cardiovascular benefits, including a significant reduction in mortality after myocardial infarction.[42] This finding was confirmed in a recent meta-analysis of 8 RCTs (relative risk = 0.43; 95% confidence interval, 0.20-0.91; cumulative N = 20,997).[43] This survival benefit was also recently shown in a large RCT (N = 6,975) in adults with chronic heart failure (hazard ratio = 0.91; 95% confidence interval, 0.833-0.998; $p = 0.041$).[44]

Consequently, it makes sense to evaluate omega-3 fatty acids for clinical benefit in cardiac surgery. A laboratory study has already shown that acute pretreatment with these agents protects saphenous vein endothelium against leukocyte-induced endothelial injury.[45] There are currently multiple RCTS evaluating omega-3 fatty acids in cardiac surgical patients, targeting clinical endpoints such as myocardial infarction and atrial fibrillation (full details available at www.clinicaltrials.gov with search terms omega-3 fatty acids and cardiac surgery). The results of these RCTs will delineate the clinical niche of these promising agents in cardiac surgical patients.

Pulmonary Protection

Postoperative pneumonia after lung resection is a serious complication because it has a mortality of at least 20%.[46] Although the recommended antibiotic prophylaxis with a second-generation cephalosporin reduces wound infection and empyema, it does not have proven efficacy against pneumonia. As a result, a prospective study was undertaken to compare cephalosporin (n = 168) with amoxicillin-clavunalate (n = 277) prophylaxis in lung resection.[47] Amoxicillin-clavulanate was chosen because it targets bacteria that also typically colonize the bronchial tree. The incidence of postoperative pneumonia was reduced by 45% in the amoxicillin-clavulanate group ($p = 0.0027$), with a decrease in mortality from 6.5% to 2.9% ($p = 0.06$). The authors concluded that targeting bronchial flora with perioperative antibiotic prophylaxis can reduce the incidence of pneumonia and improve outcome. This approach requires further investigation but will most likely lead to a significant revision of antibiotic prophylaxis for lung resection.

The definition of transfusion-related acute lung injury recently has been expanded to include not only the classic but also a delayed syndrome.[48] The classic syndrome is uncommon (1 in 5,000 transfusions) and is caused by an antineutrophil antibody reaction triggered by a single transfused unit. It often has a rapid onset of 2 hours, commonly has a fever, and typically resolves within 48 to 96 hours.

In contrast, the delayed syndrome has a slower onset up to 72 hours after the transfusion of multiple units in patients who have sepsis, burns, or major trauma. The delayed syndrome occurs in about 50% of patients with massive transfusion and rarely is associated with fever. It may progress to fibroproliferative acute respiratory distress syndrome and has a mortality rate of up to 45%.

The treatment of both syndromes is supportive. However, the recent recognition of the delayed syndrome underlies the importance of minimizing blood component transfusion, given its significant mortality and morbidity.

Renal Protection

Sodium bicarbonate therapy is protective against contrast nephropathy.[49] A recent RCT (N = 100) was undertaken to test whether sodium bicarbonate infusion (4 mmol/kg in 24 hours) reduces acute renal dysfunction after adult cardiac surgery with CPB.[50] The authors defined acute renal dysfunction as a >25% increase in plasma creatinine concentration from baseline within the first 5 postoperative days. The infusion of sodium bicarbonate significantly reduced renal injury after cardiac surgery (odds ratio = 0.43; 95% confidence interval, 0.19-0.98; $p = 0.043$). This pilot RCT requires confirmation in larger RCTs in adult cardiac surgery not only for confirmation but to determine associated clinical outcome benefits and more comprehensively explore the safety profile of this intervention. There are at least 3 such RCTs in progress, with goals to collectively recruit approximately 1,000 adult cardiac surgical patients (details available at www.clinicaltrilas.gov with search terms sodium bicarbonate and cardiac surgery). These RCTs will determine the future of nephroprotective sodium bicarbonate infusion in cardiac surgery.

CONCLUSIONS

There have been major recent advances in perioperative cardiothoracic and vascular medicine. Steroids and statins are now being evaluated in RCTS in adult cardiac surgery. Furthermore, endothelin blockade recently has been identified as an opportunity to improve outcome after cardiac surgery with CPB. In vascular surgical patients, recent meta-analysis has revealed that interventions such as perioperative beta-blockade or endovascular stenting in peripheral vascular disease may not improve perioperative outcome overall. Furthermore, anesthetic technique does not affect perioperative outcome after carotid endarterectomy. The surgical Apgar score has major potential to become part of routine clinical care of the vascular surgical patient. Recent observational studies confirm that the serious perioperative risks of hyperglycemia apply to nondiabetics as well as pediatric cardiac surgical patients. The importance of this complication has been highlighted in the new guideline from the Society of Thoracic Surgeons.

Perioperative myocardial protection is possible with ischemic preconditioning and omega-3 fatty acids. Pneumonia after lung resection may be reduced significantly by broadening perioperative antibiotic prophylaxis. Transfusion-related acute lung injury has immediate acute and delayed presentations that both highlight the dangers of blood transfusion. Pilot RCTs show that perioperative renal dysfunction after adult cardiac surgery is significantly reduced by infusion of sodium bicarbonate.

These recent advances will have significant influence on the future practice of cardiovascular and thoracic anesthesia as the ongoing search for incremental perioperative outcome improvement achieves results.

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