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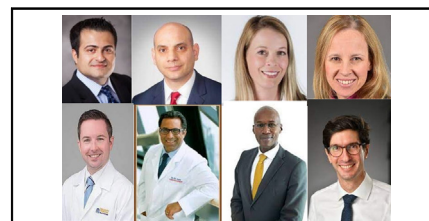
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2021: Perioperative and critical care year in review for the cardiothoracic surgery team

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ABSTRACT

For yet another year, our lives have been dominated by a pandemic. This year in review, we feature an expert panel opinion regarding extracorporeal support in the context of COVID-19, challenging previously held standards. We also feature survey results assessing the impact of the pandemic on cardiac surgical volume. Furthermore, we focus on a single center experience that evaluated the use of pulmonary artery catheters and the comparison of transfusion strategies in the Restrictive and Liberal Transfusion Strategies in Patients With Acute Myocardial Infarction (REALITY) trial. Additionally, we address the impact of acute kidney injury on cardiac surgery and highlight the controversy regarding the choice of fluid resuscitation. We close with an evaluation of dysphagia in cardiac surgery and the impact of prehabilitation to optimize surgical outcomes. (*J Thorac Cardiovasc Surg* 2022; ■:1-8)



Top (left to right): Drs Donahoe, Javidfar, Sanchez, Merritt-Genore, and Roy; bottom (left to right): Drs Teman, Lemaitre, Hayanga, and Arora.

CENTRAL MESSAGE

The most compelling articles of 2021 are reviewed.

PERSPECTIVE

The articles that had the highest impact according to the readership and editorial team are reviewed.

See Commentary on page XXX.

For another year in succession, the practice of cardiothoracic surgery has been plagued by an unrelenting pandemic. Fortunately, the synergistic effects of vaccination and a dip in the virulence of contemporary strains of SARS-Cov-2 have proffered a semblance of comparative if temporary respite. Once again, the *Journal of Thoracic and Cardiothoracic Surgery* offers a distilled expert opinion on the use of

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extracorporeal support in managing the sickest patients afflicted by the virus.¹ In the editorial, the authors challenge the status quo and offer an abbreviated algorithm of care which practical application has been associated with higher survival rates.^{1,2} We also report the results of an analysis of the effect of the pandemic on cardiac surgery volume.^{3,4} Beyond COVID-19 and its effect nevertheless, we also present 6 other articles of import that each resonated with the readership and which are summarized herein. Despite 5 decades of use, the ongoing challenge to the use of pulmonary artery catheters (PACs) rages on with renewed doubt as to the efficacy of use of this invasive monitoring tool.^{2,5,6} The prevention of renal injury and the downstream ramifications of the renal dysfunction are discussed in the context of excess attributable mortality.^{7,8} We also revisit the perennial equipose that underpins blood product transfusion thresholds.^{9,10} In a similar but separate vein, we conclude with a report on the comparison of different choices of resuscitative intravenous fluids, a decades-long dispute that as yet remained unresolved.^{4,11}

Challenging the Status Quo

Extracorporeal Life Support Organization registry data reveal patient survival to decannulation for severe respiratory failure due to COVID-19 requiring extracorporeal

Abbreviations and Acronyms

AKI	= acute kidney injury
AMI	= acute myocardial infarction
ARDS	= acute respiratory distress syndrome
BAL	= balanced solution
BaSICS	= Balanced Solution Versus Saline in Intensive Care Study
ICU	= intensive care unit
KDIGO	= Kidney Disease Improving Global Outcomes
MAKE180	= major adverse kidney events at 180 days
NS	= normal saline
PAC	= pulmonary artery catheter
RRT	= renal replacement therapy

membrane oxygenation (ECMO) of 51%, however associated with wide intercenter variability. Indeed, the use of ECMO has evolved during the pandemic. A team of experts published a consensus that provided timely guidance to the surgical community and steered practices by distilling key knowledge obtained during the care of these patients.¹ Defining candidacy in extracorporeal life support has been an area of controversy. The amalgam of discouraging single-center mortalities >80% and virulent strains, resource scarcity, and fluctuations in capacity and staffing served to complicate the efforts to manage these patients. In this article, a group of experts proffer an intuitive candidacy guide using a points system that includes age, days of mechanical ventilation, and the presence of systemic comorbidities to define the precannulation probability of survival. The practical utility of this simple scoring system can guide family conversations and serve as a “go-no-go” decision tool in the context of strained capacity or staffing conditions. The authors also suggest using ECMO to Rescue Lung Injury in Severe ARDS (EOLIA) trial oxygenation criteria to define when to cannulate (partial pressure of O_2 :fraction of inspired O_2 ratio <50 mm Hg for >3 hours, or <80 mm Hg for >6 hours, or pH < 7.25 with partial pressure of CO_2 > 60 mm Hg for >6 hours).¹²

These EOLIA criteria may be modified and used in combination with the precannulation probability of survival and stress the importance of rapid decision-making. The need for venoarterial ECMO in patients with COVID-19 acute respiratory distress syndrome (ARDS) is very rare, with most patients supported either with a 2-site cannulation strategy or a single-site, dual lumen cannula. A right atrium-pulmonary artery cannulation strategy with a dual lumen cannula has also been proposed with the theoretical benefit of right ventricle support. The drawback of dual lumen cannulation is that fluoroscopy or transesophageal echocardiography for safe placement might not always be

available. The authors also highlight key topics that deserve further investigation, such as the use of systemic steroids, cyto-reductive filters in-line with the ECMO circuit, adjudicating the risk of morbid obesity, and longitudinal effect of the duration of support. The results from the Randomized Evaluation of COVID-19 Therapy (RECOVERY) trial shed some light on the first topic: a daily dose of 6 mg of dexamethasone in hospitalized COVID-19 patients significantly reduced 28-day mortality.⁶ This finding is reflected in the Extracorporeal Life Support Organization registry, in which 82% of patients received glucocorticoids. The use of cytokine reduction by filters incorporated into the ECMO circuit is an area that deserves further investigation. In the Cytokine Adsorption in Patients With Severe COVID-19 Pneumonia Requiring Extracorporeal Membrane Oxygenation (CYCOV), a single-center, open-label and randomized study, outcomes of 17 patients who received ECMO with an in-line cytokine adsorption filter were compared with 17 control participants and showed no differences in survival.¹³ Conversely, a multicenter retrospective registry, CytoSorb Therapy in COVID-19 (CytoSorbents Corp), suggested improved survival in COVID-19 patients who receive ECMO with an in-line cytokine reduction filter however, no control data were presented for adequate comparison.¹⁴ Regarding the length of support, several groups have reported good outcomes in patients undergoing lung transplants for the treatment of COVID-19 ARDS and fibrosis.¹⁵ Early discussions with lung transplant centers, ideally within 3 to 4 weeks of cannulation, should be conducted to better define transplant candidacy and help delineate goals if the patient is considered an adequate lung transplant candidate.

KEY MESSAGE: The use of ECMO in COVID-19 ARDS continues to evolve. Algorithms developed for assessing candidacy and caring for non-COVID-19 ARDS patients should be followed, keeping in mind that patients younger than 50 years old, with single-organ disease, and mechanical ventilation for <3 days have better outcomes.

The Swan Song

PACs have long been used for the management of cardiac surgery patients in the operating room and postoperative intensive care unit (ICU). The purported benefit of using a PAC in the perioperative management of the cardiac surgery patient is to permit the estimation of such physiologic parameters as cardiac output, mixed venous oxygen saturation, and pulmonary artery pressure. Despite the theoretical advantages of monitoring these physiologic parameters, however, contention still exists as to their efficacy. Indeed, multiple studies have failed to show clinical benefit, and in some cases contend that they have been associated with worse outcomes.^{2,3} In one of our top picks for this year in review, Brown and colleagues⁵ performed a propensity matched study and evaluated >7000 patients in a bid to

determine the effect of PAC use in cardiac surgery at a single institution. Patients in whom a PAC was used were more likely to require a blood transfusion during or after surgery and had a longer ICU length of stay. Importantly, there were no observed differences in other outcomes including operative mortality. A subgroup analysis of 3 high-risk groups (patients with congestive heart failure, mitral valve disease, and moderate or greater tricuspid regurgitation) yielded no differences in operative mortality on the basis of use of a PAC. The authors concluded that PACs might have limited benefit in the management of cardiac surgery patients and might potentially serve as source of harm by increasing the risk of complications and of overtreatment on the basis of the acquired data. The study did have limitations. It was a single-center retrospective review, which carries an inherent bias and limits generalizability. The authors acquiesce to the absence of an institutional protocol to dichotomize as to which patients receive PACs or indeed how these data might be used to guide intensive care management. Despite the excellent statistical analysis and propensity matching, the potential for selection bias because of unrecognized confounders remains a prevalent threat. Furthermore, the literature review was somewhat tilted against reporting the results from studies that have shown a benefit to PAC use in cardiac surgery patients or on the effect on the association with decreased blood transfusions, shorter length of stay, or lower rates of morbidity.^{8,9} This study, nevertheless, adds to the growing body of literature that challenges the routine use of pulmonary artery catheterization in cardiac surgery patients. While admittedly a randomized controlled trial might be necessary to fully resolve the debate, the opposition is mounting.

KEY MESSAGE: This large (>7000 patients), single-center retrospective study used propensity matching to assess the effect of PAC use in cardiac surgery patients. Patients with a PAC had longer ICU length of stay and increased frequency of blood transfusion, with no difference in operative mortality or other morbidity.

Turning Down the Volume

Drs Ad, Luc, and Nguyen surveyed adult cardiac surgery programs to determine regional fluctuations in case volume due to the COVID-19 pandemic.⁴ In their study they evaluated 67 programs, which represented an annualized total of >60,000 cases, and >45,000 hospital beds. Hospitals were identified as having either a low (<100) or high burden (>100) of hospitalized patients with COVID-19. Unsurprisingly, most of the high-burden centers were categorized as an “academic” center (79%). Most hospitals (70%) converted medical wards into specific COVID-19 treatment areas out of necessity. Only 25% of the cardiac surgeons, however, were redeployed to alternative (ie, nonsurgical) duties. Most centers temporarily halted nonurgent cardiac surgery in March 2020. This was accompanied by a

commensurate decrease in cardiac surgery to 60% of baseline in March 2020, and a further 45% in April 2020. Multiple health system strains and COVID-19-related surges were each associated with a further decrease in case volumes, which also exhibited regional variability. Coronary artery bypass grafting remained the most preserved procedure type and increased in proportion from 41% to 47% of the total case mix. The implications of long-term deferment of cardiac surgery remain unknown, although previous data suggest that delays in surgical revascularization portend a poor prognosis and are associated with increased mortality (2.6%-11% mortality per month).¹⁶ During the study time frame, a total of 65 patients with suspected COVID-19 underwent cardiac surgery. Their observed mortality was substantial, at 8%.

KEY MESSAGE: The number and type of cardiac surgery procedures performed varied during the pandemic, however experienced an overall decrease in case volumes to 45% compared with baseline. Areas with the largest burden of COVID-19 were most likely to require case deferral. More urgent types of cases were performed (ie, coronary artery bypass grafting and ECMO) compared with traditionally elective cases (valve surgeries). Long-term effects of deferred cardiac surgery are yet to be determined.

The Reality of Transfusion

Anemia is common in patients with acute myocardial infarction (AMI). Indeed, this setting is associated with increased cardiovascular mortality. Transfusion is typically indicated when hemoglobin levels decrease to <10 g/dL. There are, nevertheless, large variations in clinical practice because of a lack of consensus in the literature. Large, randomized data comparing transfusion strategies in gastrointestinal bleeding or surgical procedures support restrictive strategies. Indeed, transfusion is associated with such adverse events as transfusion-related acute lung injury and circulatory overload, immune or nonimmune reactions, and infections, alongside logistical challenges and obvious costs.¹⁷ In the quest for more robust data in the context of AMI, the Restrictive and Liberal Transfusion Strategies in Patients With Acute Myocardial Infarction (REALITY) trial was performed. It was a large-scale, open-label, multicentric randomized trial designed to determine whether a restrictive transfusion strategy was clinically noninferior to a liberal transfusion strategy.¹⁰ It enrolled 668 patients with AMI and hemoglobin levels between 7 and 10 g/dL who were randomized to either a restrictive or liberal transfusion strategy with a threshold for transfusion set at a hemoglobin level <8 or <10 g/dL, respectively. The primary composite outcome (all-cause death, stroke, recurrent myocardial infarction, or emergency revascularization) at 30 days occurred in 11% versus 14% of patients, a difference that met the noninferiority criterion. Also, this primary

clinical outcome was numerically lower in the restrictive group, although it did not reach statistical significance. The authors opine therefore that there might be a merit to the restrictive approach. The confidence limit, nevertheless, set at 25% in the noninferiority design might be deemed too large, potentially masking clinically relevant harm. In addition, noninferiority does not equate to superiority. In fact, more studies are necessary to attain some resolution and clarity.

KEY MESSAGE: The REALITY trial investigated transfusion strategies in patients with AMI in a randomized, large-scale trial and showed that a liberal strategy (<10 g/dL) is noninferior to a restrictive strategy (<8 g/dL). Although such a high-quality work was critically needed, more still needs to be done because the confidence limit set by design could potentially include clinically relevant harm, and because noninferiority does not mean superiority. Further, the magnitude of effect is unclear on outcomes in patients exposed to one strategy versus another and who require cardiac surgery.

Injury Prevention

Priyanka and colleagues⁷ provide insight into the association between perioperative renal injury and the risk for major adverse kidney events at 180 days (MAKE180) in cardiac surgery patients. The authors conducted a retrospective review of 6637 patients who underwent cardiac surgery at 5 hospitals. Their records were stratified according to the presence of acute kidney injury (AKI) at 72 hours postsurgery on the basis of urine output and serum creatinine using the Kidney Disease Improving Global Outcomes (KDIGO) definition. Indeed, this has been previously validated in cardiac surgery.^{18,19} Using the Society of Thoracic Surgeons definition for AKI, this study population had a rate of renal injury (<4%) comparable with the 4% in the Society of Thoracic Surgeons database. However, on the basis of the expanded KDIGO definition, using oliguria and a lower serum creatinine level, the rate of AKI was substantially higher, at 81%.

Priyanka and colleagues reported a 49% rate of stage 2 AKI and a 12% rate of stage 3 AKI. The higher rates of reported AKI in this cohort can be partly attributed to the 43% incidence of isolated oliguria. The authors were able to show that stage 1 AKI on the basis of oliguria alone was associated with a 2 times increase in persistent renal dysfunction at 180 days (odds ratio, 2.01; 95% CI, 1.26-3.18; $P < .3$). This adverse association was more pronounced with stage 3 KDIGO AKI, which had a 61% incidence of MAKE180 and a 33% mortality rate.^{7,11} This study showed that AKI is more common than previously thought (81%) and that there is a close link between any level of perioperative renal dysfunction and adverse outcomes up to 180 days after cardiac surgery. The MAKE180 rate increased from 4.5% for those with no

AKI to 61% for those with stage 3 AKI. However, even stage 1 AKI on the basis of oliguria alone was associated with a 15% rate of MAKE180 and a nearly 7% mortality rate at 6 months.

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Basic Instinct

The Balanced Solution Versus Saline in Intensive Care Study (BaSICS) Randomized Clinical Trial is a well-executed, multi-institutional randomized clinical trial of 11,052 adult patients in 75 critical care units in Brazil, which investigated the type of intravenous fluid balanced solution (BAL; Plasma-Lyte 148; Baxter International Inc) versus normal saline (NS; 0.9% NaCl),¹¹ and rate of fluid administration (333 mL/h [SLOW] vs 999 mL/h [FAST]).²⁰ Survival at 90 days was the primary end point and secondary outcomes included renal replacement therapy (RRT), AKI, illness severity, and mechanical ventilation-free days. In the cardiac population, a slower rate of fluid administration might pose less risk of right ventricular volume overload and dysfunction, and of tissue edema.

The study results did not reveal a difference in mortality for the use of either type of fluid; mortality 26.4% BAL versus 27.2% NS; (adjusted hazard ratio, 0.97 [95% CI, 0.90-1.05]; $P = .47$), or infusion rate; mortality 26.5% for SLOW versus 27.0% for FAST (adjusted hazard ratio, 1.03 [95% CI, 0.96-1.11]; $P = .46$), in 10,520 patients. Furthermore, there was no difference in secondary outcomes. Importantly, patients in the study had low illness severity scores (median Sequential Organ Failure Assessment score, 4 [interquartile range, 2-7]) and were mostly surgical patients (61%) with either elective (49%) or emergent (12%) surgery and included patients who underwent cardiac surgery. Additionally, the median amount of study fluid administration was 2.9 L (SD, 2.4 L) over 3 days (total fluids: 1.5 L on day 1, 4.1 L in 3 days), which is similar to the fluid administered in the ICU in trials specific to cardiac surgery, such as the Hypertonic Saline for Fluid Resuscitation After Cardiac Surgery (HERACLES) trial.²¹ The applicability of the findings of the BaSICS trial are relevant to a cardiac surgical population and critical care physicians in cardiac surgical ICUs should feel safe in using either type of solution for fluid optimization, especially for routine care when modest fluid needs are expected. There was no

significant difference in serum chloride among the groups; specifically, the median value remained well in the normal range with NS. The results of BaSICS mirror those reported in the 0.9% Saline Versus Plasma-Lyte 148 for Intensive Care Unit Fluid Therapy (SPLIT) trial, which was performed in a comparable population including surgical patients, and in which there was no difference for BAL versus NS for AKI and RRT or mortality.²² The results, however, differ from the Isotonic Solutions and Major Adverse Renal Events Trial in Medicine (SMART-MED) and Surgical Patients (SMART-SURG) trial, which showed a small difference in favor of BAL for the composite outcome of death, AKI, and new RRT, in a mostly medical population.²³ The conflicting results of the different trials, fueled by vociferous opinions, will undoubtedly continue to kindle this fire.

KEY MESSAGE: After cardiothoracic surgery in critically ill patients, fluid resuscitation with a BAL or NS appears to be safe. The type of fluid or infusion rate did not significantly affect 90-day survival.

A Bitter Pill to Swallow

Dysphagia is a known risk factor after cardiac surgery with a prevalence ranging from 3% to 70%, which increases risk of pneumonia, cost of hospital stays, and risk of readmission. Plowman and colleagues²⁴ performed a prospective single-center study of 182 patients who underwent cardiac surgery to determine the prevalence, risk factors, and effect of postoperative dysphagia. After gathering baseline data to rule out preexisting dysphagia risk, fiberoptic endoscopic evaluation of swallowing was performed within 72 hours of extubation and rated by 2 blinded raters. Scales were then used to determine the depth of material entering the airway and the response, and the degree of pharyngeal residue.

After screening all patients, only 6% were classified as safe, 65% were penetrators, and 29% were aspirators, of whom 53% were found to be silent (no cough), 32% had a weak cough, and 15% were able to expel aspirate. When swallowing was examined, only 48% had efficient swallowing. In multivariable analysis, New York Heart Association classification III and IV, reoperation, a capture of more than 110 transesophageal echocardiography images, intubation >27 hours, and endotracheal tube size ≥ 8.0 were independent risk factors for aspiration. Patients who had ≥ 3 risk factors had 16.4 times higher odds of aspiration, and patients who had ≥ 4 risk factors had 22.4 times higher odds of aspiration. Aspirating patients had 2.6 higher odds of pneumonia, 5.7 higher odds of reintubation, 2.8 higher odds of death at 90 days, waited 43% longer to resume oral intake, had a mean 104-hour longer stay in the ICU, 6-day longer hospital stay, and incurred \$49,372 more in hospital costs.

KEY MESSAGE: Clinically significant aspiration is common after cardiac surgery and should be routinely investigated in patients with identified risk factors. Although most risk factors are nonmodifiable, choice of smaller ETT tube, judicious use of TEE manipulations intraoperatively, and prerehabilitation to improve respiratory muscle strength might improve outcomes in these patients.

Conflict of Interest Statement

R.C.A. has received honoraria from Abbott Nutrition, AVIR Pharma Inc, and Edwards Lifesciences for work unrelated to this manuscript. All other authors reported no conflicts of interest.

The *Journal* policy requires editors and reviewers to disclose conflicts of interest and to decline handling or reviewing manuscripts for which they may have a conflict of interest. The editors and reviewers of this article have no conflicts of interest.

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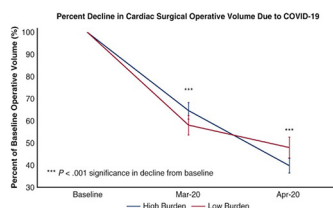
Key Words: acute kidney injury, ECMO, transfusions, critical care, catheters, fluid resuscitation

Perioperative and Critical Care Year in Review: Recent Articles From AATS Journals

COVID PCR-positive
PF ratio < 80 for > 6 hours

Maximum conventional ventilatory techniques
(including use of BiPAP)
Remdesivir
Steroids
Prone Trial
Inhaled Nitric Oxide
Target 20% increase in PF ratio
Should be restricted to 72 hours

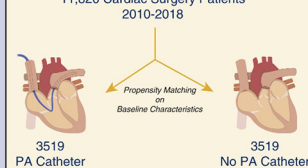
If PF ratio does not increase by 20% OR
worsens, consider transfer to nearest ECMO
center



The impact of pulmonary artery
catheterization after cardiac surgery

Methods

11,820 Cardiac Surgery Patients
2010-2018



Results

Operative Mortality	Prolonged ICU Stay	pRBC Transfusions
2.4% vs 2.4% (P = 1.00)	39 hrs vs 48 hrs (P < .001)	40.4% vs 35.5% (P < .001)

Implications

Pulmonary artery catheter may have
limited benefit in routine cardiac surgery

PA - Pulmonary Artery, ICU - Intensive Care Unit, pRBC - Packed Red Blood Cells

JTCVS: Venovenous extracorporeal membrane oxygenation in patients with COVID-19 respiratory failure. Hayanga JWA, Chatterjee S, Kim BS, Merritt-Genore H, Karianna Milewski RC, Haft JW, Arora RC. *J Thorac Cardiovasc Surg.* 2021 [In press].

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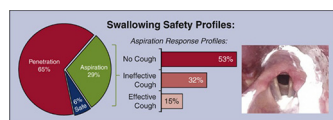
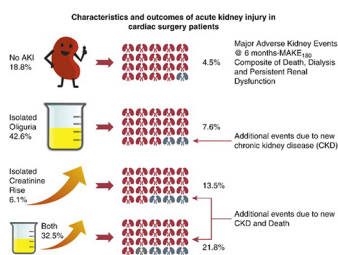
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