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Commentary: DO₂ you believe in magic? Promising oxygen delivery-based perfusion strategy for minimizing mild kidney injury in patients undergoing routine cardiac surgery

Lillian Kang, MD,^a and Marcelo Cerullo, MD, MPH^{a,b}

With a reported incidence of 20% to 30%,^{1,2} acute kidney injury (AKI) is one of the most common complications of cardiopulmonary bypass (CPB). AKI after CPB is likely multifactorial—including ischemia-reperfusion injury, oxidative stress, and microemboli—and ultimately contributes significantly to postoperative mortality.³⁻⁵ Each of these is related to successful systemic oxygen delivery (DO₂), itself a potential modifiable factor in CPB. Conventional CPB targets are based on body surface area and core body temperature; however, perfusion strategies that modulate pump flows to optimize oxygen delivery (DO₂) have been examined as a promising alternative to reduce the risk of perioperative AKI in cardiac surgery. In this issue of the *Journal*, Mukaida and colleagues⁶ from Juntendo University Hospital in Tokyo report results from a single-center randomized controlled trial (RCT) in which the surgical team was blinded to DO₂ and pump flow. They found that compared with conventional CPB, DO₂-directed CPB resulted in decreased incidence of postoperative AKI (14.6% vs 30.4%), largely accounted for by a decrease in

Marcelo Cerullo, MD, MPH, and Lillian Kang, MD

CENTRAL MESSAGE

An oxygen delivery-based cardiopulmonary bypass strategy shows promise in protecting against mild acute kidney injury in patients undergoing cardiac surgery.

stage I AKI (12.7% vs 25.4%), despite comparable rates of more severe AKI.⁶ These findings echoed those of a previous multicenter RCT, whose main critique was the nontrivial DO₂ overlap between groups.⁷

Several other aspects of the study reported herein bolster the authors' case for the renal protection conferred by DO₂-directed CPB. Pump runs had significantly higher median perfusion index as well as lower cumulative time below target DO_{2i} and mean arterial pressures <60 mm Hg. Consistent with well-established findings, they also report age and preoperative estimated glomerular filtration rate (eGFR) as risk factors for AKI. In this vein, operative features including specific operation, perfusion time, and minutes with DO_{2i} < 300 mL/min/m² were also associated with AKI. Crucially, their randomized design justifies interest in their findings in the other direction: patients age 60 to 74 years, with body surface area <1.40 m², preoperative eGFR 60 to 89 mL/min/1.73 m², nadir hematocrit <22.9, and perfusion time <120 minutes were more likely to benefit. Despite this, other outcomes were equivocal between the 2 groups, including the need for transfusion, intubation time, postoperative length of stay (both hospital and ICU), eGFR before discharge, or mortality.

The protective properties of DO₂-directed CPB against AKI as demonstrated by this trial should be considered in light of the restrictions used to select the study population. In seeking to create a uniform population and minimize unobserved bias introduced by unmeasured patient

From the ^aDepartment of Surgery, Duke University Medical Center, Durham, NC; and ^bNational Clinician Scholars Program, Duke University and Durham Veterans Affairs Medical Center, Durham, NC.

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Address for reprints: Marcelo Cerullo, MD, MPH, Duke University General Surgery Residency, Department of Surgery, Duke University Medical Center, Room 3589 Duke South, Durham, NC 27710 (E-mail: marcelo.cerullo@duke.edu).

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comorbidity, the investigators excluded patients with baseline kidney disease, operations requiring circulatory arrest or cooling below 34°C, and patients on extracorporeal membrane oxygenation or intra-aortic counterpulsation devices. Finally, the short-term follow-up limits insight into potential long-term effects of DO₂-directed CPB.

Nevertheless, this RCT presents clear evidence for the efficacy of DO₂-directed CPB in protecting against postoperative AKI. It sets the foundation for subsequent investigation of DO₂-directed CPB in sicker patients undergoing more complex procedures. These would include patients both at higher risk for perioperative kidney injury and whose postoperative course would be most affected by AKI. Further analyses of real-world data across different national contexts (eg, perhaps with patients with higher average body mass index). With the robustness of their design, the authors have presented a promising CPB management paradigm for the reduction of mild AKI in patients undergoing routine cardiac surgery while simultaneously laying the groundwork for a research agenda to generate

important results regarding more severe perioperative AKI after CPB.

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Commentary: Delivering the news about oxygen-delivery on pump

HelenMari Merritt-Genore, DO

Acute kidney injury (AKI) increases length of stay (LOS), morbidity, and mortality following cardiac surgery.^{1,2} Pre-operative risk factors such as pre-existing renal dysfunction, recent contrast, diabetes, and advanced age combined with perioperative fluctuations in cardiac output and renal perfusion may lead to impaired kidney function postoperatively. During cardiopulmonary bypass (CPB), hemodilution and

HelenMari Merritt-Genore, DO

CENTRAL MESSAGE

Greater oxygen delivery goals during cardiopulmonary bypass may be one part of a bundle to reduce postoperative kidney injury.

systemic vascular resistance alterations may decrease renal oxygen delivery (DO₂) by 20% or more.³

Mukaida and colleagues⁴ present a single-center, randomized control trial (RCT) including 300 patients undergoing normothermic CPB for routine cardiac procedures and compare a strategy of optimizing DO₂

From the Heart Consultants, Methodist Physicians' Clinic, Omaha, Neb.
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Address for reprints: HelenMari Merritt-Genore, DO, Adult Cardiothoracic Surgeon, Methodist Physicians' Clinic, 1120 S 103rd Plaza, Omaha NE 68114 (E-mail: Helenmari.merritt@gmail.com).

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