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Commentary: Goal-directed or flow-directed perfusion?

Robert S. Kramer, MD, and Tyler Kelting, CCP

Robert S. Kramer, MD (left), and Tyler Kelting, CCP (right)

CENTRAL MESSAGE

The primary focus in goal-directed perfusion should be maximizing flow and minimizing hemodilution, with transfusion of red blood cells being the last resort.

Magruder and colleagues¹ have analyzed the relationship of oxygen delivery (DO_2) on cardiopulmonary bypass (CPB) with regard to Society of Thoracic Surgeons (STS) outcomes in their article “Correlating Oxygen Delivery on Cardiopulmonary Bypass with Society of Thoracic Surgeons Outcomes Following Cardiac Surgery.” Their analysis included 834 cardiac surgery cases (CPB, crossclamped). The lead author has previously published an experience showing an association between goal-directed perfusion (GDP) and a lower incidence of acute kidney injury (AKI) after cardiac surgery.² Using an electronic perfusion record capturing real-time information during CPB, including DO_2 and flow parameters, the authors found that DO_2 (threshold $280 \text{ mL O}_2/\text{min}/\text{m}^2$) was associated with the primary composite morbidity/mortality outcome (6 STS variables) not previously reported in the literature. They were able to capture potentially harmful exposures to low DO_2 , low flow, hypotension, or relative anemia and concluded that DO_2 influences outcomes after cardiac surgery in addition to its known association with AKI.

This Magruder analysis strengthens the argument promoting the use of the GDP strategy. It helps us to understand how AKI could function as a surrogate for injury and dysfunction in other organ systems, as evidence shows that increasing severity and duration of AKI during the index admission are associated with poor immediate- and long-term outcomes that may not be directly related to renal failure.³ For the first time, these authors have shown that prolonged low DO_2 is associated with both the STS morbidity/mortality metric

and the prolonged ventilation >24 hours metric, along with what we already knew about postoperative AKI. In addition to showing that patients with anemia (present in more than 30% of cardiac surgery patients^{4,5}) and low glomerular filtration rate are particularly vulnerable to these poor outcomes, the authors make 2 other important points about anemia: The first is that the comorbidities driving anemia (“anemia of chronic disease”) are still present and not modified by intraoperative transfusions, and the second is that flow alone is often sufficient to reach greater DO_2 targets.

The 3 variables of the DO_2 formula are flow, hemoglobin, and oxygen. Adding blood to the pump may address the formula but not oxygen delivery at the tissue level, given the reluctance of stored red blood cells to give up oxygen. Accordingly, with regard to satisfying the DO_2 formula, it is no surprise that flow is the backbone of the GDP strategy. While real-time calculations of DO_2 are valuable, a focus on flow and limiting hemodilution rather than transfusing is crucial. Stored allogeneic red blood cells may satisfy the DO_2 formula, but not the patient.

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Commentary: Optimizing oxygen delivery during cardiopulmonary bypass to minimize morbidity and mortality: Have our goals been achieved?

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Strategies involving goal-directed perfusion during cardiopulmonary bypass (CPB) have been associated with decreased acute kidney injury (AKI) following cardiac surgery.¹ However, it is unclear as to what defines goal-directed perfusion during CPB and whether it can reduce not only AKI, but all morbidity and mortality in all patients undergoing cardiac surgery on CPB.

In this edition of the *Journal*, Magruder and colleagues² report the relationship between oxygen delivery (DO_2) during CPB and morbidity and mortality in 834 cardiac surgery patients on CPB using an electronic perfusion medical record system (Quantum Perfusion Systems, Spectrum Medical, Fort Mill, SC) that provides continuous online data of flow parameters and hemodynamic variables, including DO_2 , blood pressure, cardiac index, pump flow, and hemoglobin (Hgb). The institutional target for DO_2 was at least $260 \text{ mL/O}_2/\text{min/m}^2$, which was achieved by optimizing flow parameters, reinfusing blood sequestered in the operative field, and transfusing blood products. The primary outcome was the occurrence of a composite of Society of Thoracic Surgeons (STS) morbidity/mortality outcomes (mortality, postoperative renal failure, surgical reexploration,

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CENTRAL MESSAGE

Optimizing oxygen delivery during cardiopulmonary bypass may minimize morbidity and mortality.

postoperative prolonged intubation for >24 hours, deep sternal wound infection, and stroke). Although a $\text{DO}_2 < 280$ was associated with an increased incidence of the composite STS outcome, the increase failed to reach statistical significance ($P = .07$). However, in those patients undergoing nonisolated CABG procedures, a $\text{DO}_2 < 280$ was significantly associated with the primary outcome ($P = .02$). This was driven largely by an increased incidence of prolonged ventilation for >24 hours when the DO_2 was < 280 ($P = .04$). STS-defined renal failure was not associated with DO_2 in the entire patient cohort ($P = .07$); however, stage 1 AKI within 72 hours of surgery was independently associated with a $\text{DO}_2 < 280$ ($P = .02$). Overall, patients with a preoperative glomerular filtration rate $\text{GFR} < 65$ and a Hgb level $< 12.5 \text{ mg/dL}$ appeared to be most vulnerable for morbidity and mortality when the DO_2 was < 280 .

This study has several limitations, which the authors have acknowledged. The sample size was relatively small, which limited the ability to determine causality. Data obtained during the period of weaning from CPB was included, which may have altered the outcomes. The interventions used to increase DO_2 when values fell below 260 were not uniform. The database could not determine when patients were actively treated to maintain the target DO_2 ,

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