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Editorial

The Relevance of Renal Oxygen Saturation Over Other Markers in Cardiac Surgery–Associated Acute Kidney Injury

Acute kidney injury (AKI) is a severe complication and a strong risk factor for death in patients undergoing cardiac surgery,[1,2] so much so that the term cardiac surgery–associated acute kidney injury (CSA-AKI) has been coined, and establishing a predictive model for CSA-AKI has been the focus of past research. Various predictive models have been established to predict AKI, such as the AKI after cardiac surgery score, the Cleveland Clinic score, the Mehta score, and the simplified renal index score. However, the discrimination and calibration predictive value for each of these models is not convincing, and therefore these models are barely acceptable.[1]

Currently, there are several preoperative and intraoperative alternatives to reduce the risk of CSA-AKI, such as avoiding nephrotoxic drugs, ensuring convenient hydration, and optimizing the patient's hemodynamic status to maintain adequate renal perfusion. Intraoperative considerations are also available and include performing off-pump procedures when possible, minimizing bleeding, reducing cardiopulmonary bypass times, and maintaining suitable perfusion pressures (>75 mmHg to 80 mmHg).[3] Although these steps well may reduce the risk of developing CSA-AKI, little yet has been achieved regarding early CSA-AKI prevention—a topic of paramount importance.

Given that patients undergo a period of hemodynamic instability and systemic oxygenation impairment during and after cardiac surgery, continuous monitoring is required.[4] The ideal means to prevent CSA-AKI would be a continuous, noninvasive monitor capable of instantly detecting biomarker changes relevant to AKI, thus allowing for prompt and appropriate responses by the care team.[3]

Current potential biomarkers are insufficient for use in early detection and prevention. Serum creatinine (SCr) levels are influenced by a variety of factors including age, sex, ethnicity, muscle mass, and intravascular volume, regardless of renal function. Furthermore, there is no SCr level alteration until 50% of the renal function is lost, which can limit substantially and even delay the detection of CSA-AKI.[5,6] Although some biomarkers could facilitate a diagnosis of CSA-AKI, there is an impractical delay in their level changes, which rise 2 hours to 6 hours after surgery.[7] These biomarkers may be the most sensitive means of CSA-AKI detection, but their analysis and assay require a considerable amount of money and time. Furthermore, they cannot be detected faster nor measured continuously to assess renal function in real time, which is needed to preserve healthy renal conditions.

Recent guidelines focus on attaining adequate tissue perfusion along with an appropriate systemic oxygen supply–demand balance in a strategy called goal-directed therapy. Goal-directed therapy relies on the close monitoring of direct and indirect parameters ranging from cardiac index to lactate, mean arterial pressure, and venous oxygen saturation. This strategy has enhanced outcomes after cardiac surgery. However, goal-directed therapy only reflects the parameters of systemic perfusion in a global manner. Indeed, regional tissue perfusion and oxygen saturation levels differ according to various organs (eg, the greatest oxygen consumption is located in the heart as opposed to other organs, so a global assessment would obscure this important difference).[4]

Near-infrared spectroscopy (NIRS) tries to overcome the limitations of monitoring indirect perfusion and oxygenation parameters, which may be a good strategy for early CSA-AKI detection. NIRS is a noninvasive, optical technique that continuously measures the difference between oxygenated and deoxygenated hemoglobin within a regional tissue area, thus obtaining regional oxygen saturation (rSo_2).[8,9] The NIRS technique applies the Beer-Lambert law, where the concentration of a substance can be measured according to its absorption of light. From the differential absorption of 2 near-infrared wavelengths of light by oxygenated and deoxygenated hemoglobin, NIRS devices supply an assessment of the oxyhemoglobin saturation in a volume of area beneath the sensors.[10,11] In addition, NIRS provides invaluable information about the balance between tissue oxygen delivery and consumption, reflecting real-time dynamic changes in the microcirculatory bed perfusion, thus allowing rapid feedback on tissue perfusion.[12] In this way, kidney oxygen saturation (kSo_2) could be registered

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if NIRS sensors were located in the corresponding area. Indeed, NIRS can detect important alterations in critical tissue bed perfusions that might result in organ injury, including the kidney.

Unlike SCr assessments, NIRS values are not affected by the same factors altering SCr. NIRS measurement is affected primarily by its depth of penetration signal, which is limited to approximately 3 cm to 4 cm beneath the skin. Other factors potentially impairing NIRS values are a high concentration of conjugated bilirubin and the amount of skin pigment. The signal detection also can be disturbed by any external source of light, which may be caused by the reduced adhesion of the sensors owing to increased patient perspiration.[13]

Unlike SCr, which supplies almost no information regarding kidney perfusion, kSo_2 provides key information concerning kidney perfusion via a noninvasive assessment of regional oxygen supply−demand balance. Moreover, these kSo_2 continuous, noninvasive measures are suitable targets for the goal-directed therapy to treat impairments in kidney perfusion.

Similar to previous research showing that intraoperative cerebral desaturation was related to an increased risk of cognitive decline,[14] recent studies have demonstrated that intraoperative kidney oxygen desaturation is associated with postoperative CSA-AKI in adult patients undergoing cardiac surgery.[15] Therefore, intraoperative kidney oxygen monitoring gives invaluable information that reliably detects CSA-AKI and even may be used effectively to guide therapy in an earlier manner than SCr, providing a time-limited span before the onset of irreversible kidney failure.

Overall, NIRS is a cutting-edge, noninvasive, continuous, real-time assessment of regional oxygen saturation, which, if located in the corresponding kidney area, could reflect not only renal oxygen saturation but also an estimation of kidney perfusion. In this sense, NIRS supplies invaluable information that enables prompt and appropriate responses before the onset of kidney injury, significantly enhancing AKI prevention. None of these benefits can be derived from the assessment of traditional targets, such as SCr levels or even novel biomarkers. Renal oxygen saturation seems to be a promising marker for the early detection and prevention of CSA-AKI. Therefore, continuous kidney oxygen saturation monitoring may be a promising, cutting-edge, real-time, noninvasive strategy to enhance the prevention of AKI and allow for prompt, appropriate responses.

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References

1 Ortega-Loubon C, Fernandez-Molina M, Paneda-Delgado L, et al. Predictors of postoperative acute kidney injury after coronary artery bypass graft surgery. Braz J Cardiovasc Surg 2018;33:323–9.
2 Parolari A, Pesce LL, Pacini D, et al. Risk factors for perioperative acute kidney injury after adult cardiac surgery: Role of perioperative management. Ann Thorac Surg 2012;93:584–91.
3 Ortega-Loubon C, Fernandez-Molina M, Carrascal-Hinojal Y, et al. Cardiac surgery-associated acute kidney injury. Ann Card Anaesth 2016;19:687–98.
4 Kopp R, Dommann K, Rossaint R, et al. Tissue oxygen saturation as an early indicator of delayed lactate clearance after cardiac surgery: A prospective observational study. BMC Anesthesiol 2015;15:158.
5 Najafi M. Serum creatinine role in predicting outcome after cardiac surgery beyond acute kidney injury. World J Cardiol 2014;6:1006–21.
6 Onk OA, Onk D, Ozcelik F, et al. Risk factors for acute kidney injury after coronary artery bypass surgery and its detection using neutrophil gelatinase-associated lipocalin. Cardiorenal Med 2016;6:216–29.
7 Ristikankare A, Poyhia R, Kuitunen A, et al. Serum cystatin C in elderly cardiac surgery patients. Ann Thorac Surg 2010;89:689–94.
8 Olbrecht VA, Skowno J, Marchesini V, et al. An international, multicenter, observational study of cerebral oxygenation during infant and neonatal anesthesia. Anesthesiology 2018;128:85–96.
9 Gist KM, Kaufman J, da Cruz EM, et al. A decline in intraoperative renal near-infrared spectroscopy is associated with adverse outcomes in children following cardiac surgery. Pediatr Crit Care Med 2016;17:342–9.
10 Ruf B, Bonelli V, Balling G, et al. Intraoperative renal near-infrared spectroscopy indicates developing acute kidney injury in infants undergoing cardiac surgery with cardiopulmonary bypass: A case-control study. Crit Care 2015;19:27.
11 Tweddell JS, Ghanayem NS, Hoffman GM. Pro: NIRS is "standard of care" for postoperative management. Semin Thorac Cardiovasc Surg Pediatr Card Surg Annu 2010;13:44–50.
12 Burton KK, Valentine EA. Combined somatic and cerebral oximetry monitoring in liver transplantation: A novel approach to clinical diagnosis. J Cardiothorac Vasc Anesth 2018;32:85–7.
13 Biedrzycka A, Lango R. Tissue oximetry in anaesthesia and intensive care. Anaesthesiol Intensive Ther 2016;48:41–8.
14 Slater JP, Guarino T, Stack J, et al. Cerebral oxygen desaturation predicts cognitive decline and longer hospital stay after cardiac surgery. Ann Thorac Surg 2009;87:36–44;discussion 44-5.
15 Choi DK, Kim WJ, Chin JH, et al. Intraoperative renal regional oxygen desaturation can be a predictor for acute kidney injury after cardiac surgery. J Cardiothorac Vasc Anesth 2014;28:564–71.