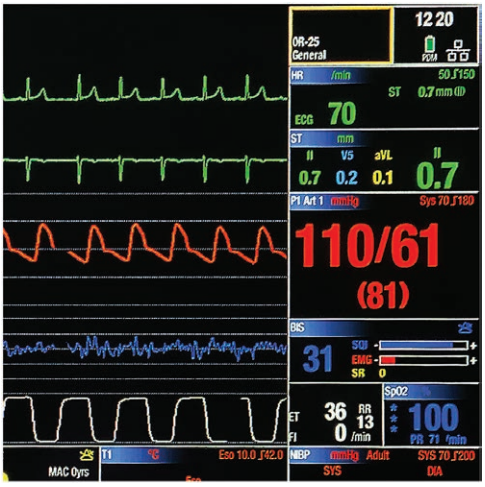
Preoperative Risk, Blood Pressure, and Acute Kidney Injury

Louise Y. Sun, M.D., S.M., F.R.C.P.C., F.A.H.A.

Acute kidney injury (AKI) is a serious complication after surgery and an important area of perioperative investigation. Recent studies have pointed to the prevention and treatment of intraoperative hypotension as a potential mitigation strategy. However, the optimal blood pressure needed to maintain end organ perfusion under general anesthesia is unclear and may vary by surgery type and individual characteristics. Hypotension is most commonly defined as systolic blood pressure of less than 80 or 90 mmHg, mean arterial pressure (MAP) of less than 55, 60, and 65, or relative decreases in MAP at or above 20% or 25% from the baseline value.[1] Single-center studies have shown that even brief periods of mild hypotension can be associated with AKI after major noncardiac, nonurologic surgery. A seminal paper by Walsh *et al.* concluded that there was no safe duration of MAP below 55 mmHg during noncardiac surgery.[2] A subsequent study by our group reported that AKI was associated with MAP below 60 mmHg in a dose-dependent fashion.[3] This was followed by a retrospective cohort study by Salmasi *et al.*, who reported an absolute MAP threshold of less than 65 mmHg, and a relative threshold of more than 20% decrease from baseline, to be associated with AKI.[4] The advent of personalized medicine calls for an approach to blood pressure management that tailors to the uniqueness of each individual undergoing surgery.



"[W]hether targeting blood pressure alone could mitigate the risk of acute kidney injury remains controversial."

In this issue of Anesthesiology, Mathis *et al.* respond to this important clinical need by exploring the differential impact of intraoperative hypotension according to baseline patient and procedure risk.[5] These authors studied the incremental predictive value of hypotension in a multicenter cohort of more than 138,000 noncardiac surgery patients and reported a varying relationship between hypotension and AKI based on underlying risk, such that AKI was not associated with hypotension of any duration in low-risk patients, whereas an association was found with severe hypotension (MAP less than 50 mmHg) in the medium-risk group, and with milder degrees of hypotension (MAP 55 to 59 mmHg) in the highest-risk group.

These findings are hardly surprising. High-risk patients are more likely to undergo complex and prolonged procedures with a higher likelihood of exposure to hypotension. They are also more likely to have comorbidities that impair, or place them at risk for end-organ hypoperfusion. For instance, advanced physiologic adaptions to longstanding hypertension include ventricular-arterial coupling and stiffening of the arterial vasculature, which eventually lead to a pulse pressure that is exaggeratedly large. In these patients, MAP rather than systolic blood pressure should be used to reliably reflect perfusion pressure.

Hypotension is quite common in the operative setting. In fact, 44% of Mathis's multicenter cohort had experienced at least one episode of intraoperative hypotension lasting more than 10 min. Vigilant intraoperative monitoring and proactive treatment are therefore important. Given the differential relationship between hypotension and AKI in each risk category, a risk-stratified approach to selecting patients for invasive arterial pressure monitoring would be most appropriate. Guided by this approach, patients with high-risk features such as anemia, preexisting renal dysfunction, high-risk surgery, advanced American Society of

Image: J. P. Rathmell.

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Anesthesiologists Physical Status, and prolonged anesthesia duration are more likely to benefit from proactive management of mild hypotension (MAP less than 65 mmHg), whereas those at medium risk for AKI may benefit from prompt treatment of moderate hypotension (MAP less than 60 mmHg).

Whether blood pressure should optimally be maintained above a certain absolute *versus* relative threshold, remains subject for debate. Similar to the recent study by Salmasi *et al.*, Mathis concluded that AKI was associated with specific levels of absolute, rather than relative hypotension. This finding should be interpreted in light of potential inconsistencies in the magnitude of relative hypotension calculated for each patient. Specifically, the definition of baseline blood pressure is diverse within a retrospective cohort and could include continuous preoperative ambulatory recording, discrete measurements from the preoperative assessment clinic, the first intraoperative value, or the first value after anesthesia induction. The lack of an observed association between relative hypotension and AKI could, in part, be explained by this discrepancy.

Few modifiable AKI risk factors have been identified to date. Hypotension has emerged as a risk factor that is potentially preventable and treatable. The critical MAP thresholds identified in Mathis's study are comparable with previous studies. However, whether targeting blood pressure alone could mitigate the risk of AKI remains controversial. Renal perfusion is dependent on both pressure and flow. This complex pressure–flow relationship has not been fully elucidated in physiologic studies, nor through trials of bundled hemodynamic management strategies. For now, treatment for hypotension should best be directed at correcting the underlying cause (*e.g.,* hypovolemic *vs.* distributive) and to restoring both pressure and flow.

Looking into the future, state-of-the-art intraoperative monitoring for hypotension should integrate all hemodynamic data that are routinely available, including blood pressure, pulse rate, contour, and variability, as well as the end tidal carbon dioxide as a surrogate of systemic perfusion. In addition, investigations are needed to determine the role of postoperative hypotension in the development of AKI. Large cohort studies including this one are an important first step toward identifying critical blood pressure thresholds under anesthesia. Multidimensional models incorporating a larger variety of hemodynamic (including elements depicting both pressure and flow), clinical, and physiologic parameters are next needed to elucidate how these parameters interact with the risk of perioperative renal injury. This multidimensional algorithm could eventually be used to inform prospective clinical trials of truly personalized, bundled therapies aimed to prevent major postoperative complications and improve the outcomes of millions of patients who undergo surgery each year.

Competing Interests

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Correspondence

Address correspondence to Dr. Sun: lsun@ottawaheart.ca

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