Prevention and treatment of acute kidney injury after cardiac surgery

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Abstract

Acute kidney injury (AKI) occurs frequently after cardiac surgery and is independently associated with increased mortality. The main cause of AKI in these patients is renal ischemia. However, data on the renal oxygenation, defined as the renal oxygen supply/demand relationship are lacking in clinical AKI, and the effects of various pharmacological interventions on renal oxygenation are not known.

Patients and methods: The effects of mannitol (n=10) and dopamine (n=12) on renal blood flow (RBF), glomerular filtration rate (GFR) and renal oxygenation were analysed in post-cardiac surgery patients using the renal vein thermodilution technique. Furthermore, RBF, GFR and renal oxygenation were studied in patients with AKI (n=12) and compared to postoperative patients with no renal impairment (n=37). Finally, the effects of norepinephrine-induced changes in mean arterial pressure (MAP) on renal variables were analysed in AKI patients (n=12) with vasodilatory shock.

Results: Mannitol increased GFR and the renal oxygen demand (RVO_2), while it had no effect on RBF. Mannitol, thus, pharmacologically improved the renal function at the cost of an impaired renal oxygenation. In contrast, dopamine redistributed blood flow to the kidney and increased RBF, but had no effect on GFR or RVO_2. Consequently, dopamine improved renal oxygenation. AKI patients had a 40% lower RBF and a 60 % lower net-sodium reabsorption and GFR compared to control patients. However, contrary to previous hypothesis, this decrease in reabsorptive workload was not accompanied with a decrease in RVO_2. Thus, renal oxygenation was severely impaired in AKI. The high RVO_2 correlated directly to the sodium reabsorption, consuming 2.4 times more oxygen for a certain amount of reabsorbed sodium in AKI compared to control. Restoration of MAP from 60–75 mmHg with norepinephrine, improved renal oxygen delivery, GFR and renal oxygenation in AKI patients. Increasing MAP to 90 mmHg had no further beneficial effect.

Conclusions: While mannitol improves GFR at the cost of an impaired renal oxygenation, dopamine, in contrast, improves renal oxygenation, but has no effect on GFR. Furthermore, renal oxygenation is severely impaired in AKI, due to renal vasoconstriction and sodium reabsorption at a high oxygen cost. Finally, norepinephrine improves GFR and renal oxygenation when used for treatment of hypotension.

Key words: Kidney failure, acute; glomerular filtration rate; renal circulation; oxygen consumption; cardiac surgery; mannitol; dopamine; norepinephrine; autoregulation.

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