Göteborg, 2018

Cardiopulmonary bypass and the kidney

Studies on patients undergoing cardiac surgery

Akademisk avhandling

Som för avläggande av medicine doktorsexamen vid Sahlgrenska akademin, Göteborgs universitet kommer att offentligen försvaras i sal Kammaren, Sahlgrenska Universitetssjukhuset, Göteborg, den 30 november, klockan 09.00

av Lukas Lannemyr

Fakultetsopponent:

Docent Henrik Bjursten

Institutionen för kliniska vetenskaper, Lunds Universitet, Lund, Sverige

Avhandlingen baseras på följande delarbeten

I. Lannemyr L, Lundin E, Reinsfelt B, Bragadottir G, Redfors B, Oras J, Ricksten SE. *Renal tubular injury during cardiopulmonary bypass as assessed by urinary release of N-acetyl-ß-D-glucosaminidase.* Acta Anaesth Scand. 2017;61(9):1075-1083.

II. Lannemyr L, Bragadottir G, Krumbholz V, Redfors B, Sellgren J, Ricksten SE. *Effects of Cardiopulmonary Bypass on Renal Perfusion, Filtration, and Oxygenation in Patients Undergoing Cardiac Surgery.* Anesthesiology, 2017;126(2):205-213.

III. Lannemyr L, Bragadottir G, Hjärpe A, Redfors B, Ricksten SE. *Impact of cardiopulmonary bypass flow on renal oxygenation in patients undergoing cardiac surgery.* Accepted for publication, Ann Thor Surg, August 2018.

IV. Lannemyr L, Ricksten SE, Rundqvist B, Andersson B, Bartfay SE, Ljungman C, Dahlberg P, Bergh N, Hjalmarsson C, Gilljam T, Bollano E, Karason K. *Differential effects of levosimendan and dobutamine on glomerular filtration rate in patients with heart failure and renal impairment: A randomized double-blind controlled trial.* J Am Heart Assoc 2018;7: e008455.

SAHLGRENSKA AKADEMIN
INSTITUTIONEN FÖR KLINISKA VETENSKAPER

GÖTEBORGS UNIVERSITET

Göteborg, 2018

Cardiopulmonary bypass and the kidney

Studies on patients undergoing cardiac surgery

Lukas Lannemyr

Department of Anesthesiology and Intensive Care Medicine,

Institute of Clinical Sciences
Sahlgrenska Academy, University of Gothenburg
Gothenburg, Sweden

Abstract

Acute kidney injury is a common complication after cardiac surgery with cardiopulmonary bypass (CPB), and has a major impact on morbidity, mortality and costs. The mechanism of CPB-related renal impairment is not fully understood. The aim of this thesis was to describe how CPB affects the kidneys, and whether increased CPB flow might improve renal oxygenation. In addition, we compared the systemic and renal effects of two inotropes in patients with impaired cardiac and renal function.

Methods: In patients undergoing cardiac surgery we used urine measurement of N-acetyl-β-D-glucosaminidase (NAG) to assess tubular cell injury (n=61). Renal vein catheterization was used to study renal blood flow, oxygenation, and filtration during normothermic CPB at 2.5 L/min/m^2 (n=18), and at different CPB flow levels (2.4, 2.7 and 3.0 L/min/m^2) applied in a randomized order (n=17). In 32 patients with cardiac and renal impairment, pulmonary artery and renal vein catheters were used to study the differential renal effects of levosimendan and dobutamine in a randomized blinded trial.

Results: NAG was elevated already after 30 minutes of CPB, and increased to a six-fold peak early after discontinuation of CPB. In a multivariate analysis, the duration of CPB and the degree of rewarming were independent predictors of peak NAG excretion. Renal oxygenation was impaired during CPB, mainly through reduced oxygen delivery due to hemodilution and renal vasoconstriction. After CPB, renal oxygenation was further impaired due to increased oxygen consumption and inefficient sodium transport. At higher than normal CPB flow rates, renal oxygen extraction was reduced by 12 – 23 %, at an unchanged filtration fraction, indicating that renal oxygenation was improved. In contrast to dobutamine, levosimendan did not only increase cardiac output and renal blood flow, but also increased the glomerular filtration rate by 22%.

Conclusions: Cardiopulmonary bypass impairs renal oxygenation due to renal vasoconstriction and hemodilution during and after cardiopulmonary bypass, accompanied by increased release of a tubular injury marker. The postoperative tubular injury is increased after longer CPB times and higher degree of rewarming. Increasing the CPB flow rate may ameliorate the impaired oxygenation seen during CPB. In patients with heart failure and renal impairment, levosimendan may be the inotrope of choice.

Keywords: cardiac surgery, cardiopulmonary bypass, glomerular filtration rate, renal blood flow, renal oxygenation, tubular injury, N-acetyl-β-D-glucosaminidase

ISBN: 978-91-7833-181-9 (TRYCK) http://hdl.handle.net/2077/56889
ISBN: 978-91-7833-182-6 (PDF)