Journal of Cardiothoracic and Vascular Anesthesia ▮ (▮▮▮▮) ▮▮▮–▮▮▮

Contents lists available at ScienceDirect

ScienceDirect

journal homepage: www.jcvaonline.com

Original Article

The Association Between Pulsatile Portal Flow and Acute Kidney Injury after Cardiac Surgery: A Retrospective Cohort Study

William Beaubien-Souligny, MD[*,1], Roberto Eljaiek, MD, MSc[*], Annik Fortier, MSc[†], Yoan Lamarche, MD, MSc[‡], Mark Liszkowski, MD[§], Josée Bouchard, MD[‖], André Y. Denault, MD, PhD[*]

[*]*Department of Anesthesiology and Intensive Care, Montreal Heart Institute, Montreal, Quebec, Canada*
[†]*Montreal Health Innovations Coordinating Center, Montreal Heart Institute, Montreal, Quebec, Canada*
[‡]*Department of Cardiac Surgery, Montreal Heart Institute, Montreal, Quebec, Canada*
[§]*Department of Cardiology, Montréal Heart Institute, Montreal, Quebec, Canada*
[‖]*Department of Nephrology, Hôpital Sacré-Coeur de Montréal, Montreal, Quebec, Canada*

Objective: Venous congestion is a possible mechanism leading to acute kidney injury (AKI) following cardiac surgery. Portal vein flow pulsatility is an echographic marker of cardiogenic portal hypertension and might identify clinically significant organ congestion. This exploratory study aims to assess if the presence of portal flow pulsatility measured by transthoracic echography in the postsurgical intensive care unit is associated with AKI after cardiac surgery.

Design: Retrospective cohort study.

Setting: Specialized care university hospital.

Participants: Patients who underwent cardiac surgery between May 2015 and February 2016 and had at least 1 Doppler assessment of portal flow performed by the attending critical care physician during the week following cardiac surgery.

Interventions: The association between portal flow pulsatility defined as a pulsatility fraction $\geq 50\%$ and the risk of subsequent AKI was assessed using univariate and multivariate logistic regression analysis.

Measurements and Main Results: The files of 132 consecutive patients were reviewed and 102 patients were included in the analysis. Significant portal flow pulsatility was detected in 38 patients (37.3%) in the week following surgery. During this period, 60.8% developed AKI and 13.7% progressed to severe AKI. The detection of portal flow pulsatility was associated with an increased risk for the development of AKI (odds ration [OR] 4.31, confidence interval [CI] 1.50-12.35, $p = 0.007$). After adjustment, portal flow pulsatility and AKI were independently associated (OR 4.88, CI 1.54-15.47, $p = 0.007$).

Conclusions: Assessment of portal flow using Doppler ultrasound at the bedside might be a promising tool to detect patients at risk for AKI due to cardiogenic venous congestion.

Key Words: cardiology and cardiac surgery; intensive care; heart failure; acute kidney injury; cardiorenal syndrome; point-of-care ultrasound

ACUTE KIDNEY INJURY (AKI) is a frequent complication following cardiac surgery. Severe AKI, defined as a Kidney Disease Improving Global Outcomes (KDIGO) stage ≥ 2, is encountered in 4% to 9% of patients.[1] AKI in this setting is an independent risk factor for death and development of end-stage renal disease.[2] The cardiorenal syndrome is a

André Y. Denault was the Speaker for Medtronic, Masimo and CAE Healthcare. The other authors have no conflict of interest to declare.

This study was supported by the Richard I. Kaufman Endowment Fund in Anesthesia and Critical Care and the Montreal Heart Institute Foundation. W. B.S. is supported by the Fonds de Recherche du Québec en Santé (FRQS).

[1]*Address reprint requests to* Dr William Beaubien-Souligny, Montreal Heart Institute, 5000 Belanger St, Montreal, Quebec H1T 1C8, Canada.

E-mail address: william.beaubien@gmail.com (W. Beaubien-Souligny).

https://doi.org/10.1053/j.jvca.2017.11.030
1053-0770/

major mechanism leading to AKI in the perioperative period.[3] While low cardiac output and low arterial pressure usually is presumed to be the principal driving factor responsible for the alteration of renal function, venous hypertension has been reported to be the most important predictor of worsening of renal function in congestive heart failure patients.[4,5] It was demonstrated in animal studies that venous hypertension decreases renal blood flow and glomerular filtration.[6–8] In patients undergoing cardiovascular surgery, high central venous pressure (CVP) after surgery has been associated with an increased risk of AKI.[9,10]

End-organ venous congestion is not easily measurable at the bedside. Absolute CVP measurements, beside jugular venous pressure estimation, peripheral edema, weight, and fluid balance remain the most commonly used tools to assess volume status. Point-of-care ultrasound is now enabling clinicians to perform Doppler assessments of the blood flow within intra-abdominal organs. Portal vein flow pulsatility is a marker of cardiogenic portal hypertension.[11–16] Normal flow in the portal system continuous toward the liver does not usually exhibit a wide variation of velocities through the cardiac cycle, which results in a flat to slightly undulating pattern on pulsed-wave Doppler.[17] Portal vein flow pulsatility occurs following the distension of the inferior vena cava, which then becomes non-compliant, resulting in the transmission of venous pressure variations during the cardiac cycle to intra-abdominal organs.[18] The presence of portal vein flow pulsatility could be a surrogate marker of venous congestion of other organs, such as the kidneys. In this exploratory study, the following hypothesis was explored: the presence of portal vein flow pulsatility after cardiac surgery is a risk factor for subsequent AKI.

Methods

Study Design

The authors performed a retrospective study at a specialized tertiary care university hospital. All cardiac surgery patients from May 2015 to February 2016 who had portal vein Doppler imaging by the end of postoperative day (POD) 7 were eligible. Screening was done in all patients who were under the care of an experienced intensive care physician with National Board Certification in critical care ultrasound from the American College of Chest Physicians during the study period (consecutive patients). Patients with stage 5 chronic kidney disease, AKI before surgery, with cirrhosis or portal vein thrombosis, who died within 12 hours after surgery, or who had a critical preoperative state were excluded. The latter was defined as aborted sudden death, preoperative cardiopulmonary resuscitation, preoperative positive-pressure ventilation, preoperative inotropes, or mechanical circulatory support. Portal vein flow Doppler assessment was performed at the bedside by the attending physician, and the difference between maximal and minimal velocities during the cardiac cycle was systematically documented. The medical team was not blinded to the Doppler results.

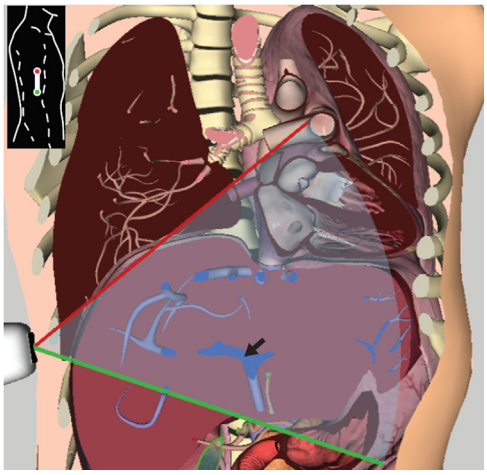

Fig 1. Portal vein position (*black arrow*) obtained from a posterior axillary view using the Vimedix simulator (CAE Healthcare, St-Laurent, Canada).

At the Montreal Heart Institute, informed consent for research purposes is obtained routinely from patients before surgery for data and ultrasound images recorded during hospitalization. The ethics committee of the Montreal Heart Institute approved the protocol of this study. Studies were performed in accordance with the Declaration of Helsinki and its later amendments.

Definitions

The technique of assessment of portal vein flow using bedside transthoracic echography has been described previously. The position of the probe and an example of the two-dimensional ultrasound image obtained is presented in Figures 1 and 2.[19] The pulsatility fraction (PF) is defined as:

$$PF(\%) = 100 * \left[(V_{Max} - V_{Min})/V_{Max}\right]$$

where V_{Max} is the maximal velocity and V_{Min} is the minimal velocity during the cardiac cycle. Portal vein flow pulsatility was defined as a PF of $\geq 50\%$ based on the available literature.[12–15,17] Examples of normal and pulsatile portal vein flow are presented in Figures 3 and 4. Among the studied patients, the PF was noted systematically in a specific portion

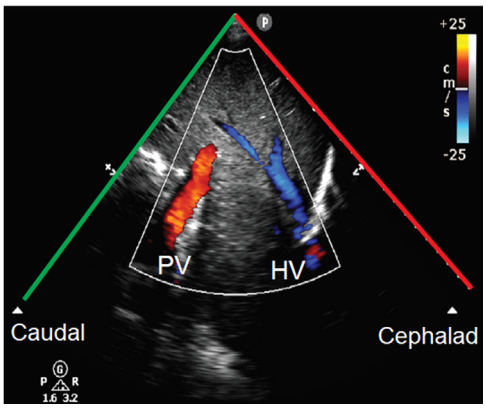

Fig 2. Transthoracic ultrasound with color Doppler showing the relative position the portal vein (PV) and hepatic vein (HV).