Vasoactive-ventilation-renal score reliably predicts hospital length of stay after surgery for congenital heart disease

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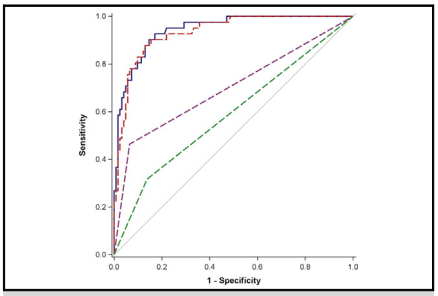
ABSTRACT

Objectives: We aimed to further validate the vasoactive-ventilation-renal score as a predictor of outcome in patients recovering from surgery for congenital heart disease. We also sought to determine the optimal time point within the early recovery period at which the vasoactive-ventilation-renal score should be measured.

Methods: We prospectively reviewed consecutive patients recovering from cardiac surgery within our intensive care unit between January 2015 and June 2015. The vasoactive-ventilation-renal score was calculated at 6, 12, 24, and 48 hours postoperatively as follows: vasoactive-ventilation-renal score = ventilation index + vasoactive-inotrope score + Δ creatinine [change in serum creatinine from baseline*10]. Primary outcome of interest was prolonged hospital length of stay, defined as length of stay in the upper 25%. Receiver operating characteristic curves were generated, and areas under the curve with 95% confidence intervals were calculated for all time points. Multivariable logistic regression modeling also was performed.

Results: We reviewed 164 patients with a median age of 9.25 months (interquartile range, 2.6-58 months). Median length of stay was 8 days (interquartile range, 5-17.5 days). The area under the curve value for the vasoactive-ventilation-renal score as a predictor of prolonged length of stay (>17.5 days) was greatest at 12 hours postoperatively (area under the curve = 0.93; 95% confidence interval, 0.89-0.97). On multivariable regression analysis, after adjustment for potential confounders, the 12-hour vasoactive-ventilation-renal score remained a strong predictor of prolonged hospital length of stay (odds ratio, 1.15; 95% confidence interval, 1.10-1.20).

Conclusions: In a heterogeneous population of patients undergoing surgery for congenital heart disease, the novel vasoactive-ventilation-renal score calculated in the early postoperative recovery period can be a strong predictor of prolonged hospital length of stay. (J Thorac Cardiovasc Surg 2016;■:1-7)



ROC curves for prolonged LOS and the multivariable model (*solid*) and its individual components (*dashed*).

Central Message

The VVR score is a novel measure that robustly predicts outcome after surgery for congenital heart disease.

Perspective

In this prospective study of patients undergoing surgery for congenital heart disease, the VVR score obtained 12 hours after ICU arrival was a strong predictor of clinical outcome. This novel score could prove to be a powerful tool for bedside assessment of illness severity and prognosis, triage of ICU resources, and stratification of clinical research subjects.

CONG

Scoring indices that can accurately reflect the severity of illness in critically ill patients can be extremely valuable in contemporary medicine, providing guidance in patient care (eg, triage, prognostication) and clinical research (eg, stratification). However, the development of a disease

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Abbreviations and Acronyms

AUC = area under the curve
CI = confidence interval
CVICU = cardiovascular intensive care unit
ECMO = extracorporeal membrane oxygenation
ICU = intensive care unit
IQR = interquartile range
LOS = length of stay
ROC = receiver operating characteristic
STAT = Society of Thoracic Surgeons-European Association for Cardio-Thoracic Surgery Congenital Heart Surgery
VI = ventilation index
VIS = vasoactive-inotrope score
VVR = vasoactive-ventilation-renal

severity index for children recovering from cardiac surgery has been somewhat elusive, in large part because of the inherent heterogeneity of anatomy and pathophysiology within this patient population. To this end, the novel vasoactive-ventilation-renal (VVR) score has recently demonstrated promise.[1,2] Specifically, the VVR calculated at 48 hours postoperatively has been shown to be a robust predictor of short-term clinical outcomes and has consistently outperformed the vasoactive inotrope score (VIS) and serum lactate, which have been used as more traditional measures of postoperative disease severity.[3-8]

Our previous studies of the VVR have had notable limitations. These studies have been restricted to patients aged less than 18 years who have required cardiopulmonary bypass. Adults undergoing surgery for congenital heart disease and children undergoing cardiac surgery without cardiopulmonary bypass (eg, systemic-to-pulmonary shunt, pulmonary artery banding) have been excluded. In addition, these prior reports focused only on VVR measurements obtained at admission, peak, and 48-hour measurements. Peak and 48-hour VVR measurements in particular were chosen for these initial studies because these measurements have been the focus of the majority of research on the VIS.[3-5] The clinical utility of measurements obtained at specific postoperative time points earlier in the postoperative course has not yet been determined. To address these gaps in what is known regarding the VVR, we sought to conduct a more inclusive prospective observational study examining the VVR score. We postulated that the VVR would continue to be more predictive of outcomes compared with the VIS and serum lactate in this broader population of patients recovering from surgery for congenital heart disease. We also sought to determine whether the VVR obtained at distinct time points earlier in the postoperative period, which would have more practical clinical value, would be as predictive of postoperative outcomes as the VVR calculated at 48 hours.

PATIENTS AND METHODS

Patient Population

This prospective observational validation study was approved by the Institutional Review Board within the Office of Research Compliance at Indiana University. Because of the observational nature of the study, consent was waived by the Institutional Review Board. All patients admitted to the cardiovascular intensive care unit (CVICU) at Riley Hospital for Children in Indianapolis, Indiana, from January 1, 2015, to June 30, 2015, were prospectively reviewed. Patients who required extracorporeal membrane oxygenation (ECMO) for the first 48 hours of CVICU admission were excluded, because their vasoactive medication regimens and ventilator requirements would not be reflective of their underlying disease severity but rather of the mechanical support provided by the extracorporeal circuit. All other patients were followed throughout their clinical courses and included in all analyses.

Data Collection

Preoperative and perioperative data collected included age, anthropometric measurements at time of surgery, anatomic diagnosis and procedure performed, Society of Thoracic Surgeons-European Association for Cardio-Thoracic Surgery Congenital Heart Surgery (STAT) mortality category,[9] cardiopulmonary bypass duration, aortic cross-clamp duration, duration of hypothermic circulatory arrest if used, and preoperative serum creatinine values. All arterial blood gas and lactate measurements (which are performed simultaneously using point-of-care testing) obtained during the first 48 postoperative hours were recorded daily by study personnel, along with the ventilator support at the time of each measurement, which included respiratory rate, fraction of inspired oxygen, peak inspiratory pressure, positive end-expiratory pressure, and mean airway pressure. Patients at our institution are typically managed postoperatively with synchronized intermittent mandatory ventilation/pressure-regulated volume control and typically extubated, at the discretion of the primary care team, from mechanical ventilator support when breathing comfortably with good gas exchange and without metabolic acidosis on the following ventilator settings: respiratory rate 10 breaths per minute or less, pressure support 10 cm H_2O or less, positive end-expiratory pressure 5 cm H_2O or less, and fraction of inspired oxygen concentration 0.4 or less. Doses of inotropic and vasopressor medications (eg, dopamine, dobutamine, epinephrine, norepinephrine, milrinone, and vasopressin) at the time of each arterial blood gas measurement also were recorded. Last, serum creatinine values obtained on admission, postoperative day 1, and postoperative day 2 were recorded.

Derivation of the Vasoactive Ventilation Renal Score

Throughout each patient's hospital course, we calculated the patient's VIS at the time of each postoperative arterial blood gas measurement. The VIS was calculated in the following manner[3]:

$$\begin{aligned}\text{VIS} = {} & \text{dopamine dose (mcg/kg/min)} + \text{dobutamine dose} \\ & \text{(mcg/kg/min)} + 100 * \text{epinephrine dose (mcg/kg/min)} + 10 * \\ & \text{milrinone dose (mcg/kg/min)} + 10{,}000 * \text{vasopressin dose} \\ & \text{(U/kg/min)} + 100 * \text{norepinephrine dose (mcg/kg/min)}\end{aligned}$$