Adult Vasoactive-Inotropic Score Predicts Mortality in Adult Patients with Shock

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Abstract

Background: Several mortality-predicting scores for hypotensive patients have been developed. However, they have not been thoroughly evaluated in the adult population. Currently, the best-known score for similar purposes is the vasoactive inotropic score (VIS), which is rarely used in clinical practice and was only designed for pediatric patients following cardiac surgery. There are no mortality prediction scores for circulatory shock currently in use for adult patients. Our aim is to develop and assess an effective mortality prediction score for circulatory shock to use in the adult population.

Methods: We used the Multiparameter Intelligent Monitoring in Intensive Care III (MIMIC III) database to retrospectively evaluate data for patients admitted to an intensive care unit with a diagnosis of shock undergoing treatment with vasopressor or inotropic agents. We developed an approximated mortality score using expert opinion and derivation of previously published shock mortality prediction data. The mortality score was calculated for each patient in the last 24 hours and then evaluated for the primary outcome of mortality during their stay. Patients were divided into two groups based on mortality, and a binary linear regression was performed.

Results: Mortality score calculated for 720 patients using linear analysis was statistically significant at a p-value of 1.83 x 10^-12.

Conclusion: This score assists in the evaluation of complex circulatory shock patients undergoing treatment using a variety of vasopressor and/or inotropic agents. The primary implication in clinical practice is to help guide resource allocation to the patients who are most in need based on a predictive model of prognosis. This has an advantage over the current VIS of no longer being limited to pediatrics. The ability for clinicians to rapidly assess the condition of patients in shock will allow for more effective care administration to the patients in the most emergent condition.

Introduction

Patients admitted to the intensive care unit (ICU) are either in critical condition or suffer acute disturbances resulting from surgery (1). Several postoperative diagnostic scoring systems have been developed to predict the clinical course of these patients and the necessary pharmacologic intervention. A scoring system tested by Wernovsky et al. used an inotropic scoring system to measure the needed pharmacologic intervention in post-heart-surgery neonates and infants (2). Although designed to apply to neonates/infants, the Wernovsky scoring system has been used in clinical practice in pediatric populations (3). The implementation of a clinically significant predictor scoring system could assist physicians and staff in directing patient care in ways that could improve outcomes.

The unknown efficacy of an inotropic scoring system in pediatric populations was explored by Gais et al. by the creation of the vasoactive inotropic score (VIS) (3). The VIS scoring system expanded upon the Wernovsky score by incorporating medications commonly used in clinical practice with the finding that a maximum VIS score in the first 24 hours had a significant correlation with increased morbidity and mortality. These findings were elucidated in a previous study by Gais on the association of the VIS scoring system with the clinical outcomes in children <6 months of age undergoing cardiac surgery with cardiopulmonary bypass using a multicenter analysis of data reported to the Pediatric Cardiac Critical Care Consortium (4). The results of the previous studies indicate that the VIS scoring system is an effective predictor of clinical outcome in pediatric populations.

Although the VIS scoring system is currently the best-known inotrope scoring system available, its applicability has been limited to pediatric patients following cardiac surgery and has not been thoroughly evaluated in adult patients. A study by Yamazaki et al. assessed VIS as a predictor of morbidity and mortality in adult cardiac surgery (5). They concluded that a high VIS score was associated with a poor outcome, including longer ICU stay and ventilation time. The study was, however, limited to patients who underwent cardiopulmonary bypass surgery. Na et al. also investigated VIS in nonsurgical cardiogenic shock patients and found an association between high levels of vasoactive inotropic support and in-hospital mortality (6). While the use of the VIS scoring system looks promising in adults, further evaluation is needed. This study aims to assess the association between the VIS scores and clinical outcomes in adult ICU patients undergoing both surgical and non-surgical hypotensive shock.

Methods

Study design and setting

This was a retrospective data analysis using data gathered through the Multiparameter Intelligent Monitoring in Intensive Care III (MIMIC III) database of adult patients admitted to the ICU at Beth Israel Deaconess Medical Center in Boston, MA. Data from MIMIC III was stored and extracted using PostgreSQL (7). An approximated mortality score was made using expert opinion and derivation of previously published shock mortality scores. Patients were excluded from the analysis if one of the following criteria were met: 1) Mean arterial pressure (MAP) was not recorded; 2) Vasopressors were not used in the treatment of the patient; 3) Patient was not treated in the ICU. After filtering the patient data based on these criteria, the data of 720 patients was used.

Clinical endpoints and outcome variables

The clinical endpoint was defined as patient mortality which marked the point at which data collection for that patient was terminated.

Statistical analysis

Shock score was calculated using Equation 1 shown below. In order to use the equation, a recording of MAP was required. Prior to the analysis, if MAP recordings were not taken, the entirety of the data set was removed. Shock predictor scores were divided into quartiles and patient mortality per quartile was measured. Using R (v3.5.2, The R Foundation)8 a Pearson's chi-square analysis was completed on the cumulative average shock predictor score per patient, as well as the average shock predictor score in the last 12, and 24 hours in their respective tables. The Pearson’s Chi-squared test was used to determine if a correlation existed between shock predictor score in these three groups (cumulative average, last 12 hours, and last 24 hours) and patient mortality.

A logistic binomial regression was then performed on these values to define the relationship between shock predictor score and patient mortality. A logistic binomial regression was completed on the cumulative average shock predictor score per patient. The shock scores of the last 12 hours per patient were averaged and then a logistic binomial regression was run to determine if there was an association between the average scores in the last 12 hours and mortality. This process was then repeated for the last 24 hours as well.

Equation 1: 20*(rate at which norepinephrine was given in mic/min + the rate at which epinephrine was given in mic/min + 2*(MAP - 65))

Results

The distribution of the AVIS score is approximately uniform (Figure 1); however, as this analysis is the first to be conducted on this assessment tool, the data was divided into equal quartiles in order to reduce bias and the complex intricacies of the data (Table 1). A chi-square test of homogeneity was performed at α = 0.05, which indicated a significant difference in the rate of patient mortality among the 4 quartiles (p < 0.001). The results indicate lower AVIS scores are associated with a higher rate of patient mortality, specifically in the lowest quartile which demonstrated an approximate 23% mortality

AVIS vs. patient mortality in last 24 hours

AVIS	No Mortality	Mortality
Q1 (≤ 5.33)	149	45
Q2 (> 5.33 & ≤ 19.6)	186	8
Q3 (> 19.6 & ≤ 37.7)	189	6
Q4 (> 37.7)	186	8
$\chi^2 = 69.869, p = 4.554 \times 10^{-15}$		

Table 1: AVIS score quartiles compared with patient mortality

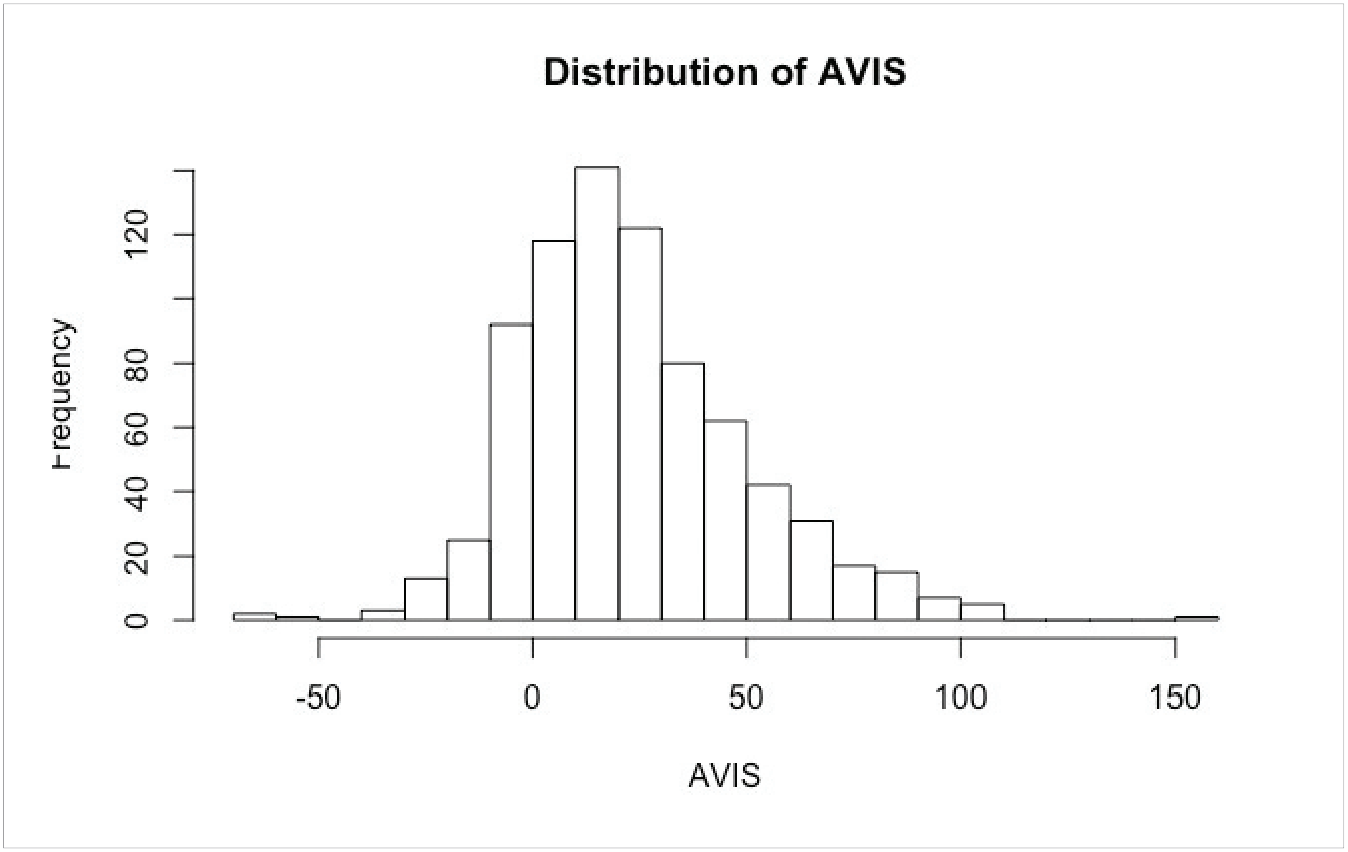

Figure 1: Frequency of AVIS scores from included patients

among the cohort. To capture the extent of this association within the continuity of the AVIS score, an odds ratio analysis with a 95% confidence interval indicated a 5% reduction in the odds of mortality as the AVIS score increased by one point (OR = 0.949).

Discussion

The goal of this study was to assess the utility of employing a modified VIS in order to determine an increased risk of mortality in the setting of an ICU. Using the framework of a previously developed score to evaluate the need for pharmacologic intervention in pediatric postoperative cardiac cases, we applied a similar set of parameters to quantify the risk of mortality in shock patients. Using the AVIS equation, AVIS = norepinephrine mic/min + epinephrine mic/min + (MAP 65) x 2, we retrospectively measured the use of these guidelines with lower scores indicating a worse prognosis. With this methodology, patients with a lower AVIS score had a six-fold higher likelihood of death within the first 24 hours of admission to the ICU with shock. This demonstrates that this score can aid physicians in rapidly considering the needs of a patient in the ICU or their probability of dying once admitted.

A review of current critical care literature illustrates a large gap in objective scoring systems to assess the risk of mortality in patients admitted to the ICU. The transparency and comprehensive documentation permitted with electronic medical records (EMR) will likely drive the advancement of further scoring systems like AVIS. Current clinical assessment tools include APACHE (Acute Physiology and Chronic Health Evaluation), MPM (mortality probability model), and SAPS (simplified acute physiology score) (9). While these tools are useful guidelines, they provide only general information regarding the length of stay and risk of mortality and subtleties between patient populations and data lead to different efficacy in the clinical space.

It is also documented that using scoring systems improves the efficiency of clinical practice. ICUs are inundated with increasing patient volumes and limited resources. The United States spends approximately $80 billion per year in the ICU alone. With increasing demands, intensivists are pressed to make difficult decisions in allocating care. Utilizing a scoring system can make difficult subjective decisions on care plans objective and efficient. Studies have demonstrated that employing scoring systems such as APACHE improve the efficiency of a hospital setting (10).

However, comprehensive meta-analysis studies assessing the accuracy and usefulness of these scoring systems or creating new ones are limited. There are data from Castella et al. suggesting that newer parameters being assessed in the APACHE, SAPS, and MPM scoring systems leads to improved discrimination inadequately assessing a patient's risk of mortality within the first 24 hours of a hospital stay (11). The lack of updated data over the past 20 years regarding this facet of intensive care emphasizes the need to create new scoring systems, and comprehensive studies need to be investigated to improve the care of our ICU patients.

Furthermore, none of these studies directly assess the risk of mortality in patients experiencing shock. Septic shock is the admitting diagnosis in 10% of patients to the ICU with an additional 8% developing septic shock during their stay (11). David Berg et al. demonstrated that of the admissions to the cardiac ICU, 22% of patients met criteria for shock (12). These figures have increased dramatically over the past 20 years, showing that rapid assessment of a patient's status will be crucial now and in the future. There is very little data regarding objective assessment of the severity of a patient's condition regarding shock. This illustrates the need for further studies like ours to assess the value of scoring systems and to begin implementation so as to better care for critically ill patients.

This study was intended to be a preliminary investigation into the application of the AVIS score for adult patients. As this is a preliminary study applied retrospectively to patients, there is a need to evaluate these data further in a clinical study employed in an ICU setting. Future developments of this study also necessitate establishing stricter scoring boundaries to apply to AVIS system. It is important to determine clinically significant restrictions in using these scoring systems to refine and maximize their use in the hospital. As in the study, the cutoff guidelines were made arbitrarily.

Furthermore, shock is often one problem amid a storm of medical problems that plague patients upon entry into the ICU. While the AVIS yielded promising data regarding its value in assessing the risk of mortality in shock patients, it does not factor in other medical maladies or treatment plans being employed on the same patients. Therefore, further studies must be conducted to evaluate the utility of the AVIS scoring system when a patient is experiencing multiple comorbid conditions.

Conclusion

In this study, we investigated the use of a previously developed scoring system to assess the mortality of pediatric patients after cardiac surgery. Using a modified version of this tool, AVIS, we retrospectively applied this formulation and scoring system to ICU patients in order to discover if lower scores were indicative of a higher risk of mortality. Our data demonstrated that lower AVIS scores inversely correlated with a higher risk of mortality in admitted ICU patients. This study illustrates that future studies such as these can assist clinicians in rapidly and objectively assessing the severity of a patient's condition and allocated resources accordingly or adjust treatments as indicated.

Acknowledgments

All data were collected by Khaled Sorour, MD, with affiliations with Harvard Medical School and Deaconess Medical Center.

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