Morbidity and mortality prediction in pediatric heart surgery: Physiological profiles and surgical complexity

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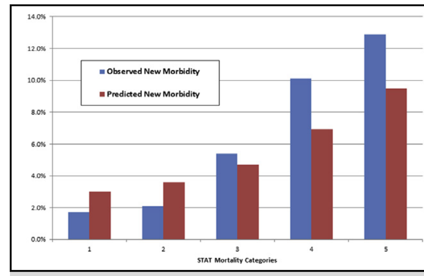
ABSTRACT

Objectives: Outcome prediction for pediatric heart surgery has focused on mortality but mortality has been significantly reduced over the past 2 decades. Clinical care practices now emphasize reducing morbidity. Physiology-based profiles assessed by the Pediatric Risk of Mortality (PRISM) score are associated with new significant functional morbidity detected at hospital discharge. Our aims were to assess the relationship between new functional morbidity and surgical risk categories (Risk Adjustment for Congenital Heart Surgery [RACHS] and Society for Thoracic Surgery Congenital Heart Surgery Database Mortality Risk [STAT]), measure the performance of 3-level (intact survival, survival with new functional morbidity, or death) and 2-level (survival or death) PRISM prediction algorithms, and assess whether including RACHS or STAT complexity categories improves the PRISM predictive performance.

Methods: Patients (newborn to age 18 years) were randomly selected from 7 sites (December 2011-April 2013). Morbidity (using the Functional Status Scale) and mortality were assessed at hospital discharge. The most recently published PRISM algorithms were tested for goodness of fit, and discrimination with and without the RACHS and STAT complexity categories.

Results: The mortality rate in the 1550 patients was 3.2%. Significant new functional morbidity rate occurred in 4.8%, increasing from 1.8% to 13.9%, 1.7%, and 12.9% from the lowest to the highest RACHS and STAT categories, respectively. The 3-level and 2-level PRISM models had satisfactory goodness of fit and substantial discriminative ability. Inclusion of RACHS and STAT complexity categories did not improve model performance.

Conclusions: Both mortality and new, functional morbidity are important outcomes associated with surgical complexity and can be predicted using PRISM algorithms. Adding surgical complexity to the physiologic profiles does not improve predictor performance. (J Thorac Cardiovasc Surg 2017;154:620-8)



New functional status morbidity increases with Society for Thoracic Surgery Congenital Heart Surgery Database Mortality Risk score mortality categories and can be accurately predicted.

Central Message

New, functional morbidity is associated with surgical complexity and can be predicted with mortality by a physiology-based algorithm.

Perspective

Mortality is infrequent, whereas new functional morbidity at hospital discharge is common, after congenital heart surgery. Studies focused on mortality may miss meaningful clinical issues and require large samples. We found that new functional morbidity at hospital discharge as well as mortality increased with increasing surgical risk and can be simultaneously predicted by a physiology-based algorithm.

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Outcome prediction for critically ill children following congenital heart surgery has centered on operative mortality. One prominent approach uses the anatomic diagnosis and/or specific operation performed for palliation or repair as the core risk-adjustment methodology. The Risk Adjustment for Congenital Heart Surgery (RACHS) score relies

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Abbreviations and Acronyms

AUC	= area under the curve
FSS	= Functional Status Scale
ICU	= Intensive care unit
PICSIM	= Pediatric Index of Cardiac Surgical Intensive Care Mortality
PRISM	= Pediatric Risk of Mortality
RACHS	= Risk Adjustment for Congenital Heart Surgery
ROC	= receiver operating characteristic
STAT	= Society for Thoracic Surgery Congenital Heart Surgery Database Mortality Risk
STS-CHSD	= Society for Thoracic Surgery Congenital Heart Surgery Database
TOPICC	= Trichotomous Outcome Prediction in Critical Care
VUS	= volume under the surface

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on subjective assessments of operative risk and cardiac anatomy by congenital heart surgeons and pediatric cardiologists.[1] The most recent method, the 2014 Society for Thoracic Surgery Congenital Heart Surgery Database (STS-CHSD) Mortality Risk (STAT) model, estimates risk by calculating an expected rate of mortality that accounts for the operation performed and a number of preoperative variables.[2,3] Mortality risks for individuals are computed using the risk of each combination of primary procedure, age group, and other cofactors to adjust for individual patient factors. Recently, these cofactors have expanded to include preoperative intensive care unit (ICU) clinical factors and therapies.[4] The risk for inpatient morbidity has been similarly developed.[5] This approach is the foundation for a major quality program.[3,6]

Physiology-based severity of illness methods used in adult, pediatric, and neonatal intensive care for decades have also centered on mortality.[7-10] The Pediatric Risk of Mortality (PRISM) score is a frequently used, physiology-based measure that assigns numeric values reflective of mortality risk to derangements of 17 commonly measured physiologic variables. The PRISM score is the summation of these values, whereas mortality risk is computed using the PRISM score and other cofactors.[8] The numeric PRISM score is termed severity of illness.[11] PRISM has been a foundation of national quality programs. It has performed well in congenital heart surgery patients consistent with the observation that postprocedure physiological status reflects mortality risk.[8] Recently, PRISM has undergone a revision of its data collection methods.[12,13] Most importantly, the PRISM outcome algorithm estimates simultaneously the risk of new functional morbidity as well as mortality at hospital discharge.[13] PRISM algorithms are also available for estimation of mortality risk alone.[12] PRISM prediction algorithms have not been rigorously assessed in a modern cohort of congenital heart surgery patients.

A third approach for pediatric risk assessment is based on general and targeted categorical variables, and a limited set of physiologic variables and therapies. The Pediatric Index of Cardiac Surgical Intensive Care Mortality (PICSIM)[14] overlaps with the Pediatric Index of Mortality, which did not perform well in cardiac surgery patients.[15,16] Because most of the PICSIM predictive power comes from the surgical complexity score, its use to assess intensive care quality is limited.[17]

Mortality rates in pediatric heart surgery and critical care are low and decreasing, with rates reported to be <4%.[2,14,18] Yet, modern risk assessment methods continue to focus on operative or intensive care mortality. In contrast, new morbidity rates assessed as functional status changes in critically ill children measured at hospital discharge are approximately twice as high as mortality rates and it has been suggested that functional morbidity is replacing mortality.[19] Recently, the Eunice Kennedy Shriver National Institute of Child Health and Human Development Collaborative Pediatric Critical Care Research Network developed a granular measure of functional morbidity that is age independent and sufficiently rapid, accurate, and reliable for population-based outcome studies.[20] This method, the Functional Status Scale (FSS), is a significant improvement over common subjective scales.[21,22] Importantly, we recently demonstrated that the development of new functional status morbidities was associated with physiological status early in the ICU course in a manner that parallels the association between physiological status and mortality. Further, we demonstrated that we could simultaneously estimate the risk of both functional morbidity and mortality from data obtained during the first 4 hours of intensive care.[13]

The analyses described in this article had 3 specific aims. Our first aim was to examine how the risk of developing new, significant functional morbidity was associated with levels of a physiology-based score, and with the risk categories of the RACHS and STAT scores. Second, we assessed the performance of the recently published 3-level PRISM prediction algorithms (ie, death; survival with new, significant functional morbidity; and survival without new, significant