Accuracy of the Aristotle Basic Complexity Score for Classifying the Mortality and Morbidity Potential of Congenital Heart Surgery Operations

Sean M. O'Brien, PhD, Jeffrey P. Jacobs, MD, David R. Clarke, MD, Bohdan Maruszewski, MD, PhD, Marshall L. Jacobs, MD, Henry L. Walters III, MD, Christo I. Tchervenkov, MD, Karl F. Welke, MD, Zdzislaw Tobota, MD, Giovanni Stellin, MD, Constantine Mavroudis, MD, J. R. Leslie Hamilton, FRCS, J. William Gaynor, MD, Marco Pozzi, MD, and Francois G. Lacour-Gayet, MD

Duke University Medical Center, Durham, North Carolina; The Congenital Heart Institute of Florida (CHIF) and Cardiac Surgical Associates (CSA), All Children's Hospital and Children's Hospital of Tampa, University of South Florida, Saint Petersburg and Tampa, Florida; Children's Hospital, Denver, Colorado; Memorial Hospital Child's Health Centre, Warsaw, Poland; St. Christopher's Hospital for Children, Philadelphia, Pennsylvania; Wayne State University School of Medicine, Detroit, Michigan; Montreal Children's Hospital, Montreal, Quebec, Canada; Division of Cardiothoracic Surgery, Oregon Health and Science University, Portland, Oregon; Children's Memorial Health Institute, Warsaw, Poland; Policlinico Universita, Padova, Italy; Children's Memorial Hospital, Chicago, Illinois; Freeman Hospital, Newcastle Upon Tyne, United Kingdom; The Children's Hospital of Philadelphia, Philadelphia, Pennsylvania; Royal Liverpool Children's Hospital Alder Hey, Liverpool, United Kingdom; and Children's Hospital Heart Institute, Denver, Colorado

Background. **The Aristotle Basic Complexity Score (ABC score) was derived by consensus of an international surgeon panel to facilitate assessment of surgical performance for quality improvement in congenital heart surgery. The utility of the ABC score depends on its ability to correctly classify procedures according to their potential for morbidity, mortality, and technical difficulty. This collaborative study combined two multiinstitution databases to assess how well the ABC score predicts the actual morbidity and mortality potential of 131 congenital heart surgery procedures.**

Methods. **Data from the European Association of Cardiothoracic Surgery (EACTS) congenital database (17,838 operations, 56 centers) and the Society of Thoracic Surgeons (STS) congenital database (18,024 operations, 32 centers) were analyzed. Discrimination of the ABC score for predicting in-hospital mortality and postoperative length of stay (PLOS) of more than 21 days was quantified by the C statistic. Procedure-specific rates of mortality and prolonged PLOS were compared with predictions from a logistic regression model, and an exact binomial test was used to identify procedures that were mortality and morbidity outliers.**

Results. **There was a significant positive correlation between the ABC score of a procedure and its observed procedure-specific risk of mortality (C = 0.70) and prolonged PLOS (C = 0.67). Several individual procedures were identifed as mortality and morbidity outliers.**

Conclusions. **The ABC score generally discriminates between low-risk and high-risk congenital procedures making it a potentially useful covariate for case-mix adjustment in congenital heart surgery outcomes analysis. Planned revisions of the ABC score will incorporate empirical data and will benefit from the large sample sizes of the STS and EACTS databases.**

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The evaluation of the quality of care delivered to patients with congenital heart disease relies heavily on the analysis of outcomes. Yet, the analysis of congenital heart surgery outcomes is challenging owing to the large number of surgical procedures that vary in complexity. One method that has been proposed for complexity-adjusted outcomes analysis is known as the Aristotle Basic Complexity Score (ABC score) [1–3].

The ABC score expresses the case complexity of congenital heart surgery procedures based on three components: the potential for mortality, the potential for morbidity, and the technical difficulty of the procedure. The grading of individual procedures was subjectively determined and represents the consensus opinion of 50 surgeon experts. Since 2002, this methodology has been used by both the Society of Thoracic Surgeons (STS) and the European

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Address correspondence to Dr O'Brien, Box 17969, Duke Clinical Research Institute, Durham, NC 27715; e-mail: obrie027@mc.duke.edu.

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Association of Cardiothoracic Surgery (EACTS) in their yearly analysis and reporting of outcomes for a current aggregate of more than 80,000 operations [4–7].

The utility of the ABC score depends on its ability to correctly classify procedures according to their potential for morbidity, mortality, and technical difficulty. Although the difficulty of a procedure is inherently subjective and difficult to validate, the accuracy of the ABC score with respect to mortality and morbidity can be objectively determined for procedures with adequate sample size. Previous efforts to determine the mortality and morbidity potential of congenital heart procedures were hindered by the large number of procedures with small patient sample sizes. Since 1998, however, the STS and EACTS databases have grown substantially. We combined these two large multiinstitution databases to assess how well the ABC score predicts the actual morbidity and mortality potential of 131 congenital heart surgery procedures.

Material and Methods

Data Sources

The STS Congenital Heart Surgery Database was established in 1994 to measure clinical performance and report outcomes of congenital heart surgery operations [8]. As of 2005, the database included 34 participating centers and contained clinical data on more than 35,000 operations. The EACTS Congenital Heart Surgery Database was established in 1992 and is the largest European congenital heart surgery database, containing data on more than 40,000 operations from 88 participating centers [4, 6, 7].

The STS and EACTS Congenital Databases identify procedures by a common nomenclature published by the International Congenital Heart Surgery Nomenclature and Database Project [9, 10]. Participation in the EACTS and STS Congenital Databases is voluntary. An ongoing audit program assesses data accuracy in the EACTS database [6, 7, 11], and similar efforts are planned for the STS database. Linking of data elements in STS and EACTS is possible owing to the use of a common nomenclature and compatible data elements.

Patient Population

The study population consisted of patients undergoing cardiovascular operations who were admitted to hospitals participating in the STS or EACTS databases between January 1, 2002, and December 31, 2004. The data for 568 patients from two hospitals were excluded because these hospitals did not report discharge mortality during the study period. An initial data set was created by including all operations coded as type "CPB" (cardiopulmonary bypass) or "No-CPB cardiovascular" and excluding operations of type "thoracic," "ECMO" (extracorporeal membrane oxygenation), "interventional cardiology," or "other." To avoid double-counting mortality, only the first operation for each admission was retained. From the resultant data set (initial operations of a hospitalization that were CPB or No-CPB cardiovascular), operations were selected if they involved one of the cardiovascular procedures (listed in Table 1) for which the ABC score is defined.

Although the ABC score is actually defined for 132 cardiovascular procedures, there were no instances of a "Fontan, atrioventricular connection" in the STS or EACTS databases during the study period; thus, the analysis was limited to 131 procedures. Other procedures not on this list were included if they were done during the same operation with one of the procedures on the list.

In addition to the cardiovascular procedures listed in Table 1, the ABC score is also defined for 13 noncardiovascular procedures (Table 2) that were excluded from the analysis owing to their noncardiovascular focus. The decision to exclude noncardiovascular procedures was made prospectively before the data were analyzed.

Patients that weighed 2500 grams or less undergoing patent ductus arteriosus ligation as their primary procedure were also excluded from the analysis because they are not included in mortality calculations in the EACTS and STS Congenital Database reports [12].

The final study population consisted of 18,024 operations from 32 centers in the STS database and 17,838 operations from 56 centers in the EACTS database for a total of 35,862 operations.

End Points

The study focused on two endpoints: (1) in-hospital mortality, defined as death during the same hospitalization as the operation regardless of cause; and (2) prolonged postoperative length of hospital stay (PLOS) defined as a PLOS exceeding 21 days. Prolonged PLOS was regarded as a very general proxy measure of morbidity. Other measures of morbidity had high rates (>10%) of missing data (eg, length of mechanical ventilation time and complications such as stroke, renal failure, and heart block) or are not tracked by the database (eg, intensive care unit LOS) and were therefore not analyzed.

Aristotle Scoring System

In creating the ABC scoring system, 145 congenital procedures were subjectively graded on three components: mortality potential, morbidity potential, technical difficulty. Each component received a score of between 0.5 and 5 points. The ABC was defined as the sum of the three components: overall ABC score = mortality component + morbidity component + technical difficulty component. The overall ABC score ranges from 1.5 to 15 points, with larger scores indicating greater overall complexity.

Classification of Multiple-Procedure Operations

Operations were classified according to the 131 procedure types listed in column 1 of Table 1. Operations involving two or more procedures done concurrently were assigned to the procedure having the highest ABC score. In case of a tie, the operation was assigned to the procedure that was designated as the primary procedure by the surgeon performing the operation. If no procedure was designated as primary, or if two or more procedures

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