Revisiting the utility of technical performance scores following tetralogy of Fallot repair

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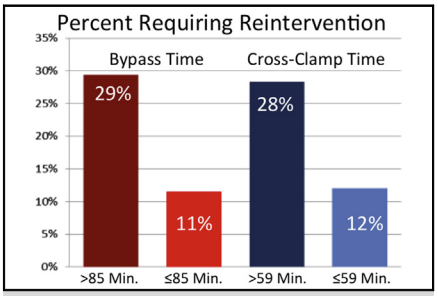
ABSTRACT

Objective: Although an important quality metric, current technical performance scores may not be generalizable and may omit operative factors that influence outcomes. We examined factors not included in current technical performance scores that may contribute to increased postoperative length of stay, major complications, and cost after primary repair of tetralogy of Fallot.

Methods: This is a retrospective single site study of patients younger than age 2 years with tetralogy of Fallot undergoing complete repair between 2007 and 2015. Medical record data and discharge echocardiograms were reviewed to ascertain component and composite technical performance scores. Primary outcomes included postoperative length of stay, major complications, and total hospital costs. Multivariable logistic and linear regression identified determinants of each outcome.

Results: Patient population (n = 115) had a median postoperative length of stay of 8 days (interquartile range, 6-10 days), and a median total cost of $71,147. Major complications occurred in 33 patients (29%) with 1 death. Technical performance scores assigned were optimum in 28 patients (25%), adequate in 59 patients (52%), and inadequate in 26 patients (23%). Neither technical performance score components nor composite scores were associated with increased postoperative length of stay. Optimum or adequate repairs versus inadequate had equal risk of a complication ($P = .79$), and equivalent mean total cost ($100,000 vs $187,000; $P = .25$). Longer cardiopulmonary bypass time per 1-minute increase ($P < .01$) was associated with longer postoperative length of stay and reintervention ($P = .02$). The need to return to bypass also increased total cost ($P < .01$).

Conclusions: Current tetralogy of Fallot technical performance scores were not associated with selected outcomes in our postoperative population. Although returning to bypass and bypass length are not included as components in the current score, these are important factors influencing complications and resource use in our population. Revisions anticipated from a prospective trial should consider including these variables. (J Thorac Cardiovasc Surg 2017;154:585-95)



Percent of tetralogy of Fallot cases with reintervention during index hospitalization after repair stratified by cardiopulmonary bypass time and crossclamp time.

Central Message

Important factors that influence patient outcomes are not included in the current technical performance scores for tetralogy of Fallot repair.

Perspective

This study demonstrates that currently available technical performance scores for tetralogy of Fallot may lack generalizability. Specific operative characteristics, such as the length of cardiopulmonary bypass and crossclamp times, and the need to return to bypass, although resulting in the same reported score, influence clinical outcomes differently.

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Tetralogy of Fallot (TOF) is among the benchmark operations in congenital heart surgery, with excellent short- and long-term contemporary outcomes.[1] Surgical repair has evolved from an initial strategy of complete relief of right

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Abbreviations and Acronyms

CPB = cardiopulmonary bypass
DORV = double-outlet right ventricular
POLOS = postoperative length of stay
RVOT = right ventricular outflow tract
RVOTO = right ventricular outflow tract obstruction
TOF = tetralogy of Fallot
TPS = technical performance score
VSD = ventricular septal defect

ventricular outflow tract obstruction (RVOTO) with consequent free pulmonary insufficiency to a strategy of valve-preservation and permissive mild pulmonary valvular stenosis. A technical performance score (TPS) for the subdomains of TOF repair, as originally described by Larrazabal and colleagues in 2007,[2] has likewise evolved. The original lexicon specified no residual stenosis as optimal and any mild residual gradient of $\leq$ 40 mm Hg as adequate. Subsequent iterations of the TPS for the subdomains of RVOTO specified an optimal repair as a gradient $<$ 2.2 m/s across the subpulmonary area and a gradient or $<$ 2.0 m/s across the pulmonary valve itself.[3,4] The original description of an optimum status of the right ventricular outflow tract (RVOT) following correction, therefore, may not actually reflect the best physiologic repair. Moreover, whereas the TPS represents an important metric to objectively assess the quality of surgical repairs and has been correlated with specific short-term outcomes, our group,[5] and others,[6] have commented on the limitations of the current TPS. One of these critical assumptions is the premise that the final result (ie, TPS composite score) is equivalent regardless of the amount of time necessary to achieve it or the number of tries necessary. Indeed, the recently launched Pediatric Heart Network-sponsored Residual Lesions Trial endeavors to address many of these shortcomings.

The objectives of this study, therefore, were to determine whether the currently available TPS for TOF are associated with purported clinical outcomes, including reintervention, morbidity, and cost (ie, determine generalizability with the current score) in infants undergoing complete repair of TOF and to determine whether there are additional intraoperative factors not currently captured by the TPS that are associated with these same outcomes (we specifically focused on cardiopulmonary bypass (CPB) time and number of CPB runs based on a priori assumptions).

METHODS

Data Source, Patient Population, and Data Collection

This retrospective study from the University of California, San Francisco, used single-site patient records between January 2007 and June 2015. Institutional records and Society of Thoracic Surgeons Congenital Heart Surgery Database were concurrently scanned for consecutive patients with a diagnosis of TOF undergoing surgical primary repair before age 2 years. An estimated 268 TOF interventions were initially found that included reintervention, additional repairs, and prerepair palliative interventions such as the modified Blalock-Tausig shunt, ductal stent, pulmonary valvotomy, or RVOT stent. Patients diagnosed with a variation of TOF, such as pentalogy of Cantrell, TOF with pulmonary atresia and multiple aortopulmonary collaterals, and complete atrioventricular canal were excluded from this study. However, those with tetralogy-type double-outlet right ventricle (DORV) were included, given that these patients are anatomically similar to those with TOF and there were no obvious differences in patient characteristics between these patients and the entire population. Patients undergoing right ventricle-pulmonary artery conduits were included given that the patients within this category were not those with severely hypoplastic branch pulmonary arteries and/or major aortopulmonary collateral arteries, and underwent otherwise similar repairs. Right ventricle-pulmonary artery conduits were implanted in the following 2 conditions: in patients with valvular stenosis that prohibited a valve-sparing approach or a nontransannular incision in the presence of important crossing coronary branches and patients with pulmonary atresia. This left 115 patients available for study, 113 of whom had full echocardiographic review. Preoperative, intraoperative, and discharge echocardiograms were reviewed by 2 pediatric cardiologists (S.S. and K.H.) with oversight by 2 experienced pediatric echocardiologists (S.P. and A.M.G.), with specific attention to the anatomic components needed to construct TPS scores. Only the discharge echocardiograms and in-hospital reinterventions were used to determine the component TPS scores and the final score as described by Larrazabal and colleagues.[2] Updated TPS criteria proposed by Nathan and colleagues[3] were also incorporated, for comparison. Appropriate anatomic factors were converted to z scores, using the Boston Children's Hospital z score algorithm for calculating z scores by patient body surface area, height, and weight.[7] Specific repair techniques and strategies were at the discretion of the surgeon and the referring cardiologist, with input from a multidisciplinary care team.

Outcomes of Interest and Study Variables

Our primary outcomes of interest were postoperative length of stay, reintervention during hospitalization, and hospital cost. Additional bypass runs were not considered additional reinterventions. We also examined in-hospital mortality and the prevalence of the 6 major complications, as defined by the Society of Thoracic Surgeons Congenital Heart Surgery Database.[8] The 6 major complications include renal failure requiring temporary or permanent dialysis, neurologic deficit persisting at discharge, atrioventricular block, or arrhythmia requiring a permanent pacemaker, postoperative mechanical circulatory support, phrenic nerve injury, or any unplanned reintervention before discharge. Total cost was calculated summing the direct cost (the cost of services rendered during each patient's hospitalization) and the indirect cost (expenses that cannot be directly associated with patient care, such as hospital utilities, security, and administrative fees). Indirect costs were computed using an algorithm to calculate variable and fixed indirect costs.[9] Values were adjusted for inflation using Bureau of Labor Statistics US Consumer Price Index for Medical-Cost inflation.[10] Total costs were considered with and without statistical outliers, and total costs were also related to the length of stay to determine cost per day (total cost divided by total length of stay). Patient insurance status was also included in this study.

Data Analysis

Study power and type II error were 0.95 ($\alpha = 0.05$) and 0.80 ($\beta = 0.2$), respectively. The percentage of missing values was calculated before analysis and all variables with more than 25% incomplete data were excluded from our analysis. Descriptive and demographic data were conveyed with ratios and percentages for dichotomous and categorical variables, with means and standard deviations for continuous normalized variables, and