

STS Benchmarking in Congenital Heart Disease Surgery in Argentina: Is Comparison Feasible?

Uso de Benchmarking STS en cirugía de cardiopatías congénitas en Argentina: ¿es posible compararse?

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ABSTRACT

Background: The Society of Thoracic Surgeons (STS) cardiac surgery database reports the outcomes of benchmark procedures in pediatric cardiac surgery (STS-CHSD). Its primary objective is to support quality improvement in pediatric cardiac surgery programs in North America by evaluating and reporting in-hospital mortality outcomes, expressed as interquartile ranges (IQRs), for the 10 benchmark procedures since 2012, at 5-year intervals.

Objective: To evaluate the outcomes of an Argentine pediatric cardiovascular surgery unit for these 10 benchmark procedures by comparing them with those reported by the STS-CHSD.

Methods: Using our pediatric cardiovascular surgery unit database, we identified all patients who underwent procedures defined as STS-CHSD benchmarks over the past 15 years and compared the local outcomes with the external, with their international interquartile ranges (IQRs).

Results: A total of 412 patients who underwent surgery were identified, including 7 deaths, with the following results: mortality (STS IQR): 1) Surgical repair of aortic coarctation without cardiopulmonary bypass: 0% (0.0–1.71%); 2) ventricular septal defect (VSD) closure: 0% (0–0.78%); 3) tetralogy of Fallot repair: 1.8% (0–1.96%); 4) complete atrioventricular (AV) canal repair: 1.88% (0 to 1.75%); 5) arterial switch operation for simple transposition of the great arteries (TGA): 0% (0 to 3.45%); 6) arterial switch operation for TGA with VSD closure: 10% (0 to 7.14%); 7) Glenn procedure: 1.69% (0 to 2.53%); 8) Fontan-Kreutzer procedure: 1.75% (0 to 1.84%); 9) truncus arteriosus repair: 0% (0 to 18.75%); and 10) Norwood procedure: 6.66% (5.77–15%).

Conclusion: Our results are better or similar to STS CHSD. Only in 2 procedures are above the STS IQR, demonstrating the feasibility of using STS benchmarking in our country with excellent results.

Key words: benchmarks - pediatric cardiovascular surgery - mortality - Norwood - arterial switch - Fontan-Kreutzer

RESUMEN

Introducción: La base de datos de cirugía cardíaca de la Sociedad de Cirujanos Torácicos de los Estados Unidos (STS) reporta los resultados de procedimientos Benchmark (punto de referencia) en cirugía cardíaca pediátrica (STS-CHSD). El objetivo principal es mejorar la calidad de los programas de cirugía cardíaca pediátrica en América del Norte, al evaluar y reportar desde 2012, en periodos de 5 años, los resultados de mortalidad hospitalaria con rango intercuartilico (RIC) para 10 procedimientos Benchmark.

Objetivo: Comparar los resultados de una unidad de cirugía cardiovascular pediátrica argentina en esos 10 procedimientos con los resultados reportados por la STS-CHSD.

Materiales y métodos: De nuestra base institucional de los últimos 15 años se identificaron todos los casos correspondientes a los 10 procedimientos benchmark STS-CHSD y se comparó la mortalidad local con la reportada por STS y su RIC.

Resultados: Se identificó un total de 412 pacientes sometidos a cirugía, incluidas 7 muertes, con los siguientes resultados: mortalidad (RIC STS): 1) Coartación de aorta sin CEC: 0% (0,0 a 1,71%); 2) Cierre de CIV: 0% (0 a 0,78%); 3) Corrección de Fallot: 1,8% (0 a 1,96%); 4) Corrección de Canal AV completo: 1,88% (0 a 1,75%); 5) Cirugía de switch arterial para TGA simple: 0% (0 a 3,45%); 6) Cirugía de switch para TGA con CIV: 10% (0 a 7,14%); 7) Procedimiento de Glenn: 1,69% (0 a 2,53%); 8) Operación de Fontan-Kreutzer: 1,75% (0 a 1,84%); 9) Corrección de tronco arterioso: 0% (0 a 18,75%); 10) Cirugía de Norwood: 6,66% (5,77 a 15%).

Conclusión: Nuestros resultados son en general mejores o similares a los de STS-CHSD; solo en dos procedimientos se encuentran por encima del RIC de referencia, demostrando la posibilidad de utilizar el Benchmarking STS en el país con excelentes resultados.

Palabras clave: Benchmarks - Cirugía cardiovascular pediátrica - Mortalidad - Norwood - Switch - Fontan-Kreutzer

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INTRODUCTION

Surgery for congenital heart diseases in Argentina faces challenges related to variability in clinical outcomes and the lack of standardized indicators for evaluating the quality of care. (1-3) In this context, benchmarking tools, such as the model developed by the Society of Thoracic Surgeons (STS), provide a robust reference framework for comparing outcomes and promoting improvements in surgical practice. (4-5) This national database was established in 1989 as an initiative to improve the quality and safety of cardiothoracic surgery, providing an accurate and valid basis for measuring the performance of units in our specialty. (6) It currently comprises three databases: the STS Adult Cardiac Surgery Database (ACSD), the STS Congenital Heart Surgery Database (CHSD), and the STS General Thoracic Surgery Database (GTSD). (7) It is one of the largest and most comprehensive clinical registries, containing data on nearly 10 million procedures performed by more than 4300 surgeons, including 95% of adult cardiac surgery procedures. (2)

The STS Congenital Heart Surgery Database (STS-CHSD) is the largest of its kind in North America. It reports 30-day postoperative mortality rates for benchmark procedures (3) and publishes results every five years based on four-year datasets. (4-8) To ensure methodological validity in international comparisons, the STS, in collaboration with the European Association for Cardio-Thoracic Surgery (EACTS), promoted the universal standardization of diagnoses and surgical procedures through the IPCCC (International Pediatric and Congenital Cardiac Code) nomenclature system. (9) The latest report, from 2022, recorded a total of 623 907 surgeries, with the participation of 92% of the country's pediatric cardiac surgery programs (125 hospitals). (8) The 10 benchmarks were selected by the STS-CHSD working group based on the procedures most commonly performed across all participating centers, to provide more procedure-specific data to the participating institution. (10,11)

Its primary objective is to support quality improvement in pediatric cardiac surgery programs in North America by evaluating and reporting in-hospital mortality outcomes, expressed as interquartile ranges (IQRs), for the 10 benchmark procedures.

OBJECTIVE

The aim of this study is to evaluate the outcomes of an Argentine pediatric cardiovascular surgery unit for these 10 benchmark procedures by comparing them with those reported by the STS-CHSD.

METHODS

In 2011, the STS CHSD defined the benchmark procedures for congenital heart surgery. (10,11) The mortality results with their interquartile range (IQR) reported in 2023 are as follows: (4) 1) Surgical repair of aortic coarctation without cardiopulmonary bypass: 0.89% (0 to 1.71%); 2) ventricular septal defect (VSD) closure: 0.35% (0 to 0.78%); 3) tetralogy of Fallot repair: 1.09% (0 to 1.96%); 4) complete atrio-

ventricular (AV) canal repair: 1.38% (0 to 1.75%); 5) arterial switch operation for simple transposition of the great arteries (TGA): 1.83% (0 to 3.45%); 6) arterial switch operation for TGA with VSD: 5.15% (0 to 7.14%); 7) Glenn procedure: 1.99% (0 to 2.53%); 8) Fontan-Kreutzer procedure: 1.08% (0 to 1.84%); 9) truncus arteriosus repair: 8.1% (0 to 18.75%); and 10) Norwood procedure: 11.68% (5.78% to 15%).

Using our pediatric cardiac surgery unit database, we identified 412 patients who underwent procedures defined as STS benchmarks over the past 15 years and assessed 30th postoperative day mortality for each patient.

Operative mortality is defined in all STS databases (5) as: 1) all deaths, regardless of cause, occurring during the episode of care in which the operation was performed, even if after 30 days (including patients transferred to other acute care facilities), and 2) all deaths, regardless of cause, occurring after discharge home from the hospital but before the end of the 30th postoperative day. The interquartile range (IQR), a measure of dispersion, is calculated from the data distribution. In this study, procedure-specific mortality from Hospital Austral is presented as an aggregated value (a single percentage for each type of surgery). Therefore, we cannot calculate an individual IQR for each procedure, as there is no internal variability within each reported value.

Consequently, we calculated only the overall IQR, considering all 10 benchmark procedures.

Ethical Considerations

The study was approved by the institutional review board.

RESULTS

The following results were obtained for each benchmark procedure: 1) Surgical repair of aortic coarctation without cardiopulmonary bypass: n=37, mortality 0%; 2) VSD closure: n=80, mortality 0%; 3) tetralogy of Fallot repair: n=55, mortality 1.8%; 4) complete AV<canal repair: n=53, mortality 1.75%; 5) arterial switch operation for TGA: n=21, mortality 0%; 6) arterial switch operation for TGA with VSD: n=10, mortality 10%; 7) Glenn procedure: n=59, mortality 1.69%; 8) Fontan-Kreutzer procedure: n=57, mortality 1.75%; 9) truncus arteriosus repair: n=10, mortality 0%, and, 10) Norwood procedure with Blalock Taussig shunt: n=30, mortality 6.66% (Table 1). The total number of deaths was 7, with an overall mortality rate of 1.7% (7/412). The overall IQR ranged from 0% to 1.86%. This value reflects the central variability of mortality in our institution compared with the interquartile ranges reported by the STS-CHSD.

Causes of death:

- Intracranial bleeding in one patient with Fontan-Kreutzer procedure for LV hypoplasia.
- Rhinovirus pneumonia in one patient with a Glenn procedure and tricuspid valve repair for LV hypoplasia.
- Massive intracranial bleeding in one patient (2.3 kg) with refractory preoperative heart failure and a history of cerebral bleeding with an arterial switch with VSD closure.
- Sepsis in one patient with a complete unbalanced AV canal (26 kg).
- Biventricular failure due to tachyarrhythmia in

one patient with Tetralogy of Fallot and a transannular patch.

- Two deaths associated with Norwood procedure for mitro-aortic atresia: one (2.2 kg) due to supraventricular tachycardia and the other (2.8 kg) due to rotavirus gastroenteritis.

DISCUSSION

The STS-CHSD is an essential tool for measuring and recording not only mortality in the ten defined benchmark procedures, but also other valuable indicators that help evaluate each surgical program's performance. (4,7) Its use facilitates comparisons between different centers and contributes to the continuous improvement of care. Historically, assessment of surgical quality in congenital heart disease was limited to isolated and non-standardized reporting of in-hospital mortality by each center. However, current trends in quality management and patient safety indicate that objective evaluation requires standardized, reproducible tools adjusted for risk or anatomical complexity, thereby minimizing biases arising from case selection. (4,12) In this context, the ten benchmark procedures selected by the STS-CHSD play a strategic role. Because these procedures encompass the entire spectrum of complexity—from low-mortality operations such as VSD closure or aortic coarctation repair to highly complex palliative or neonatal procedures such as the Norwood procedure or truncus arteriosus repair—they function as a highly sensitive indicator of the overall operational performance of a surgical program, reflecting not only surgical technique but also perfusion, cardiovascular anesthesia, and postoperative intensive care. (10)

In addition to the STS-CHSD, other measurement and statistical systems are widely used in the field of congenital heart diseases, including the RACHS (Risk

Adjustment for Congenital Heart Surgery), (13,14) the Aristotle Score, (15) and the STAT (STS-EACTS Congenital Heart Surgery Mortality Categories) score. (16) RACHS is a stratification system that classifies patients into six risk levels based on the severity of their condition and the type of surgery to be performed, with the aim of predicting associated mortality and morbidity. (13) However, since it encompasses 207 procedures across its categories, the wide heterogeneity within each category requires large sample sizes to achieve significant statistical power, which dilutes or distorts the analysis in small- or medium-volume centers. (13,14) The Aristotle Score, designed by an international group of experts based on the concept of "Aristotle's Doxa," seeks to standardize surgical assessment by assigning a score based on anatomy, ventricular function, and associated anomalies to estimate complexity and predict risk. (15) Although it provides a valuable conceptual framework, the subjectivity inherent in certain factors has limited its systematic adoption as a single indicator. Similarly, the STAT score empirically categorizes surgeries into 5 groups based on mortality observed in tens of thousands of procedures from consolidated registries. (16) Unlike these synthetic risk tools, the fundamental advantage of the STS 10 benchmark procedures lies in their anatomical and technical specificity. (10) By comparing identical procedures "case by case," the model dispenses with numerical abstractions and offers a transparent measurement that is directly interpretable by medical teams, auditors, and institutions. (4,17)

In our department, the outcomes over the last 15 years for the ten benchmark procedures indicate highly favorable performance when compared with North American standards. The recorded mortality rate was lower than that reported by the STS-CHSD for six procedures (aortic coarctation, VSD closure, Glenn

Table 1. Benchmark procedure mortality

Procedure	n (Hospital Austral)	Mortality STS (IQR)	Hospital Austral mortality
Surgical repair of aortic coarctation without cardiopulmonary bypass	37	0.89 % (0–1.71)	0 %
VSD closure	80	0.35 % (0–0.78)	0 %
Tetralogy of Fallot repair	55	1.09 % (0–1.96)	1.8 %
Complete AV canal repair	53	1.38 % (0–1.75)	1.88 %
Arterial switch operation for TGA	21	1.83 % (0–3.45)	0 %
Arterial switch operation for TGA with VSD	10	5.15 % (0–7.14)	10 %
Glenn procedure	59	1.99 % (0–2.53)	1.69 %
Fontan-Kreutzer procedure	57	1.08 % (0–1.84)	1.75 %
Truncus arteriosus repair	10	8.1 % (0–18.75)	0 %
Norwood procedure	30	11.68 % (5.78–15)	6.66 %
Total	412	-	1.7% (7/412)

AV: atrioventricular; IQR: interquartile range; TGA: transposition of the great arteries; VSD: ventricular septal defect

procedure, truncus arteriosus repair, arterial switch operation in simple TGA, and Norwood procedure). In low-mortality surgeries (surgical repair of aortic coarctation without cardiopulmonary bypass, and VSD closure), in-hospital mortality was 0% vs. 0.89% and 0.35% in the STS, reaffirming the robustness of our care pathways and the effectiveness of early surgical repair. During the cavopulmonary anastomosis, the Glenn procedure had a mortality rate of 1.69% vs. 1.99% in the STS, while the Fontan-Kreutzer procedure had a mortality rate of 1.75% (within the STS IQR range of 0–1.84%); the only death occurred due to massive intracranial bleeding in a patient with single-ventricle physiology and left ventricular hypoplasia, reflecting the high prothrombotic and hemodynamic risk in this population. Among highly complex neonatal procedures, truncus arteriosus repair achieved 100% survival (0% mortality vs. mean STS mortality of 8.10%), and the Norwood procedure showed a mortality rate of 6.66% compared with a mean STS mortality of 11.68%, close to the lower limit of the STS IQR (5.78%–15%). This represents a noteworthy result given the extreme technical and intensive care demands of this condition. (10, 18) In two other cases (Tetralogy of Fallot and Fontan-Kreutzer procedure), the results remained within the IQR.

In only two procedures the values slightly exceeded the upper limit of the IQR published by the STS: complete AV canal repair (1.88% compared with an IQR of 0–1.75% in the STS, which represents a marginal deviation of 0.13%, corresponding to 1 death in 53 cases, caused by sepsis in an infant weighing 2.6 kg) and the arterial switch in TGA with VSD (10% vs. STS IQR 0–7.14%). In this latter subgroup, it is critical to consider the impact of sample size: with a total of 10 patients who underwent surgery, the occurrence of a single death (a newborn with preoperative refractory heart failure and prior intracranial bleeding) results in a drastic percentage jump from 0% to 10%. This statistical instability in small cohorts, known as the “small denominator effect,” is well documented in the clinical literature (17,19), indicating that consolidated analyses over 5- to 10-year periods are needed to identify true trends while minimizing the distortion by isolated events in small subgroups. (4,19)

These results demonstrate the feasibility of applying the STS benchmarking model in our country and in Latin America, where the literature agrees that implementing registration and quality programs reduces morbidity and mortality rates in emerging economies. (17,20) Unlike the historical argument that structural barriers to access prenatal diagnosis, timely referral, equipment, and funding make international standards and interquartile ranges unattainable, (1-3) this empirical evidence confirms that an Argentine university-affiliated center can achieve a consolidated overall mortality rate of 1.7% (7/412), which is equivalent to and even lower than the averages in North America. Moreover, a culture of transparency and systematic

clinical data auditing promotes the development of highly cohesive multidisciplinary teams and provides families and healthcare professionals with access to objective, clearly reported information through the institution’s official website. (4,20)

In summary, adopting the STS benchmarking model for congenital heart disease surgery in Argentina represents a strategic opportunity to raise quality standards, promote equity in care, and improve health outcomes. Although implementing these benchmarks poses considerable challenges, the international experience demonstrates that objective and transparent evaluation systems can generate substantial and sustainable benefits over time.

Conflicts of interest

None declared.

(See authors’ conflict of interests forms on the web).

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