# Practice Patterns in Postoperative Echocardiographic Surveillance after Congenital Heart Surgery in Children: A Single Center Experience

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**Objectives** To review current institutional practice and describe factors contributing to variation in inpatient postoperative imaging surveillance after congenital heart surgery.

**Study design** We reviewed records of all children who underwent congenital heart surgery from June to December 2014. Number and primary indications for postoperative transthoracic echocardiograms (TTEs), providers involved, cardiovascular intensive care unit (CVICU) and total hospital length of stay, and Risk-Adjustment for Congenital Heart Surgery-1 scores were recorded.

**Results** A total of 253 children (age at surgery: 8 months [2 days-19 years]) received 556 postoperative TTEs (median 1 TTE/patient [1-14]), and 23% had ≥3 TTEs. Fifteen of 556 TTEs (2.7%) revealed a new abnormal finding. The majority of TTEs (59%) were performed in the CVICU (1.5 ± 1.1 TTEs/week/patient), with evaluation of function as the most common indication (44%). Attending physician practice >10 years was not associated with fewer TTEs ($P = .12$). Patients with ≥3 TTEs had higher Risk-Adjustment for Congenital Heart Surgery-1 scores ($P = .001$), longer CVICU lengths of stay (22 vs 3 days; $P < .0001$), longer overall hospitalizations (28 vs 7 days; $P < .0001$), and a higher incidence of mechanical circulatory support (10% vs 0%; $P < .0001$) than those with <3 TTEs. Eight patients with ≥3 TTEs did not survive, compared with 3 with <3 TTEs ($P = .0004$).

**Conclusions** There was wide intra-institutional variation in echocardiographic use among similar complexity surgeries. Frequency of postoperative echocardiographic surveillance was associated with degree of surgical complexity and severity of postoperative clinical condition. Few studies revealed new abnormal findings. These results may help establish evidence-based guidelines for inpatient echocardiographic surveillance after congenital heart surgery. *(J Pediatr 2017;180:87-91).*

Transthoracic echocardiography is an essential diagnostic tool for pediatric patients with congenital heart disease (CHD). In general, research has focused on criteria for the appropriate utilization of echocardiography in adults and the feasibility of applying these criteria in clinical practice.[1-5] There are no guidelines for postoperative echocardiographic surveillance in children with CHD. The lack of guidelines may result in significant variation in the number of transthoracic echocardiograms (TTEs) obtained despite patients undergoing cardiac surgeries of similar complexity.

Although inadequate echocardiographic surveillance may contribute to increased patient morbidity, overutilization of noninvasive diagnostic imaging has not been shown to result in improved outcomes[1,2] and contributes to increased hospital costs and risks associated with performing sedated echocardiograms. The goals of this study were to review current institutional practice on postoperative TTE surveillance and describe factors contributing to variation in postoperative TTE surveillance including surgical complexity, physician experience, and patient acuity. These findings may serve as a framework for the eventual creation of standard algorithms for postoperative TTE surveillance in children after congenital heart surgery.

## Methods

The Lucile Packard Children's Hospital (Stanford Children's Health) Heart Center database was queried retrospectively to identify all children (≤19 years old) who underwent surgical repair or palliation for CHD from June to December 2014. We excluded patients who were transferred out of our institution prior to hospital discharge. The study protocol was approved by the Stanford University Institutional Review Board.

| | |
|---|---|
| CHD | Congenital heart disease |
| CVICU | Cardiovascular intensive care unit |
| RACHS-1 | Risk-Adjustment for Congenital Heart Surgery-1 |
| TTE | Transthoracic echocardiogram |

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Each patient's diagnosis, sex, age at surgery, surgery performed, length of cardiovascular intensive care unit (CVICU) stay, length of hospital stay, and survival status at discharge were recorded. We categorized surgical complexity by the Risk-Adjustment for Congenital Heart Surgery-1 (RACHS-1) score with the exception of those undergoing cardiac transplantation, ventricular assist device implantation, and epicardial pacemaker placement; these patients are not categorized by the RACHS-1 scoring system.[6]

All inpatient postoperative TTEs were included in our analysis. Because routine intraoperative transesophageal echocardiograms were required on all patients at our institution, these studies were not included. A Philips iE33 (Philips Medical Systems, Bothell, Washington) ultrasound system was used for all studies. For each postoperative TTE, the examination location (CVICU or acute care floor), referring physician on-service (attending cardiologist or cardiac intensivist), and presence of significant new findings were recorded. "New" findings were those not noted on either the intraoperative transesophageal echocardiogram or prior TTE if a second or more postoperative TTE was performed. For example, if a residual ventricular septal defect or moderate ventricular dysfunction was described on the intraoperative transesophageal echocardiogram, these findings would not be considered "new" if noted again on the postoperative TTE.

The primary indications for the study were recorded as stated by the referring physician. "Complete postoperative" and "postoperative discharge" TTEs were grouped together, as they represented a similar comprehensive evaluation of all valves, outflows, intracardiac and surgical shunts, residual lesions, and ventricular function.

### Statistical Analyses

Descriptive statistics were calculated, with continuous data presented as mean ± SD and medians (minimum-maximum). Comparisons were made between patients with <3 and ≥3 postoperative TTEs, and physicians with <10 and ≥10 years of attending experience practicing in the CVICU. As part of institutional standard, all postoperative patients required (at minimum) 1 TTE before discharge. Often, patients received an additional TTE prior to transfer from the CVICU to acute care floor. Taking both of these TTEs into account, having 3 TTEs was used as an arbitrary cut-off for disproportionate echocardiographic surveillance. We used parametric testing to compare data with normal distributions and nonparametric testing to compare data with non-normal distributions. All comparisons were performed using the Student *t* test, Mann-Whitney U test, or a Fisher exact test.

## Results

The study included 253 pediatric patients who underwent surgical repair or palliation at our institution from June to December 2014 (**Table I**). The median age at the time of surgery was 8 months (2 days-19 years). Median RACHS-1 score was 3 (1-6). Median CVICU length of stay was 9 days (1-234), and total hospital length of stay was 16 days (2-234). Overall hospital mortality was 4% (11/253).

Postoperative TTEs (n = 556) were performed during this time period, ranging from 1 to 14 studies per patient (median 1). All patients underwent at least 1 TTE, and 57 of 253 patients (23%) had ≥3 TTEs. The primary indications for postoperative TTEs obtained in the CVICU are listed in **Table II**.

Of those patients with the median RACHS-1 score of 3, the range of postoperative TTEs varied between 1 and 8 (median 1). **Figure 1** (available at www.jpeds.com) illustrates the range and median number of TTEs per patient by RACHS-1 score.

The majority of TTEs (326/556, 59%) were performed in the CVICU, with a median of 1 TTE (1-14) per patient and mean of 1.5 ± 1.1 TTEs/week per patient. Of the postoperative TTEs performed in the CVICU, evaluation of ventricular function was the most common indication (132/326, 40%), followed by postoperative discharge study (79/326, 24%) (**Table II**). In comparison, a median of 1 TTE (1-5) was

**Table I. Patient demographics and comparison of patients with <3 vs ≥3 postoperative TTEs**

| Characteristics | All patients (n = 253) | <3 TTEs (n = 196) | ≥3 TTEs (n = 57) | *P* value |
|---|---|---|---|---|
| Age at surgery (y) | 0.7 (2 d-19 y)<br>3.4 ± 5.1 | 1.1 (3 d-19 y)<br>3.7 ± 4.9 | 0.5 (3 d-16 y)<br>2.5 ± 4.4 | .11 |
| Male | 155 (61%) | 120 (61%) | 35 (61%) | 1.0 |
| Number of TTEs per patient | 1 (1-14)<br>2.2 ± 2.1 | 1 (1-2)<br>1.3 ± 0.5 | 4 (3-14)<br>4.9 ± 2.6 | **<.0001** |
| Number of TTEs in CVICU (n = 326, 59%) per patient | 1 (1-14)<br>1.3 ± 2.1 | 0 (0-2)<br>0.5 ± 0.7 | 3 (1-14)<br>3.9 ± 2.9 | **<.0001** |
| Number of TTEs on acute care floor (n = 230, 41%) per patient | 1 (1-5)<br>0.9 ± 0.8 | 1 (1-2)<br>0.9 ± 0.5 | 0 (0-5)<br>1.0 ± 1.4 | **<.0001** |
| RACHS-1 score | 3 (1-6) | 3 (1-6) | 3 (2-6) | **.001** |
| CVICU length of stay (d) | 9 (1 – 234)<br>20.1 ± 25.2 | 3 (0-53)<br>5.6 ± 7.0 | 22 (2-234)<br>30.9 ± 36.3 | **<.0001** |
| Total hospital length of stay (d) | 16 (2-234)<br>26.3 ± 28.2 | 7 (2-56)<br>9.7 ± 8.4 | 28 (5-234)<br>39.4 ± 37.4 | **<.0001** |
| Incidence of mechanical circulatory support | 6 (2%) | 0 (0%) | 6 (10%) | **<.0001** |
| Hospital mortality | 11 (4%) | 3 (2%) | 8 (14%) | **.0004** |

Data are presented as number (percentage), median (range), and mean ± SD.
Bold values highlight statistically significant comparisons ($P < .05$).