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Impact of Truncal Valve Repair on Survival, Reintervention, and Left Ventricular Function

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ABSTRACT

BACKGROUND Truncal valve insufficiency (TVI) is one of the risk factors for death in neonatal primary repair for common arterial trunk (CAT).

METHODS In this single-center retrospective case-matched controlled study, 16 consecutive CAT patients from 2000 to 2018 with moderate to severe truncal valve regurgitation (TVR2-3), undergoing primary CAT surgery with truncal valve repair, were matched to 16 CAT patients with none or mild truncal valve regurgitation (TVR1-0).

RESULTS The TVR2-3 group had 11 (69%) patients with moderate and 5 (31%) patients with severe TVI, with an operative median age of 7 (4-19) days. Survival at median follow-up of 17 years after repair was 70% and 80% in the TVR2-3 and TVR0-1 groups, respectively ($P > .99$), with 2 early deaths in the TVR2-3 group occurring after reintervention for residual TVI. Rate of surgical truncal valve reintervention at 5 years postoperatively was 67% for TVR2-3 ($P = .005$). TVR2-3 experienced greater residual TVI at discharge and 1 year after repair, with severity of truncal valve dysfunction converging between groups as more patients in TVR0-1 developed mild to moderate TVI over time and TVR2-3 patients underwent reintervention for clinically significant TVI. Significant left ventricular (LV) dilation was observed in the TVR2-3 group after 3 years from repair ($P = .001$), but LV ejection fraction was comparable between groups.

CONCLUSIONS Truncal valve reintervention burden (ie, repair or replacement) is greater in the TVR2-3 population, with higher truncal valve–related early death. Progressive LV enlargement in the TVR2-3 group due to residual TVI was well tolerated. Ventricular remodeling did not have a notable impact on LV ejection fraction or clinical status.

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Truncal valve is the single semilunar valve that arises from the common arterial trunk (CAT). Hemodynamically significant truncal valve insufficiency (TVI) is a critical factor associated with perioperative death[1,2] and reoperation.[3] Many neonatal patients who undergo intracardiac repair for CAT with concomitant truncal valve repair leave the operating room with some residual TVI.[4-6] Requirement of repeated surgical reinterventions to the truncal valve

IN SHORT

- Moderate to severe truncal valve insufficiency (TVI) has higher early truncal valve–related mortality and reintervention burden than none or mild TVI.
- Left ventricular dilation due to residual TVI was well tolerated and did not affect left ventricular function or cause significant heart failure symptoms.

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further poses a risk of myocardial injury on an already chronically volume-loaded left ventricle. In this case-matched controlled study, we sought to examine the impact of moderate or severe preoperative TVI on survival, reintervention, and medium-term left ventricular (LV) function and dimension.

PATIENTS AND METHODS

All children diagnosed with CAT who underwent neonatal surgical repair at The Hospital for Sick Children, Toronto, between June 2000 and June 2018 were retrospectively reviewed. Neonates who had moderate or severe truncal valve regurgitation (TVR2-3) on preoperative echocardiography were matched to the neonates with trivial or mild truncal valve regurgitation (TVR1-0). Our operative strategy is described in detail elsewhere[1] (Supplemental Table 1), and dyad matching criteria can be found in Supplemental Figure 1. Typical timing of primary repair was 5 to 10 days of age in the historical era; it is now 2 to 5 days of age in recent years. The primary outcomes are survival and freedom from reintervention. Secondary outcomes include postoperative LV function, LV dilation, and functional health status as determined by the modified Ross score for pediatric heart failure. The study was approved by the Research Ethics Board at The Hospital for Sick Children, and patient consent was waived.

TRUNCAL VALVE REPAIR. All patients who had severe TVI underwent truncal valve repair at the time of CAT repair. Most patients with moderate TVI underwent truncal valve repair if it was amenable to simple repair, with only 1 moderately regurgitant truncal valve left untouched at the surgeon's discretion. Repair techniques included unilateral or bilateral commissure attachment to the adjacent leaflet either fully (complete adaptation) or partially (commissuroplasty), cusp thinning, leaflet plication, and subcommissural annuloplasty (Supplemental Figure 2). Moderate or less residual TVI on intraoperative post-bypass transesophageal echocardiography was deemed acceptable in the neonatal period.

TRUNCAL VALVE REOPERATION. Reoperative indications are similar to those for chronic aortic valve regurgitation and include severe residual TVI, presence of symptoms, and progressive LV dilation or dysfunction. We have a low threshold to intervene on the truncal valve if a patient needs conduit exchange or branch pulmonary artery reconstruction. Valve replacement is indicated when residual moderate or greater TVI remains after 1 or 2 attempts of truncal valve repair, with mechanical valve typically being the device of choice.

STATISTICAL ANALYSIS. Continuous variables were described using median and interquartile range; dichotomous and polytomous variables were described using frequencies. Between-group (case vs control) differences in the continuous, dichotomous, and polytomous variables were evaluated by signed rank, McNemar, and McNemar-Bowker tests, respectively. All analyses were conducted assuming a significance level of 0.05 and implemented using R version 3.5.3 (R Foundation for Statistical Computing).

RESULTS

DEMOGRAPHICS AND PREOPERATIVE ASSESSMENT. Of the 97 patients who underwent CAT repair between 2000 and 2018, there were 16 consecutive TVR2-3 patients matched to 16 TVR1-0 patients. The TVR2-3 group had 11 (69%) patients with moderate and 5 (31%) patients with severe TVI. There were no significant differences in the demographics of the 2 groups (Supplemental Table 2), except for genetic syndromes being more prevalent in the TVR0-1 group. DiGeorge syndrome is not a predictor of CAT postoperative death or reoperation as reported in recent large cohort studies.[2,7]

TRUNCAL VALVE REPAIR AND IN-HOSPITAL RECOVERY. Only 1 patient in the TVR1-0 group underwent truncal valve repair, for which commissuroplasty was performed. In TVR2-3, most patients (n = 10 [63%]) underwent complete adaptation (Supplemental Table 3). There were no differences in operative and postoperative variables between groups (Supplemental Table 4). Two in-hospital deaths were seen in each group. In the TVR0-1 group, deaths were unrelated to the truncal valve; 1 patient succumbed to multiorgan dysfunction, and another with ischemic brain injury died after withdrawal of extracorporeal membrane oxygenation (ECMO). Two deaths in the TVR2-3 group occurred after reoperation for TVI during index admission; 1 involving truncal valve re-repair for cusp dehiscence causing severe TVI, and another after homograft truncal valve replacement for worsening TVI on ECMO support after initial truncal valve repair. Two patients in the TVR2-3 group required permanent pacemaker insertion, with the devices placed after index admission.

LV FUNCTION AND GEOMETRY. Postoperatively, the TVR2-3 group had greater prevalence of residual regurgitation, with 14% (n = 2) reporting severe TVI (P = .001; Supplemental Figure 3; Supplemental Table 5). There were no differences in LV ejection fraction between the groups at 3- and 5-year follow-up (Figure 1A) despite significant LV dilation (Figure 1B). Difference in the degree of TVI became statistically insignificant as incidence of regurgitant truncal valves in the TVR0-1 group increased, whereas residual TVI in

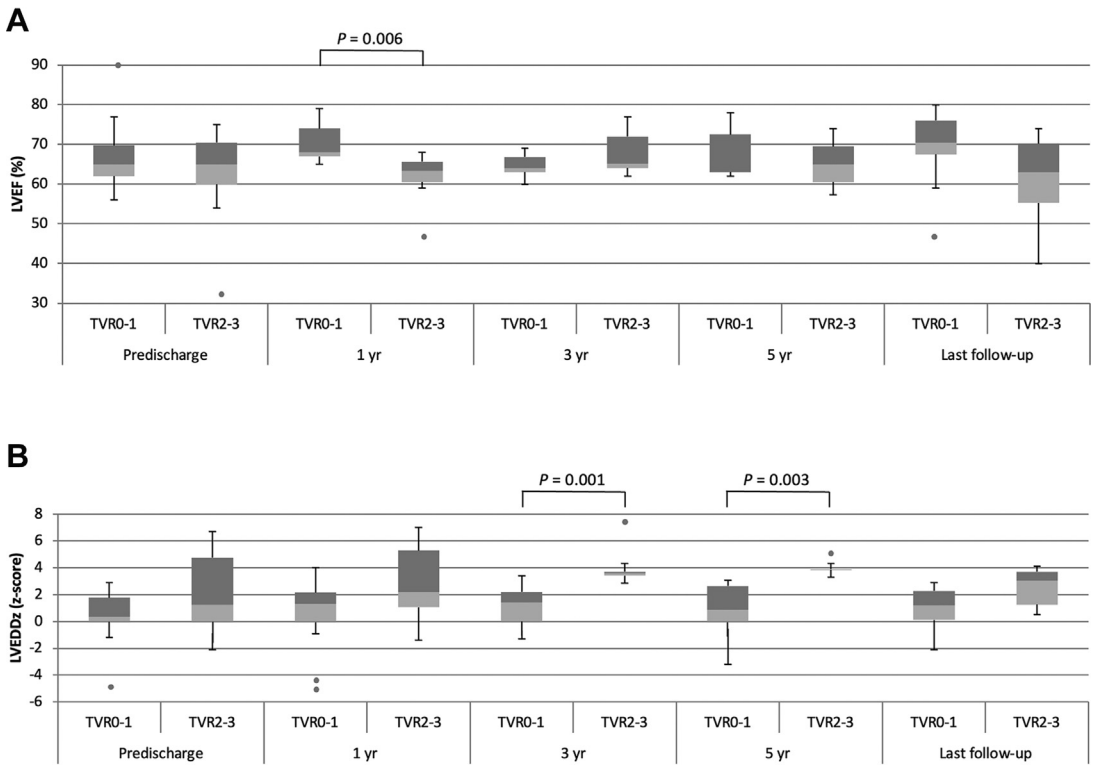

FIGURE 1 Left ventricular function and left ventricular size between groups with none or mild truncal valve regurgitation (TVR0-1) and moderate to severe truncal valve regurgitation (TVR2-3) at predischarge, 1 year, 3 years, and 5 years after repair and at latest follow-up. The upper and lower borders of the box represent the upper and lower quartiles. The middle horizontal line represents the median. Dots represent outliers. (A) Left ventricular ejection fraction (LVEF). (B) Left ventricular diastolic diameter *z*-score (LVEDDz).

the TVR2-3 group was surgically intervened on. Median modified Ross score was 0 for both groups from postoperative 3 years and onward.

SURVIVAL. At median follow-up of 9.17 (1.40-15.12) years, there were 3 deaths among survivors to discharge. One death occurred within 1 year of initial surgical repair in each group, with 1 additional late death at 13 years in the TVR2-3 group. Actuarial survival for TVR2-3 was 81.2% at 1 year and 69.6% at 13 years (Figure 2A; $P > .99$).

FREEDOM FROM REINTERVENTION. Throughout follow-up, 13 patients (TVR0-1, 1 patient; TVR2-3, 12 patients) had at least 1 truncal valve reintervention (Figure 2B; $P = .005$). Of the 16 truncal valve reinterventions done in TVR2-3, there were 10 truncal valve re-repairs and 6 truncal valve replacements; 2 patients in the TVR2-3 group underwent truncal valve replacement after re-repair. In the TVR0-1 group, 1 patient underwent 2 truncal valve repair reinterventions. Overall, TVR2-3 and TVR0-1 observed more surgical truncal valve (with concomitant surgical right-sided heart procedure) and percutaneous right-sided heart reinterventions, respectively (Supplemental Figure 4).

COMMENT

This single-center retrospective cohort study analyzed the survival, reintervention, and ventricular functional outcomes associated with truncal valve repair during primary CAT intervention in 16 consecutive CAT patients with moderate to severe TVI matched to CAT patients with negligible to mild TVI. Overall, postoperative actuarial survival was similar, but the rate of truncal valve reintervention was greater in TVR2-3. At latest follow-up, LV function and residual TVI severity were similar, and symptomatic heart failure was uncommon for both groups.

TVI, LV FUNCTION AND DIMENSION. Residual TVI from insufficient repair causes persistently elevated volume loading, whereas overly zealous repair through complete adaptation may cause truncal valve stenosis. TVR2-3 experienced greater residual TVI compared with the control group at predischarge ($P = .001$) and 1 year after repair ($P = .03$). However, severity of truncal valve dysfunction converged between groups as more patients in the TVR0-1 group developed mild or moderate TVI over time. Although LV dilation in the TVR2-3 group at 3 and 5 years after repair was a likely

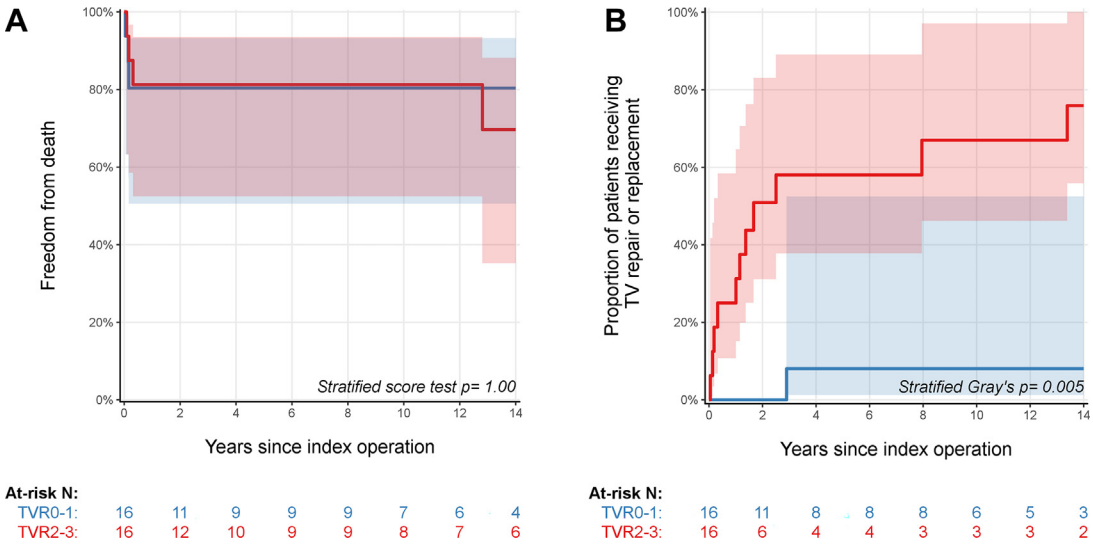

FIGURE 2 Kaplan-Meier graph of (A) actuarial survival and (B) freedom from reintervention of truncal valve (TV) repair or replacement in moderate to severe truncal valve regurgitation (TVR2-3, red; n = 16) and none or mild truncal valve regurgitation (TVR0-1, blue; n = 16) groups between 0 and 16 years after index operation. Shaded areas represent 95% CIs.

sequela of chronic TVI, it did not impair LV ejection fraction. Chronic TVI was well tolerated and reintervention was appropriately timed before residual TVI led to LV dysfunction.

TRUNCAL VALVE DYSFUNCTION. Both preoperative TVI and truncal valve stenosis were observed. The median peak truncal valve gradient was 21 (17-26) mm Hg and 26.5 (21.8-45.0) mm Hg for TVR0-1 and TVR2-3, respectively ($P = .142$). The prevalence of truncal valve stenosis was greater in the TVR2-3 group when stratified by severity ($P < .001$), which was mainly a manifestation of hyperdynamic flow secondary to TVI. We observed no association between quadricuspid truncal valve and greater TVI, which is in keeping with other literature.[3]

TRUNCAL VALVE REPAIR. Our approach is to first attempt truncal valve repair for neonates with moderate or severe TVI so that truncal valve replacement can be deferred until the patient can receive a decent size (17 mm or larger) mechanical valve. Henaine and colleagues[3] identified initial truncal valve replacement as the single risk factor for mortality. For repair, commissuroplasty and complete cusp adaptation are preferentially performed in our institution. Bicuspidization is avoided as it carries the risk of valvular stenosis, and achieving symmetrical coaptation can be technically challenging.[6] Of the 3 patients in TVR2-3 who underwent cusp thinning, one patient later required complete cusp adaptation 2 years from index operation and died at age 13 years of an unknown cause. Cusp thinning was reported to be an independent predictor for reoperation and is reserved only for thickened and immobile neonatal valves.[8]

MORTALITY. Although in-hospital and long-term survival was quantitatively comparable between TVR0-1 and TVR2-3 ($P > .99$), scrutinizing the cause of death suggests that moderate to severe TVI portends higher valve-related early mortality, particularly if there is postoperative residual TVI necessitating reoperation. With that said, ongoing TVI after discharge did not appear to have an impact on long-term survival in our cohort. Existing literature remains inconclusive; some studies identified significant TVI as a main risk factor for both poor early and late survival,[6,9] whereas others more conservatively noted its impact on long-term survival only.[2] Conversely, a contemporary multicenter analysis demonstrated neither TVI nor truncal valve repair to be significantly associated with the composite outcome of postoperative ECMO, cardiopulmonary resuscitation, or operative death.[7]

REINTERVENTIONS. Our institution has previously demonstrated that of 93 CAT repair survivors beyond 1 year of life, 76 (82%) had undergone a total of 224 reinterventions.[1] Baseline moderate or severe TVI is an independent predictor for reintervention,[3] with McElhinney and coworkers[9] reporting an actuarial freedom from reintervention of 50% at 4 years and 15% at 7 years. Guariento and colleagues[2] found quadricuspid truncal valve, preoperative TVI, and concomitant truncal valve repair to be associated with increased risk of reoperation.

STUDY LIMITATIONS. The primary limitations of this study are its retrospective nature and recruitment of patients from a single quaternary center. The modest sample size precluded completion of competing risk analysis.

CONCLUSION. Our experience suggests that irrespective of baseline TVI severity, there is reasonable long-term survival but high reintervention burden associated with CAT. In patients with moderate to severe preoperative TVI, residual insufficiency is common and causes progressive LV dilation. However, LV remodeling is well tolerated and did not have a notable impact on LV function or clinical status, likely due to timely truncal valve reinterventions.

The Supplemental Material can be viewed in the online version of this article [https://doi.org/10.1016/j.atssr.2023.02.022] on http://www.annalsthoracicsurgery.org.

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DISCLOSURES

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