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Distal Transverse Arch Dimensions Dictate Long-Term Aortic Arch Gradients following Coarctation of the Aorta Repair during Early Infancy

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Abstract

Background: Regardless of the surgical approach to repair coarctation of the aorta (CoA), a portion of the distal transverse arch (DTA) remains incorporated within the anastomosis. We hypothesized that retention of a smaller DTA segment results in an elevated gradient.

Methods: Infants were divided into two groups based on the surgical approach: 1) Sternotomy and aortic arch repair where the DTA was nearly excised and 2) Thoracotomy and extended end-to-end anastomosis (EEEA), which incorporates most of the DTA within the anastomosis. Follow-up echocardiograms quantified the aortic arch gradient, and children with a gradient in the upper quartile for each surgical approach were analyzed.

Results: From 230 infants, 51.3 % (118) underwent sternotomy and aortic arch repair, and 48.7% (112) underwent thoracotomy and EEEA. Post-operatively, the sternotomy group had a significantly greater duration of ventilation and hospital length of stay but without a difference in mortality. Follow-up aortic arch gradients were significantly lower within the sternotomy group (11.9 ± 7.0 mmHg vs. 14.5 ± 7.5 mmHg; p=0.002). Children with an aortic arch gradient in the upper quartile from the thoracotomy group had significantly smaller preoperative DTA dimensions. Multivariate regression demonstrated that sternotomy and aortic arch repair independently reduced the follow-up aortic arch gradient (Odds Ratio: 0.075 95% CI 0.006, 0.877; p-value=0.039).

Conclusions: Incorporating smaller DTA segments within the anastomosis results in higher gradients that may have implications in the development of hypertension during adulthood and suggests the consideration of the DTA dimension during CoA repair.

Introduction

Coarctation of the aorta (CoA) during early infancy is often associated with concomitant hypoplasia of the proximal and distal transverse aortic arch. However, the anatomic features that define significant aortic arch hypoplasia (AAH) and the corresponding surgical methodology remain controversial.[1-6] Although several algorithms have been proposed to guide the surgical approach, the majority focus solely on the proximal transverse arch (PTA) dimension,[5-9,] and little attention has been given to the distal transverse arch (DTA). Following a thoracotomy, the DTA is largely incorporated within the extended end-to-end anastomosis (EEEA). Although a portion of the DTA is incised, the DTA immediately adjacent to the left carotid artery (LCA) often remains intact due to the location of the proximal clamp. Retention of small segments of circumferential hypoplastic DTA tissue may not universally contribute to higher re-intervention rates but may result in higher aortic arch gradients that, over time, will increase the risk for hypertension.[10] In contrast, following a sternotomy and aortic arch repair, the majority of a hypoplastic DTA can be excised, and the anastomosis brought onto the PTA or ascending aorta, resulting in complete relief of the obstruction.

For nearly 25 years,[1,11] we have utilized the DTA:LCA to help guide our surgical approach for the repair of CoA in conjunction with AAH. We sought to understand the outcomes of children repaired using either a sternotomy and aortic arch repair vs. thoracotomy and EEEA. We hypothesized that sternotomy and aortic arch repair would result in significantly lower aortic arch gradients when compared to thoracotomy and EEEA and that children within the thoracotomy group with higher gradients would have smaller distal transverse arch dimensions prior to surgery.

Methods

Patient Recruitment

Following approval from the Institutional Review Board, infants (< 180 days) requiring either sternotomy or thoracotomy to repair CoA between 2001-2021 were reviewed. Pre-operative trans-thoracic echocardiography was used to delineate the cardiac and aortic anatomy and to calculate the corresponding Z-scores.[12,13] The PTA was defined as the aortic arch segment between the innominate artery and LCA. The PTA measurement was not obtained when the LCA arose from a common brachiocephalic artery. The DTA was defined as the aortic arch segment between the LCA and left subclavian artery. A sternotomy and aortic arch repair were commonly performed in children with a concomitant cardiac lesion requiring repair, a bovine aortic arch, or DTA:LCA ≤ 1.0. In all other cases, a thoracotomy was performed. Two surgeons performed all surgeries during the study period.

Surgical Approach

Aggressive tissue mobilization of the aortic arch, head and neck vessels, and descending thoracic aorta was obtained regardless of the approach. Sacrifice of the left subclavian artery was routinely performed to obtain a tension-free primary anastomosis greater in diameter than the descending thoracic aorta using only autologous aortic tissue. When necessary, a thoracotomy at the 4th intercostal space was performed. Following heparinization with 100 U/kg, a Satinsky and DeBakey clamp were placed on the PTA and approximately 1 cm distal to the ductal insertion. The undersurface of the distal transverse arch was incised proximally, and the anastomosis was performed with either 6-0 or 7-0 prolene (Figure 1). Infants requiring sternotomy and aortic arch repair during most of the first decade underwent central arterial cannulation in conjunction with deep hypothermic circulatory arrest at 18 °C. Following 2009, a Gore-Tex chimney was sewn to the innominate artery in an end-to-side fashion for arterial cannulation, and antegrade cerebral perfusion was performed between 22-25 °C. During aortic arch repair, most of the DTA was excised, leaving only a cuff of tissue distal to the LCA (Figure 1) and the undersurface of the aortic arch incised toward the ascending aorta.

Outcome Methods

Echocardiogram measurements obtained the peak gradient from the aortic arch. The gradient at the time of hospital discharge was considered time 0, and subsequent measurements were obtained based on follow-up. Follow-up echocardiograms were reviewed until the point of re-intervention, and clinically

significant gradients were considered if there was a diastolic tail.[1] Children with an aortic arch gradient within the upper quartile were compared to those within the lower 75% based on the surgical approach. Secondary outcomes included peri-operative morbidity, based upon definitions established by the Society of Thoracic Surgeons Congenital Heart Surgery Database.[14]

Propensity Matching

Children having an aortic arch repair often have intra-cardiac lesions, which increase the complexity of the operation and may contribute to the overall peri-operative morbidity. To further evaluate differences in the peri-operative outcomes between the sternotomy and thoracotomy approaches, infants requiring only isolated aortic arch repair were propensity matched to the thoracotomy cohort by matching age, gender, weight, and the DTA dimension.

Statistical Analyses

Variables are reported as median and inter-quartile range or mean ± standard deviation. Patient variables were evaluated for the equality of variances ensuring normal distribution and compared using a 2-tailed Student's t-test or Mann-Whitney test. Comparisons between categorical variables were made using Fisher's exact Test. Kaplan-Meier curves were constructed, and groups were compared using a Mantel-Cox (Log-rank) test. Spaghetti plots for the follow-up aortic arch gradients and the systolic blood pressure were constructed. Linear regression and Pearson's value were measured, and differences in the slope and intercept were compared using an analysis of variance. Variables between upper quartile and lower 75% based upon the surgical approach were compared using Two-Way ANOVA. Multivariate regression identified variables independently associated with a lower follow-up aortic arch gradient where a p-value of < 0.05 was considered significant. All statistics were completed using SPSS 27 (IBM, Armonk, NY) and Graphpad Prism (Dotmatics, San Diego, CA). A power calculation was not performed, as this was a retrospective study.

Results

From 230 infants, 51.3 % (118) underwent sternotomy and aortic arch repair, and 48.7% (112) underwent thoracotomy and EEEA (Figure S1). Pre-operative aortic arch measurements and corresponding Z-scores were significantly smaller within the sternotomy group (Table 1). Although there was no consistency in the percentage of children with AAH based on published definitions[1-11], the sternotomy group had a consistently higher and significantly greater percentage of infants that met each definition. Peri-operative demographics demonstrated that infants within the sternotomy group were significantly younger and more often had an associated genetic, somatic, or chromosomal abnormality (Table 2).

Post-operative morbidity was significantly lower within the thoracotomy group (Table 2). The duration of ventilation and the percentage of infants requiring mechanical ventilation > 7 days were significantly greater within the sternotomy group. Although there was no difference in the incidence of diaphragm plication or tracheostomy, the hospital length of stay was significantly longer within the sternotomy

group. There were no differences in the operative mortality between groups. Details regarding the operative deaths are provided in Table S1.

Propensity Match

From the 230 CoA repairs, 114(49.5 %) infants were propensity-matched (Thoracotomy-57, Sternotomy -57) (Table 3). There were no significant differences between the matched variables; however, the PTA Z-scores were significantly smaller within the sternotomy group. Although the percentage of children requiring mechanical ventilation for more than 7 days and the hospital length of stay was significantly greater in the sternotomy group, the discharge aortic arch gradient was significantly lower in the sternotomy group.

Survival and Aortic Arch Re-Intervention

There were no significant differences in the 15-year survival between groups (Sternotomy-96.5 % vs. Thoracotomy 93.6 %; p=0.23). Five children required catheter-based aortic arch re-intervention (Sternotomy-2, Thoracotomy-3), and one patient within the thoracotomy group required both catheter re-intervention in conjunction with surgical re-operation. The 15-year freedom from aortic arch re-intervention was 98.2 vs. 96.7 % in the sternotomy and thoracotomy groups, respectively (p=0.6) (Figure S2). Details regarding the aortic arch re-interventions are provided in Table S2.

With 100% follow-up at 9.1 ± 6.0 years, the age and weight were similar between groups (Table S3). However, the discharge and most recent follow-up aortic arch gradients were significantly lower within the sternotomy group (Figure 2A). There was a weak correlation between the follow-up systolic blood pressure and the aortic arch gradient (R=0.1; p<0.01). Linear regression of the aortic arch gradient over time demonstrated a near-zero slope for both groups. However, the Y-intercept was significantly greater within the sternotomy group (Figure 2B). The systolic blood pressure increased during the follow-up period without a significant difference between groups (Figure 2C).

The threshold for an aortic arch gradient within the upper quartile was greater than 20 mmHg (Figure 2D). Of the 53 children whose gradient fell into the upper quartile, a significantly greater percentage were repaired using the thoracotomy approach (16.9% vs. 29.4 %; p=0.028). There were no significant pre-operative differences between those in the upper quartile and lower 75 % from infants repaired in the sternotomy group. However, the DTA Z-score and the DTA:LCA were significantly smaller in children within the upper quartile when repaired using a thoracotomy (Table 4). Linear regression of the aortic arch gradients over time between the upper quartile and lower 75% demonstrated a near-zero slope (Figures 3A and 3B). However, the systolic blood pressure was significantly greater in children within the upper quartile (Figure 3C and 3D). Multivariate regression demonstrated that sternotomy and aortic arch repair independently reduced the follow-up aortic arch gradient (Odds Ratio: 0.075 95% CI 0.006, 0.877; p-value=0.039) (Table 5).

Discussion

Despite smaller pre-operative aortic dimensions, infants with CoA repaired using a sternotomy approach, where the majority of the DTA was excised, had significantly lower discharge and follow-up aortic arch gradients. Children with a follow-up aortic arch gradient within the upper quartile, when repaired using a thoracotomy approach where the majority of the DTA was incised but incorporated into the anastomosis, had significantly smaller DTA dimensions prior to surgery. Multivariate analysis confirmed that infants with CoA repaired using a sternotomy and aortic arch repair had significant and independently lower follow-up aortic arch gradients. This suggests that excising a hypoplastic DTA segment at the time of surgery results in a superior hemodynamic result.

There are several reasons why retention of smaller DTA segments results in greater aortic arch gradients. In the presence of a critical coarctation within the DTA segment, there is both limited blood flow and growth. Subsequently, and as seen in our data, the DTA diameter in most cases remains substantially smaller than the PTA. Although the DTA is incised during the EEEA, the degree of anastomotic expansion remains constricted by the hypoplastic tissue. In the setting of a hypoplastic DTA, our preference is to hinge the anastomosis off the larger PTA and ascending aorta. Although using the ascending aorta and PTA as the anastomosis point is technically more challenging[15-17], the resulting anastomosis is substantially larger in circumference. In addition, although all effort is taken to incise the lesser curvature of the DTA proximally during a thoracotomy and EEEA, the proximity of the clamp when placed on the PTA results in a small section of concentric DTA that may contribute to a higher aortic arch gradient. In addition, previous studies have demonstrated that aortic arch tissue proximal to the coarctation is histologically[18] and transcriptionally[19,20] dysregulated compared to the descending thoracic aorta. Both animal and human data suggest that these changes, even if repaired during the neonatal period, may be irreversible, contribute to increased arterial stiffness, and are associated with an increased risk for hypertension.[18-20] Removing a greater percentage of hypoplastic aortic arch tissue proximal to the coarctation and incorporating more tissue from the descending thoracic aorta into the aortic arch anastomosis may be further beneficial and requires investigation.

Within the last decade, there has been an increased awareness regarding the importance of the aortic arch shape following CoA repair.[21-23] A gothic aortic arch has been associated with higher rates of hypertension and left ventricular dysfunction.[21] Removal of the DTA can shorten the transverse arch. However, by extensively mobilizing the aortic arch, head and neck vessels, and the descending thoracic aorta, the anastomosis remains tension-free and limits the angulation of the aorta. Further, a beveled incision on the descending thoracic aorta increases the length of the aortic arch and minimizes the angular acuity.

Based on the current follow-up, the surgical approach did not result in a difference in systolic blood pressure. However, there was a direct correlation between aortic arch gradient and systolic blood pressure from within the entire group and a significantly greater systolic blood pressure from children with an aortic arch gradient within the upper quartile. Although these differences at 10 years were only 7 mmHg, if these trends continued into senescence, by 60 years, there would be a 37-mmHg difference in

systolic blood pressure between those children within the upper quartile and lower 75%, significantly increasing the risk for cardiovascular events by 150%.[24,25]

The re-intervention rate from within the cohort was low and not significantly different between either approach. It is interesting, however, that in several patients who required re-intervention, patient characteristics warranted a deviation from our standard practice. Premature infants with a prior intra-cerebral hemorrhage or those in shock due to a partially closed or occluded patent ductus arteriosus, irrespective of the aortic arch anatomy, may benefit from a thoracotomy approach despite the greater risk for re-intervention. Similarly, during sternotomy and aortic arch repair, either an aberrant right subclavian artery or a large vertebral artery from the left subclavian may necessitate preserving a portion of the DTA, leading to a higher risk for re-intervention.[26]

Our group has had the same philosophy for several decades. The primary goal for CoA repair should be near laminar aortic arch blood flow. Achieving this goal requires an understanding of where to optimally position the descending thoracic aorta and using a tension-free primary anastomosis greater than the diameter of the descending thoracic aorta. Although we historically viewed the DTA:LCA as the threshold as to where to best position the anastomosis,[1-11] like many other groups, we have gotten more aggressive given the increase in safety of antegrade cerebral perfusion within this population[28] and similar neurodevelopmental outcomes[29] when comparing either the thoracotomy and sternotomy approach. Although the sternotomy group had a greater peri-operative morbidity, these differences did not translate into a difference in survival, and the benefit of achieving a lower gradient may have much greater long-term implications on cardiovascular health.

Limitations

There are several limitations to this work. This is a retrospective study, and although serial follow-up was obtained, the follow-up interval and the use of echocardiography varied. Although rates of stroke and seizure were similar between groups, the use of continuous EEG monitoring was only performed within the past five years of the study period, and the use of post-discharge brain MRI imaging was not routinely performed. Although systolic blood pressure rates were analyzed over time, few children have had ambulatory blood pressure monitoring to evaluate for both daytime and nocturnal hypertension. Although measurements of the echocardiographic aortic arch gradient were routinely performed, measurements of the aortic arch to evaluate for serial growth were not universally available.

Conclusions

The use of sternotomy and aortic arch repair resulted in a significantly lower aortic arch gradient during follow-up. Children with an aortic arch gradient within the upper quartile had significantly greater systolic blood pressure, suggesting that even small differences in the peak aortic arch gradient may have long-standing implications on cardiovascular health. When repaired via thoracotomy, children with a gradient

within the upper quartile had significantly lower DTA dimensions, suggesting the importance of the DTA in considering the surgical approach to coarctation repair.

Declarations

- The authors have no relevant financial or non-financial interests to disclose.
- The authors have no competing interests to declare that are relevant to the content of this article.
- All authors certify that they have no affiliations with or involvement in any organization or entity with any financial interest or non-financial interest in the subject matter or materials discussed in this manuscript.
- The authors have no financial or proprietary interests in any material discussed in this article.

Author Contribution

Conception or design of the work (GMA, NAY, MFS); acquisition of data (MFS, BH, JGM, SY, NAY, GMA), analysis (BH, MFS) and interpretation of data (MFS, BH, JGM, SY, NAY, GMA). The manuscript was written by MFS, and edited by MFS, BH, JGM, SY, NAY, and GMA. All authors have reviewed and approve of the version of the manuscript and the corresponding data.

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Tables

Table 1. Baseline Cardiac Anatomy

	Stern-118	Thor-112	p value
Bi Ao Valve	51.47 % (61)	54.4 % (62)	0.59
Aortic valve Annulus (mm)	5.8 (5.2, 6.6)	6.6 (5.8, 7.7)	0.007
Ascending Aorta (mm)	7.5 (6.7, 8.5)	8.3 (7.0, 9.7)	0.007
PTA (mm)	4.1 (3.4, 5.1)	5.0 (4.5, 5.8)	<0.001
DTA (mm)	3.4 (2.9, 3.9)	4.1 (3.3, 5.0)	0.0002
CTO	19.5 % (23)	5.4 % (6)	0.001
LCA (mm)	3.2 (2.9, 3.8)	3.2 (2.8, 3.6)	0.23
Z-Score			
AA	-0.8 (-1.4, 0.2)	-0.3 (-1.1, 0.6)	0.02
PTA	-2.4 (-3.3, -1.4)	-1.7 (-2.3, -1.0)	<0.0001
DTA	-3.1 (-3.6, -2.5)	-2.5 (-3.2, -1.8)	0.001
DTA:LCA	1.0 (0.89, 1.2)	1.3 (1.0, 1.5)	<0.001
PTA:LCA	1.3 (1.0, 1.6)	1.6 (1.3, 1.9)	
AAH Definitions			
DTA:LCA < 1.0	47.5 % (56)	18.8 % (21)	<0.001
PTA Z-Score < - 2.5	38.1 % (45)	13.4 % (15)	<0.001
PTA Z-Score < -3.5	11.0 % (13)	0	<0.001
Weight + 1PTA	33.1 % (39)	58.9 % (66)	<0.001

Abbreviations: Stern-Sternotomy, Thor-Thoracotomy, Bi Ao Valve -Bicuspid Aortic Valve, AA-Ascending Aorta, PTA-Proximal Transverse Arch, DTA-Distal Transverse Arch, CTO-Common Take Off, LCA-Left Common Carotid.

Table 2. Peri-Operative Demographics

	Stern-118	Thor-112	P value
Age (days)	10.5 (7.0, 20.3)	21.0 (10.0, 50.5)	<0.001
Male Gender	62.7 % (74)	70.5 % (79)	0.89
Weight (kg)	3.4 (2.9, 3.7)	3.6 (2.9, 4.4)	0.04
Height (cm)	50.0 (48.0, 52.2)	51.0 (48.0, 55.0)	0.11
Gestation (weeks)	39.0 (38.0, 40.0)	39.0 (36.0, 40.0)	0.36
Prematurity < 37 weeks	18.6 % (22)	29.4 % (33)	0.06
Extra-Cardiac Abn	23.7 % (28)	19.6 % (22)	0.52
Chromosomal Abn	21.1 % (25)	8.9 % (10)	0.01
Syndrome	25.4 % (30)	15.2 % (17)	0.07
Primary Procedure			
Arch Repair	51.7 % (61)		
Arch Repair + VSD	31.4 % (37)		
Arch Repair + AVSD	2.5 % (3)		
Arch Repair + ASO ± VSD	13.6 % (16)		
Arch Repair + TOF rpr	0.8 % (1)		
Urgent Operation	90.7 % (107)	79.5 % (89)	0.02
Operative Details			
Aortic Clamp Time (min)		15.0 (13.0, 16.0)	
CPB time (min)	117.0 (93.5, 141.0)		
X-Clamp time (min)	58.0 (36.0, 75.0)		
ACP	56.8 % (67)		
ACP Time (min)	29.0, (26.0, 31.0)		
DHCA	57.6 % (68)		
DHCA Time (min)	28.0 (20, 32.8)		
Post-Operative Outcomes			
Duration Vent (days)	4.0 (2.0, 7.3)	2.0 (1.0, 4.0)	<0.001

Duration Vent > 7 days	21.2 % (25)	8.0 % (9)	0.003
Par chord			
Par Dia	0.8 % (1)	0	0.99
Stroke	1.7 % (2)	0.9 % (1)	0.99
Seizure	3.4 % (4)	1.8 % (2)	0.68
Hosp LOS (days)	17.0 (12.0, 24.3)	8.0 (6.0, 12.0)	<0.001
Mortality	3.4 % (4)	3.6 % (4)	0.99

Abbreviations: Stern-Sternotomy, Thor-Thoracotomy, CPB-Cardiopulmonary Bypass, ACP-Antegrade Cerebral Perfusion, DHCA-Deep Hypothermic Circulatory Arrest, Min-Minutes, Vent-Ventilation, Dia-Diaphragm, LOS-Length of Stay.

Table 3. Propensity Matched Cohort

	Arch Rpr-57	Thor EEEA-57	P value
Age (days)	13.0 (8.0, 13.0)	13.0 (9.0, 26.0)	0.46
Male Gender	39	39	0.99
Weight (kg)	3.4 (2.9, 3.9)	3.5 (2.9, 4.0)	0.97
Z-Scores			
PTA	-2.5 (-3.3, -1.6)	-2.1 (-2.5, -1.3)	0.03
DTA	-3.1 (-3.6, -2.3)	-2.9 (-3.5, -2.1)	0.99
DTA:LCA	1.0 (0.9, 1.2)	1.1 (0.9, 1.4)	0.08
Post-Operative Data			
Vent Duration (days)	4.0 (2.0, 7.0)	2.0 (1.0, 4.0)	0.08
Vent > 7 days	19.3 % (11)	5.3 % (3)	0.04
LOS (days)	17.0 (14.0, 21.0)	8.0 (6.0, 12.0)	0.01
Mortality	1.8 % (1)	5.3 % (3)	0.64
Discharge Arch Grad (mmHg)			

Abbreviations: PTA-Proximal Transverse Arch, DTA-Distal Transverse Arch, LCA-Left Carotid Artery, Vent-Ventilation, LOS-Length of Stay

Table 4. Upper Quartile Follow-up Aortic Arch Gradients by Surgical Approach

	75 % Stern-98	25% Stern (20)	P value	75% Thor-79	25 % Thor-33	P value
Age (days)	10.0 (7.0, 19.0)	19.0 (8.3, 40.0)	0.34	25.0 (10.0, 53.0)	19.0 (9.5, 47.5)	0.98
Male (%)	64.2 % (63)	55.0 % (11)	0.9	69.6 % (55)	72.7 (24)	0.21
Weight (kg)	3.4 (3.0, 3.6)	3.2 (2.8, 4.2)	0.98	3.5 (2.8, 4.3)	3.8 (3.2, 4.6)	0.99
Height (cm)	50 (48.0, 52.0)	51.0 (46.2, 55.6)	0.88	51 (48, 55)	50.0 (47.0, 56.0)	0.88
Gest (wks)	39.0 (38.0, 40.0)	38.9 (36.3, 40.0)	0.69	39.0 (36.0, 40.0)	39.0 (36.0, 40.0)	0.45
Prematurity	17.3 % (17)	25.0 % (5)	0.99	27.8 % (22)	33.3 % (11)	0.72
Ao Size						
AoV (mm)	5.8 (5.2, 6.6)	7.9 (6.0, 8.5)	0.74	6.7 (5.9, 7.8)	6.5 (5.6, 7.7)	0.70
AA (mm)	7.5 (6.8, 8.5)	7.9 (6.0, 8.5)	0.98	8.5 (7.0, 9.7)	7.5 (6.5, 9.3)	0.47
PTA (mm)	3.9 (3.4, 7.3)	4.3 (3.6, 5.7)	0.14	5.1 (4.6, 5.8)	4.8 (4.0, 5.8)	0.68
DTA (mm)	3.4 (2.8, 3.9)	3.6 (3.1, 4.6)	0.15	4.3 (3.3, 5.0)	4.0 (2.9, 5.0)	0.78
CTO (%)	20.4 % (20)	15.0 % (3)	0.99	6.3 % (5)	3.0 % (1)	0.99
LCA (mm)	3.2 (2.9, 3.7)	3.4 (2.9, 4.1)	0.79	3.1 (2.7, 3.6)	3.4 (3.0, 3.8)	0.37
Z-Score						
AA	-0.8 (-1.3, 0.2)	-0.6 (-1.7, 0.5)	0.69	-0.2 (-1.0 (0.57)	-0.4 (-1.2, 0.3)	0.31
PTA	-2.5 (-3.3, -1.6)	-1.4 (-3.1, -0.6)	0.40	-1.7 (-2.1, -0.8)	-1.7 (-2.7, -1.3)	0.49
DTA	-3.2 (-3.6, -2.5)	-2.9 (-3.5, -1.9)	0.62	-2.4 (-2.9, -1.6)	-2.8 (-3.2, -1.9)	0.03
DTA:LCA	1.0 (0.85, 1.2)	1.1 (0.9, 1.2)	0.97	1.4 (1.1, 1.6)	1.1 (1.0, 1.4)	0.001
PTA:LCA	1.2 (1.0, 1.5)	1.3 (1.1, 1.8)	0.74	1.7 (1.4, 2.0)	1.4 (1.2, 1.7)	0.056

Abbreviations: Stern-Sternotomy, Thor-Thoracotomy, AoV-Aortic Valve, AA-Ascending Aorta, PTA-Proximal Transverse Arch, DTA-Distal Transverse Arch, CTO-Common Take Off, LCA-Left Carotid Artery.

Table 5 Multivariate Analysis

	Odds Ratio	95 % CI	P value
Age at Repair	1.000	0.997, 1.003	0.963
DTA:LCA	1.186	0.899, 1.565	0.225
PTA Z-Score	0.711	0.888, 1.050	0.418
DTA Z-Score	1.022	0.904, 1.156	0.719
Sternotomy	0.838	0.705, 0.998	0.047

Abbreviations: DTA-Distal Transverse Arch, LCA-Left Carotid Artery, PTA-Proximal Transverse Arch

Figures

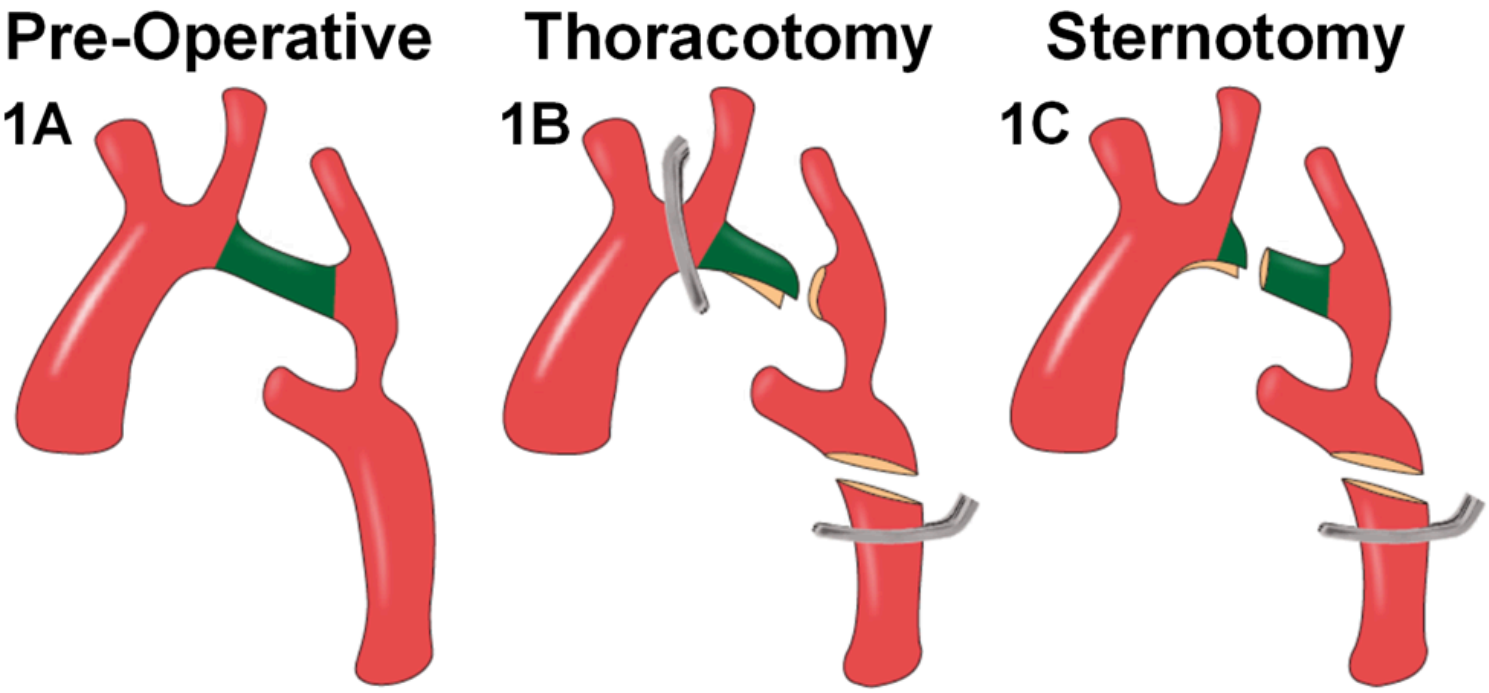


Figure 1

Pre-operative diagram of an aortic arch with coarctation and concomitant distal transverse aortic arch hypoplasia (green). Diagram of an aortic arch with coarctation and concomitant distal transverse aortic arch hypoplasia approached using a thoracotomy incision. Although an incision is placed on the lesser

curvature of the distal transverse arch, much of this tissue is retained within the anastomosis). Diagram of an aortic arch with coarctation and concomitant distal transverse aortic arch hypoplasia approached using a sternotomy where the majority of the DTA segment has been removed leaving only a small segment distal to the left carotid artery.

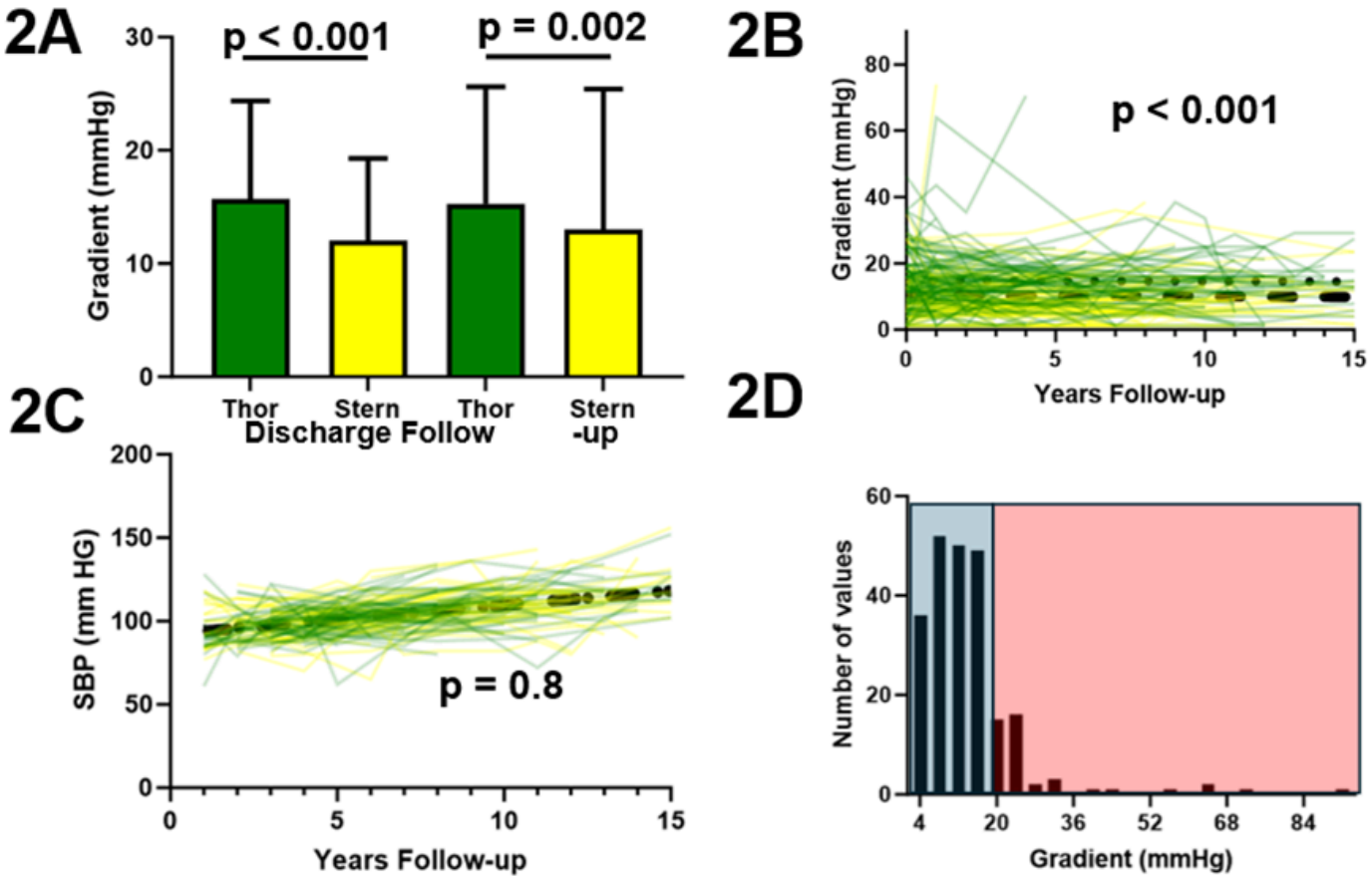


Figure 2

A: Echocardiographic derived peak gradients obtained from the proximal descending thoracic aorta at the time of operative discharge and most recent follow-up; 2B: Spaghetti plots and linear regressions of the echocardiographic derived peak aortic arch gradient over time between patients repaired using a sternotomy(yellow, dashed line) and thoracotomy (green, dotted line); 2C: Spaghetti plots of the Systolic Blood Pressure (SBP) obtained during follow-up between infants repaired using a thoracotomy (green) and sternotomy (yellow); 2D: Histogram of the follow-up aortic arch gradients where the lower 75% are shaded in blue, and the upper quartile shaded in red.

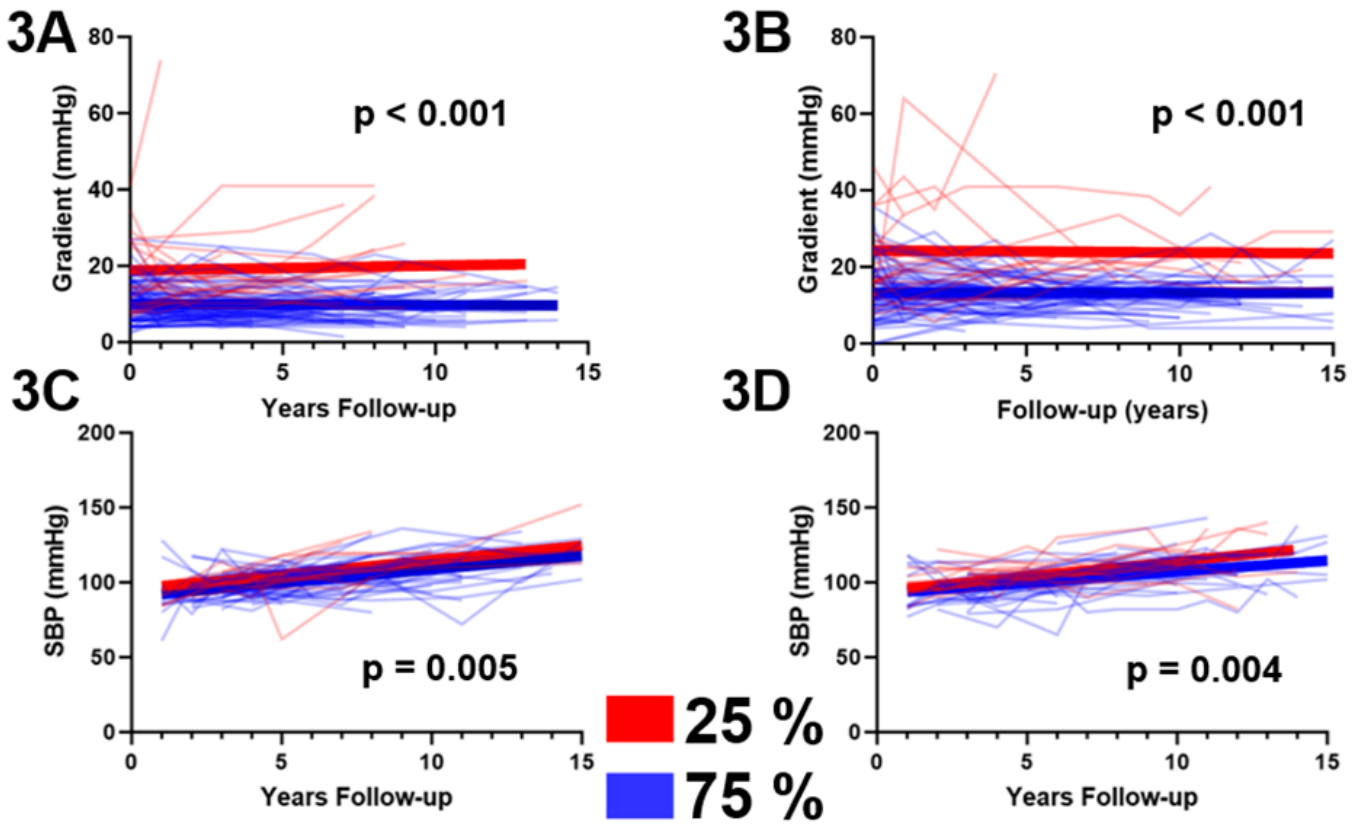


Figure 3

Spaghetti plots and linear regressions of the peak aortic arch gradient over time between infants in the lower 75 % (blue) and upper quartile (red) from infants repaired using a sternotomy (3A) and thoracotomy (3B); Spaghetti plots and linear regressions of the systolic blood pressure over time between infants in the lower 75 % (blue) and upper quartile (red) from infants repaired using a sternotomy (3C) and thoracotomy (3D).

Supplementary Files

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