Utility of CT Angiography in Neonates with Coarctation of the Aorta

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Background

- Coarctation of the aorta may be associated with intrinsic abnormalities of the vessel wall, including hypoplasia of the proximal and transverse aortic arch.
- When present, surgical repair of coarctation must also address arch hypoplasia to prevent recurrence of arch obstruction (recoarctation).
- Standard operative approach for isolated coarctation is via left thoracotomy. This is inadequate to repair a hypoplastic arch, which requires median sternotomy and cardiopulmonary bypass.
- Preoperative cardiac imaging with echocardiography (ECHO) and/or computed tomographic angiography (CTA) is used to determine the presence of arch hypoplasia and guide surgical approach.
- Methods to assess for arch hypoplasia using standardized preoperative ECHO measurements have been described to determine if they accurately predict optimal surgical approach and ultimately decrease the risk of recoarctation[1].

Hypothesis

- ECHO analysis alone is insufficient to guide surgical approach. CTA allows more precise measurement of aortic dimensions and delineation of 3D morphology.

Objectives

- Determine if pre-defined measurements of the aortic arch made on ECHO differ significantly from those made on CTA.
- Determine if CTA is superior to ECHO at predicting arch hypoplasia
  - Need for median sternotomy
  - Incidence of post-operative intervention and hypertension
- Characterize how cross-sectional imaging may inform surgical decision making.

Methods

- Retrospective chart review of pts treated at Children's Memorial Hospital/Ann & Robert H. Lurie Children's Hospital of Chicago 6/04-8/13
- Inclusion criteria:
  - Age <6 months at intervention
  - Underwent isolated repair of coarctation of the aorta
  - Preoperative CTA and ECHO performed
- Patient demographics, preoperative CTA and ECHO data, operative reports and post-operative variables were studied.
- Arch hypoplasia was defined as Z-score less than -2.5 at the distal transverse arch based on body surface area.
- Recoarctation defined as need for anti-hypertensive medication > 12 mos post-operatively, balloon angioplasty or arch repair.

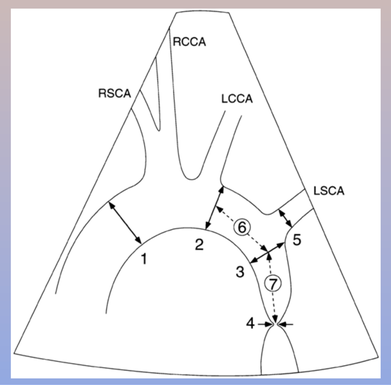


Figure 1[2]. Measurements at the distal transverse arch (2) were indexed to body surface area to determine arch hypoplasia.

Results

- 28 pts met inclusion criteria (Table 1).
- 16 (57%) of patients met criteria for arch hypoplasia based on either CTA or ECHO measurement
  - 9 of these met criteria on both CTA and ECHO
  - 3 met criteria based on ECHO alone, 4 based on CTA measurements alone
- Using the Signed Rank Test, there was no statistical difference between distal transverse arch measurements by CTA and ECHO (p=0.216) across all patients.
- Using the two-sample t-test, no significant difference existed between the mean distal transverse arch measurements of the lateral thoracotomy versus the median sternotomy group on either CTA or ECHO (p=0.058 and p=0.154, respectively).

Results

Table 1

Variables of Interest	Left Thoracotomy	Median Sternotomy
Number of Patients	N=23 (82%)	N=5 (18%)
Mean Age at Surgery	28.3 days	32.8 days
Mean Distal Arch (ECHO)	3.90 mm	3.14 mm
Mean Distal Arch (CTA)	4.18 mm	3.20 mm
Mean Z-score of Transverse Arch (ECHO)	-2.48	-3.13
Mean Z-score of Transverse Arch (CTA)	-2.23	-3.08
Mean Length of Follow-Up	43 months (11d-8yr)	32 months (8mos-4yrs)
Recoarctation	1 (4%)	1 (20%)

Table 2. Patients with Recoarctation.

Patient Number	Approach	Intervention	Hypoplastic Arch (ECHO/CTA/both)
1	Lateral Thoracotomy	-balloon angioplasty -transverse arch repair	Yes (both)
2	Median Sternotomy	balloon angioplasty	Yes (both)

- When comparing patients who underwent lateral thoracotomy with those who underwent median sternotomy, we found that median sternotomy patients were significantly more likely to have an abnormal branching pattern of the great vessels of the arch (80%) than those who underwent lateral thoracotomy (30%).

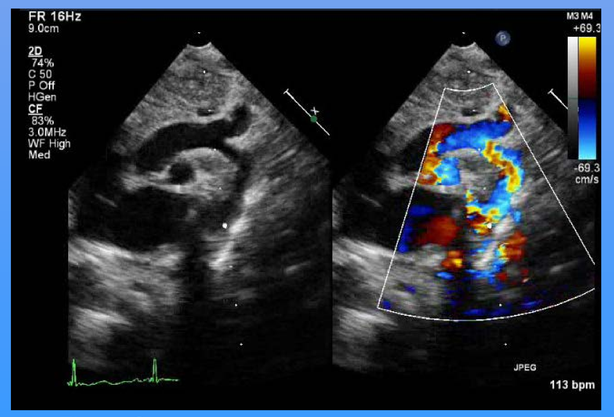
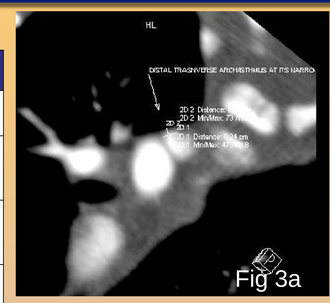


Figure 2. ECHO image of distal transverse arch in a patient with arch hypoplasia.



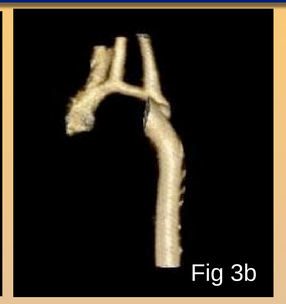
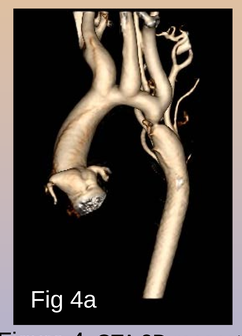


Figure 3. CTA images of a hypoplastic arch obtained from CTA. 3D reconstruction demonstrates the vessel branching pattern in relation to the coarctation.



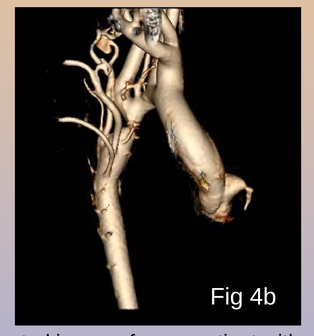


Figure 4. CTA 3D reconstructed images from a patient with isolated coarctation of the aorta.

Conclusion

Based on this limited study of patients undergoing coarctation repair, there is no significant difference in the measures of transverse arch size using preoperative CTA vs. ECHO, and no clear advantage of CTA in predicting which surgical approach is optimal. While preoperative CTA may equip the surgeon with a better understanding of arch geometry, branching pattern and the extent of resection needed, this requires further characterization as this study is limited in qualifying advantages of 3D visualization.

Future Directions

- Calculation of radiation exposure from CTA over the course of the study period
- Better characterization of 3-Dimensional geometry of aortic arches, including the extent of coarctation and hypoplasia
- Collect surgical opinions regarding preoperative imaging preference to study additional variables which may improve outcome

References

1. Rao RP, Connolly D, Lamberti JJ, Fripp R, El Said H. Transverse Aortic Arch to Descending Aorta Ratio: A New Echocardiographic Parameter for Management of Coarctation of the Aorta in the Infant. Congen Heart Dis. 2012; 7:1600-1609.
2. Kaine S F et al. Circulation1996;94:1056-1062