3DRA Assessment of Airway Compression in Biventricular Congenital Heart Disease

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Disclosures

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Speaking Bureau / Teaching

Airway Abnormalities and Congential Cardiac Disease

- Frequently associated
- Trisomy 21
  - 40-50% CHD
  - 75% airway abnormalities
- 22q11 syndromes
  - 50% conotruncal abnormalities
  - 56% tracheal or bronchial stenosis
- Vascular sling
  - Up to 50% complete tracheal rings

Iserin, *Eur J Pediatr.* 1998;157:881–884
Bertrand, *Pediatr Pulmonol.* 2003;36:137–141
Cohen, *Ann. Otol.* 1976;85:582

Airway Abnormalities and Congential Cardiac Disease

- Extrinsic airway compression
  - Vascular rings / sling
  - Dilated pulmonary arteries / Absent pulmonary valve
  - Anomalous aortic course
  - Dilated aorta
- Intrinsic airway disease
  - Laryngomalacia
  - Tracheomalacia
  - Bronchomalacia
  - Tracheal stenosis / complete tracheal rings

Airway Abnormalities and Congential Cardiac Disease

- Interventions for CHD may be complicated by or exacerbate airway abnormalities
- Surgical
  - PA bifurcation side-to-side arterioplasty
  - Stage I Norwood
- Interventions
  - Pulmonary artery stent placement
  - Coarctation stent placement / Hybrid Stage I Norwood
  - Pulmonary vein stent placement

Holst, *J Thorac Cardiovasc Surg* 2012;144:1257–1259
Sidoti, *JACC Cardiovasc Interv*. 2014 Oct;7(10):e143-4
Grohmann, *Clin Res Cardiol*. 2016 Apr;105(4):323-31
Borik, *Pediatr Cardiol.* 2015 Jun;36(5):1083-9
Brown, *CCI*. 2016 Jul;88(1):103-6
Ferandos, *CCI*. 2009;74:132-136

Airway and Cardiac Disease

Iatrogenic Airway Compression

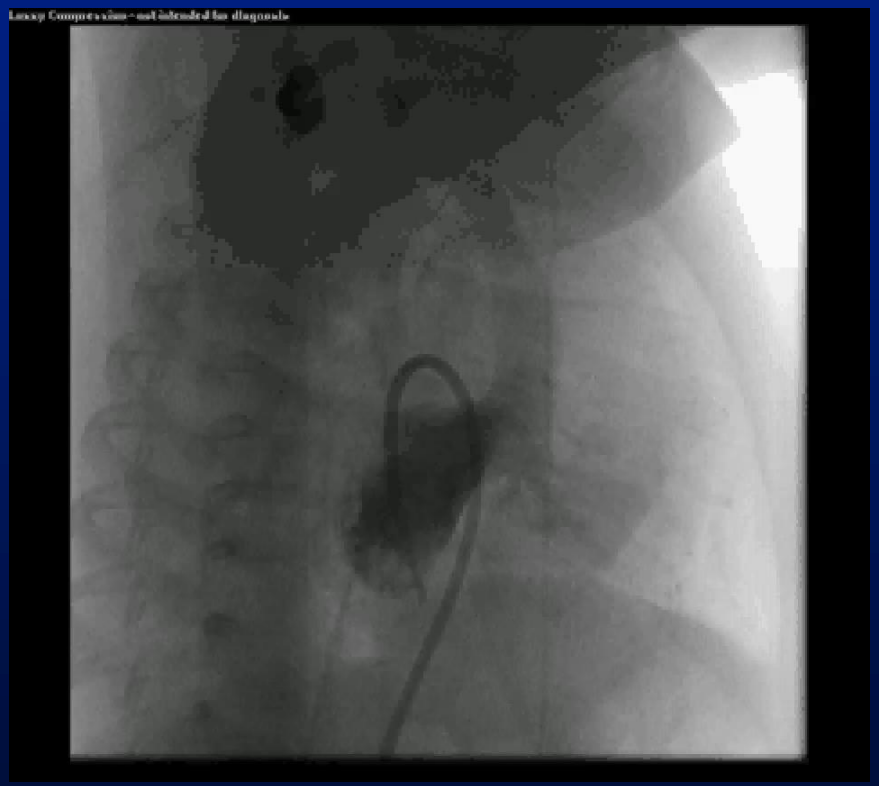
- Can be a significant problem
  - Novel therapies for acute decompensation
- Bronchoscopy
  - Dynamic vascular testing reported
  - High yield described
  - *Invasive*

Ebrahim, *Cathet. Cardiovasc. Intervent*. 85: 832–836
Truong, *Catheter Cardiovasc Interv*. 2015 Aug;86:1068–1077
Brown, *CCI*. 2016 Jul;88(1):103-6
O'Byrne, *Pediatr Cardiol.* 2016 Mar;37(3):433-41

Airway and Cardiac Disease Diagnosis

- Bronchoscopy
  - High yield
  - Dynamic vascular testing possible
  - Dynamic ventilatory testing possible
  - Invasive
  - Sensitive but not specific
- CT imaging
  - High spatial resolution
  - Airway visualization
  - Minimally invasive / rapid
  - Angiography demonstrates vascular/airway
  - Dynamic ventilatory testing possible
  - Dynamic vascular testing not possible

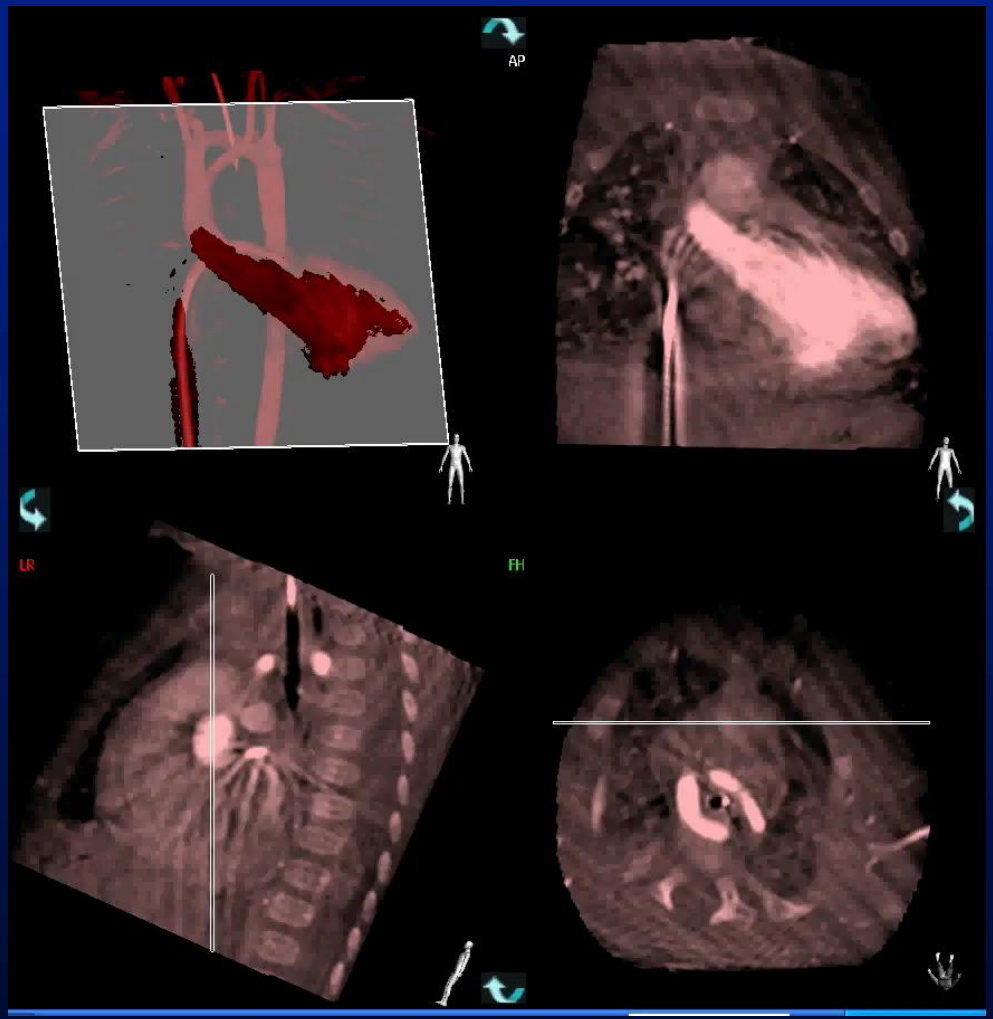
Airway and Cardiac Disease
3DRA



- Similar attributes as CT imaging
- Protocols same as cardiac 3DRA
  - Multiplanar reformat
  - Post processing minimal
- Dynamic vascular testing possible

Truong, *Catheter Cardiovasc Interv*. 2015 Aug;86:1068–1077
Borik, *Pediatr Cardiol.* 2015 Jun;36(5):1083-9

Airway and Cardiac Disease
3DRA Multiplanar Reformat



Double Aortic Arch

- 2D slices through 3DRA dataset
- Airway well defined
- Especially in relation to contrast filled vasculature

Borik, *Pediatr Cardiol.* 2015 Jun;36(5):1083-9
Truong, *CCI*. 2015 Aug;86:1068–1077

Airway and Cardiac Disease
3DRA Multiplanar Reformat

- We postulated utility of 3DRA MPR imaging to define vasculature / airway relationship in selected patients referred for cardiac catheterization
- First used 3DRA specifically to define possible airway anomalies in January 2011
- Subsequently performed retrospective review of patients who underwent 3DRA for this indication
- “What was clinical impact of 3DRA MPR”
- Jan 2011 – Nov 2013; 8 patients were identified

Truong, *Catheter Cardiovasc Interv*. 2015 Aug;86:1068–1077

Airway and Cardiac Disease
3DRA

Patient Demographic and Procedural Data.								
Case	Age	Wt	DAP (mGycm2)	Diagnosis	Treatment History	MPR findings	Bronch	Affect on clinical management
Clinical Symptoms								
1	3 y	11kg	1021	IAA-B; Shones; VSD; Resp illnesses	5 major CV repairs	No vascular encroachment on airway; Airway unobstructed	Yes	No*: SVC stented
Surgical Planning								
2	5 w	3.4kg		Double aortic arch; VSD	None	Double aortic arch; no airway compression	No	Yes: No additional imaging prior to surgical repair
3	3 y	15.7kg	850	Truncus arteriosus	RV-PA conduit	Criss-cross branch pulmonary arteries; PAs anterior to trachea	Yes	Yes: Planning for posterior pulmonary arterioplasty
4	7 y	21.4 kg	2249	Truncus arteriosus	RV-PA conduit; LPA stent	Criss-cross branch pulmonary arteries; PAs anterior to trachea	No	Yes: Planning for posterior pulmonary arterioplasty

Truong, *Catheter Cardiovasc Interv*. 2015 Aug;86:1068–1077

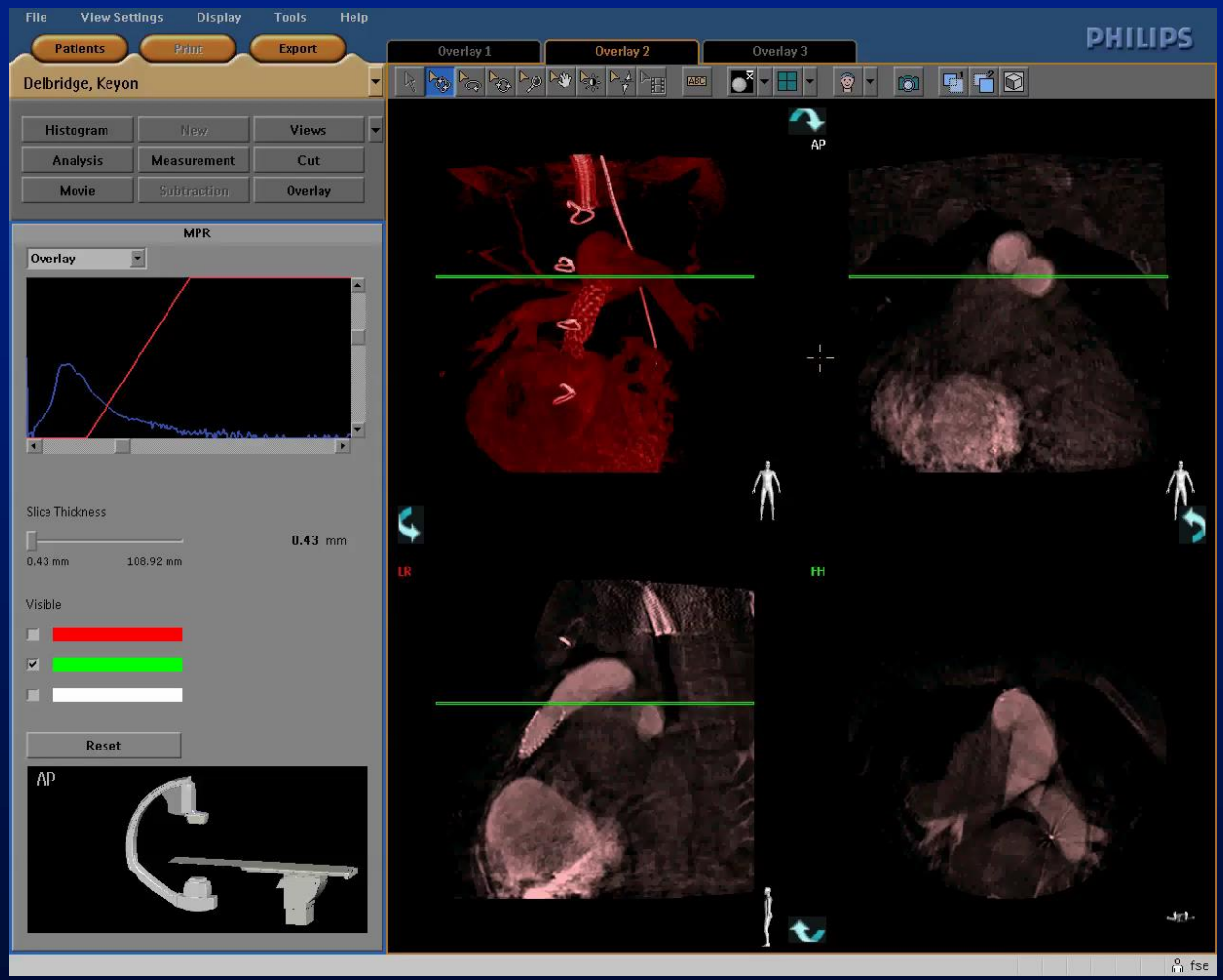
Airway and Cardiac Disease
3DRA

Patient Demographic and Procedural Data.								
Case	Age	Wt	DAP (mGycm 2)	Diagnosis	Treatment History	MPR findings	Bronch	Affect on clinical management
Interventional Planning								
5	2 y	10.8kg	574	DORV / PA	RV-PA conduit	Posterior compression of the left mainstem bronchus	Yes (CT)	Yes: Conduit balloon angioplasty
6	2 y	10.3kg	756	Absent pulmonary valve	PA repair; LeCompte	Balloon testing: No airway compression	No	Yes: Stent angioplasty
7	2 y	10.4kg	475	Double inlet left ventricle	Complex hybrid paliation; Glenn; LPA stent revascularization	Airway relatively distant to stented LPA	No	Yes: Cutting balloon LPA angioplasty
8	6 y	12.7kg	850	Coarctation of the aorta; Pulmonary sling; Complete tracheal rings	Vascular ring repair; airway reconstruction	Balloon testing: RPA without compression; LPA severely compressed	Yes	Yes: RPA Stent; LPA angioplasty

Truong, *Catheter Cardiovasc Interv*. 2015 Aug;86:1068–1077

Airway and Cardiac Disease

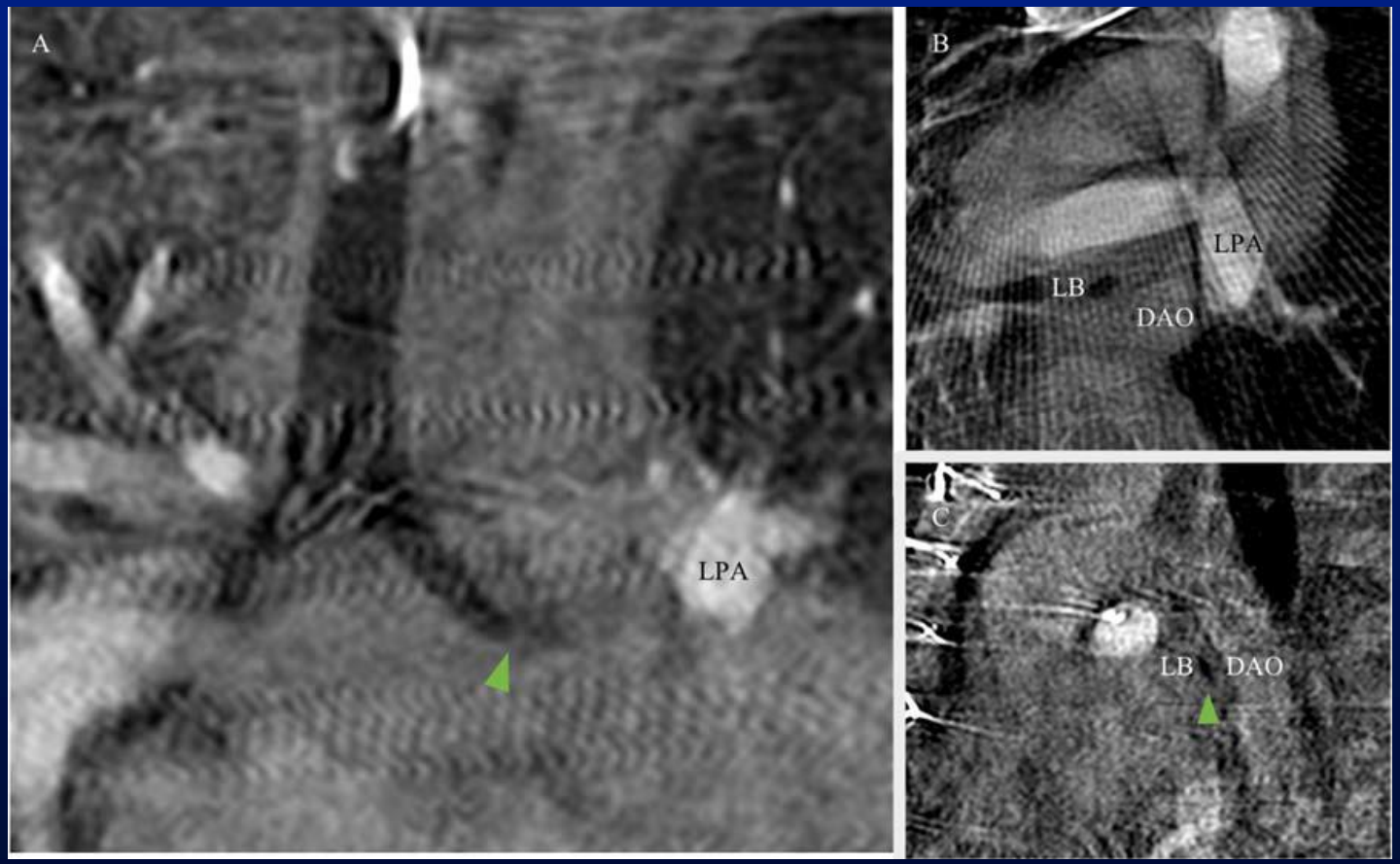
3DRA



Truncus Arteriosus; Criss-Crossed PAs

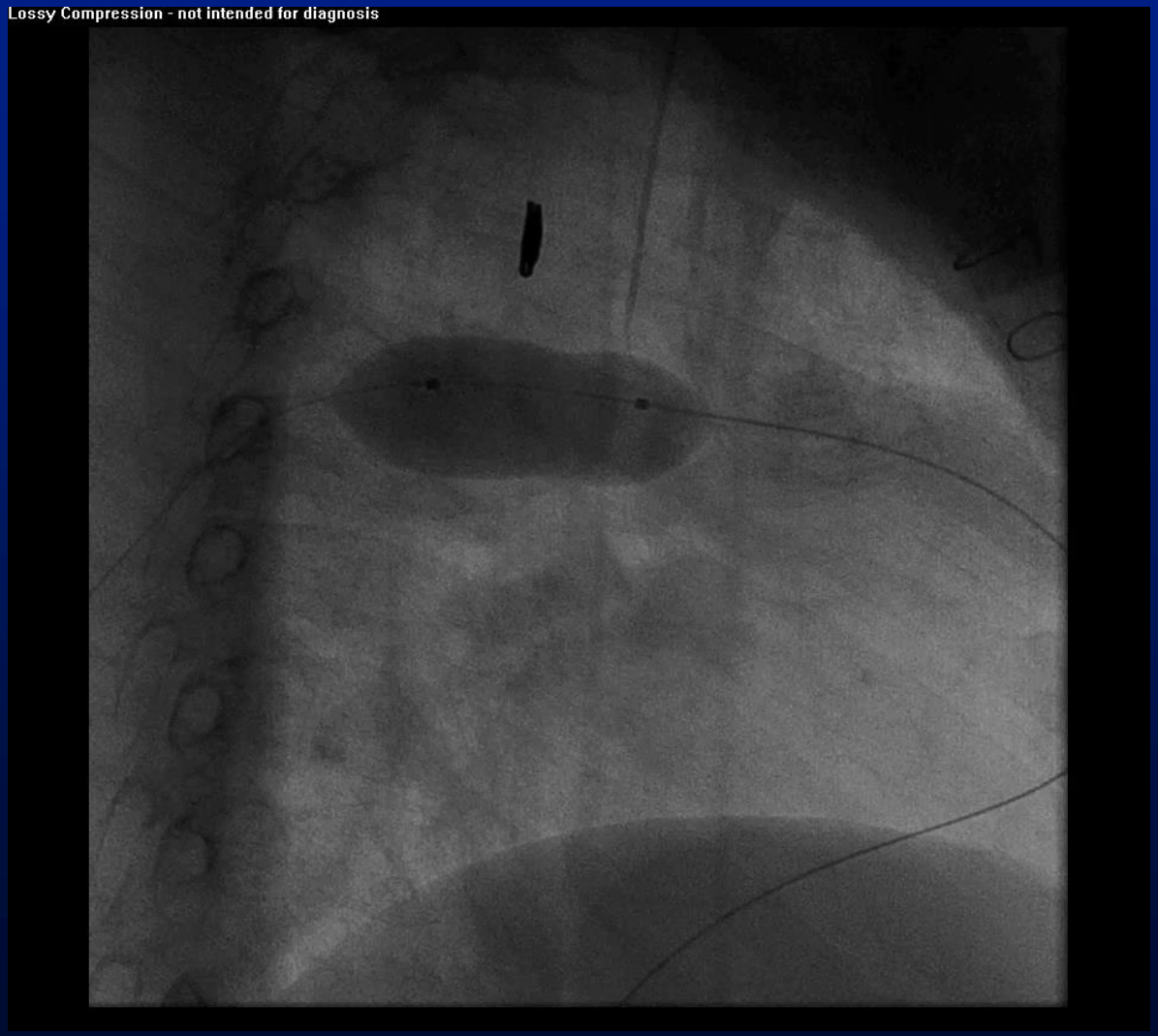
Airway and Cardiac Disease

MPR – Left Bronchus Compressed by DAo



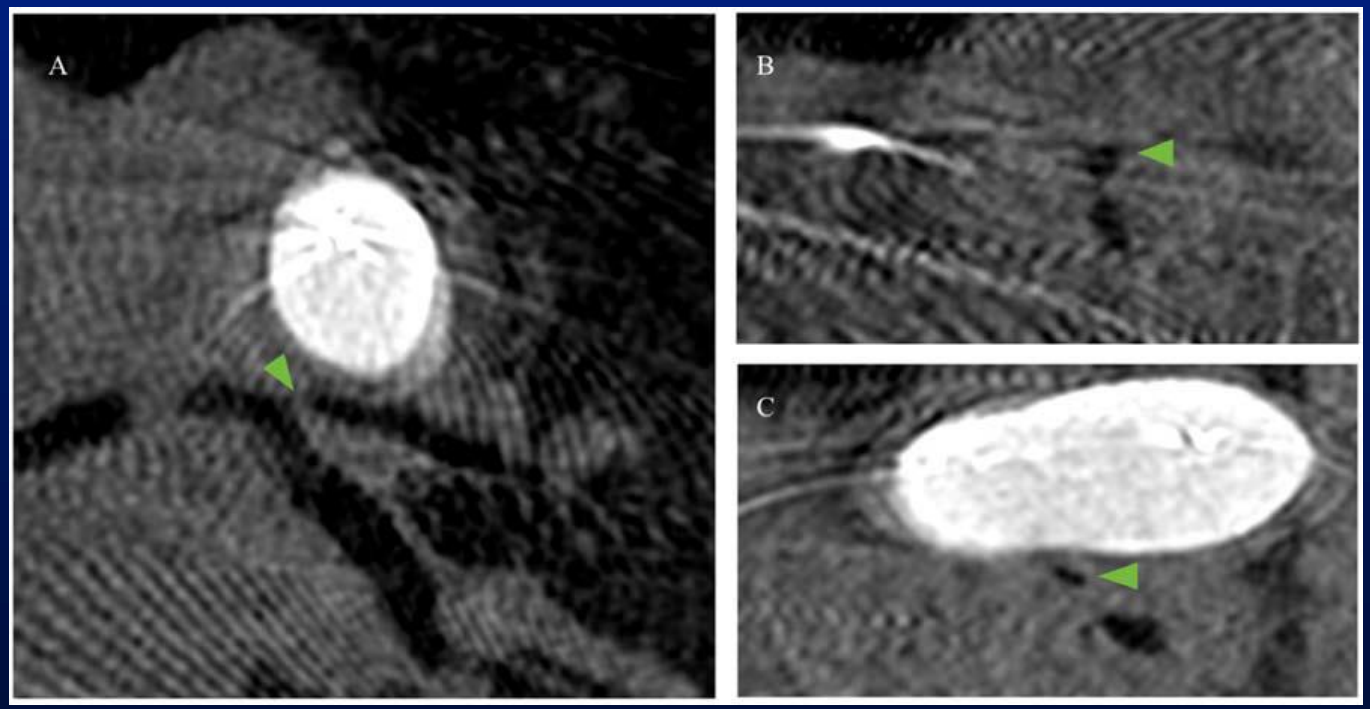
DORV / PA; RV-PA Conduit

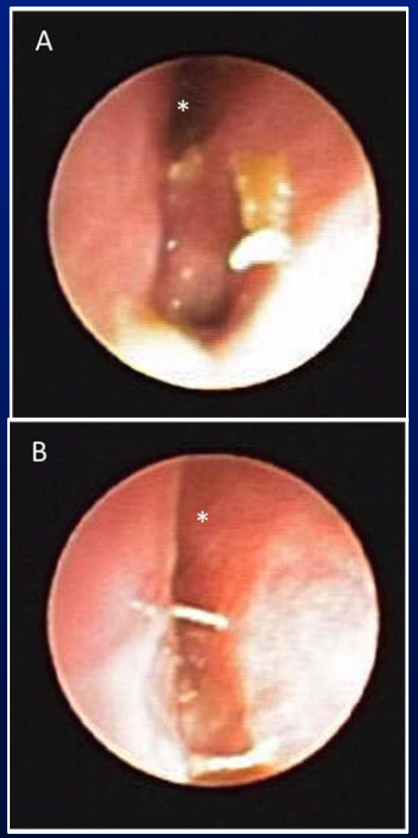
Airway and Cardiac Disease
3DRA



- Dynamic vascular testing
- 3DRA during LPA angioplasty
- Evaluation of airway compression

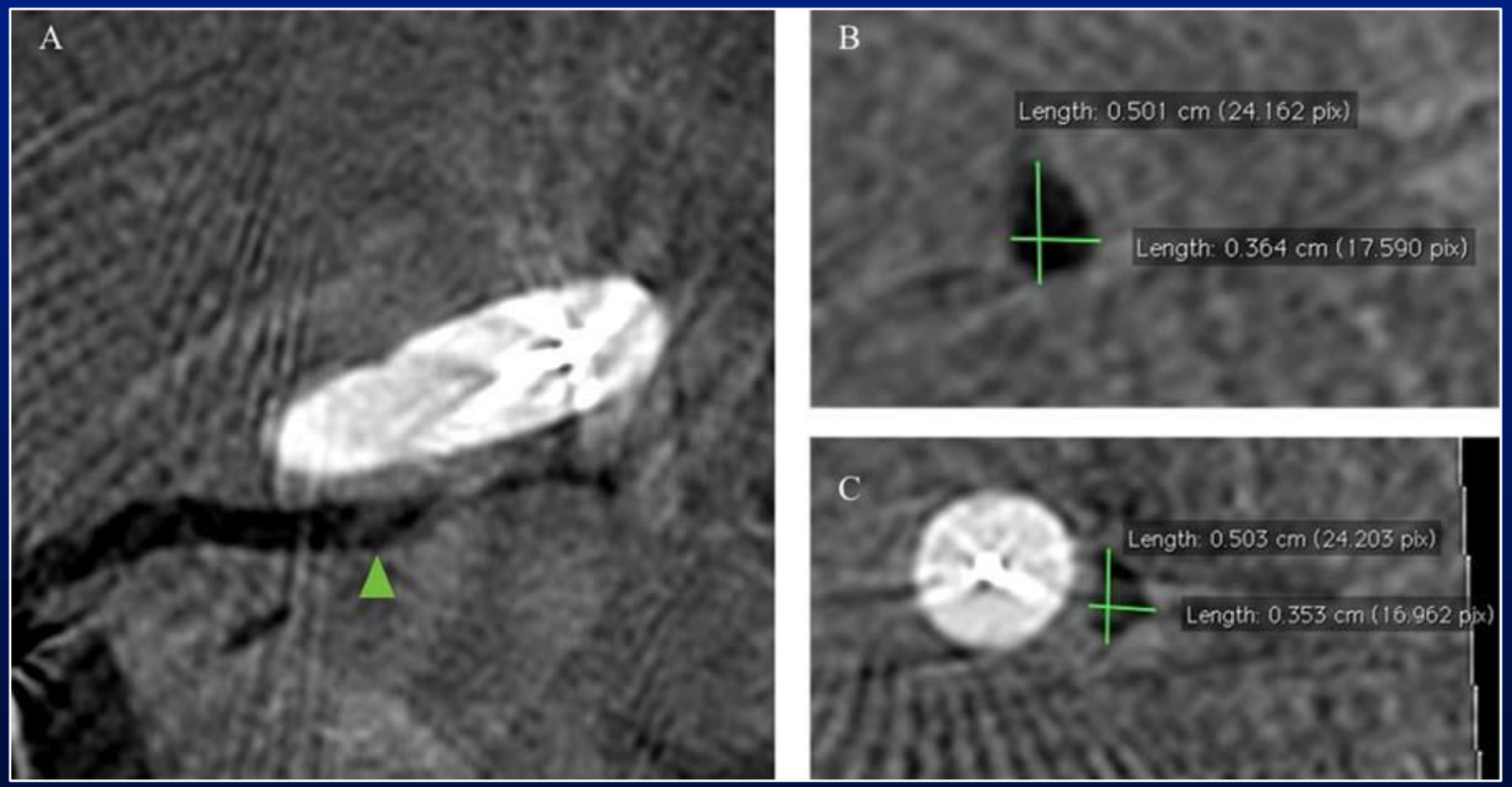
Airway and Cardiac Disease
MPR – Balloon Test in LPA





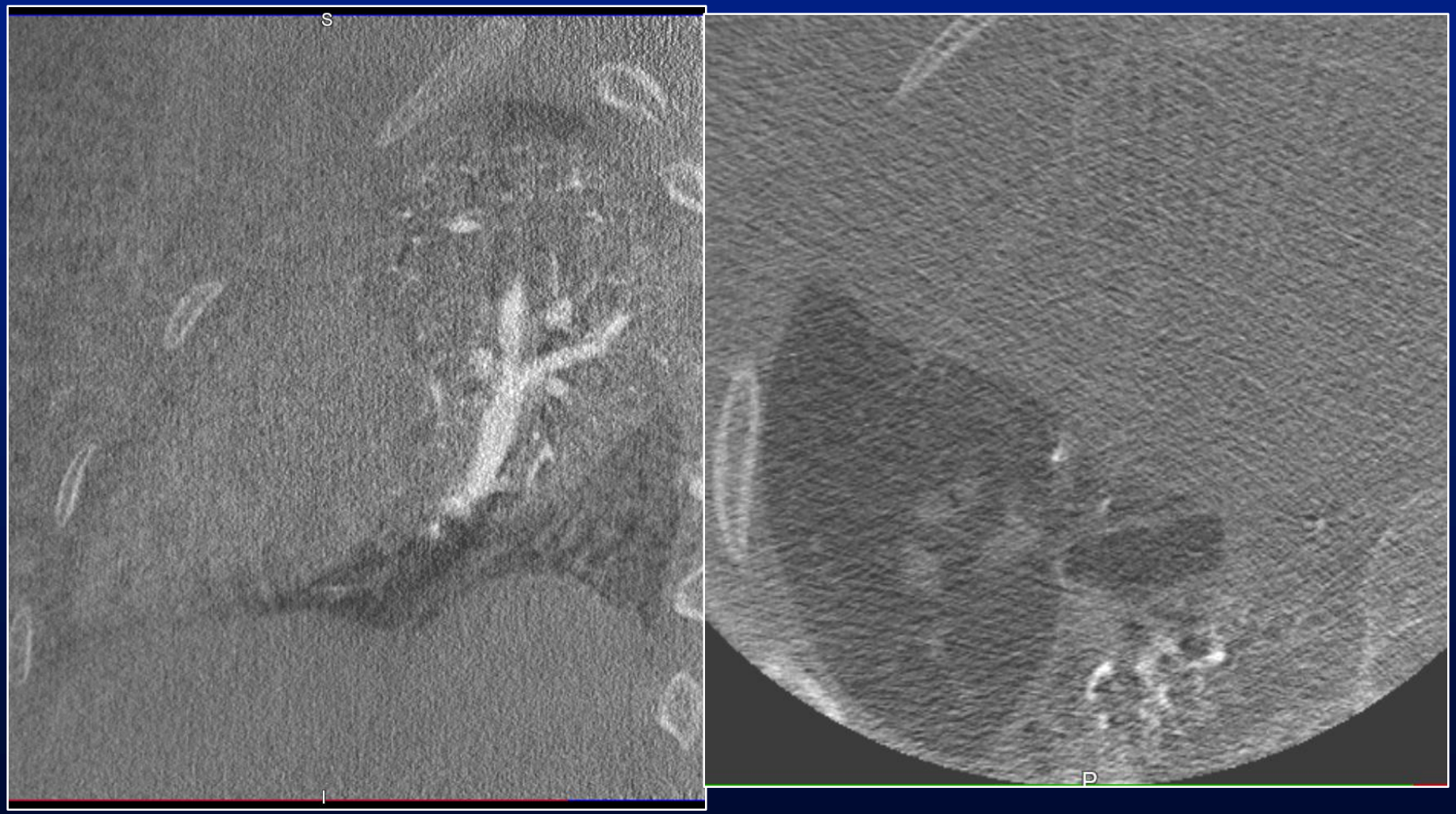
Repaired LPA Sling; Tracheal Rings

Airway and Cardiac Disease
MPR – Balloon Test in RPA

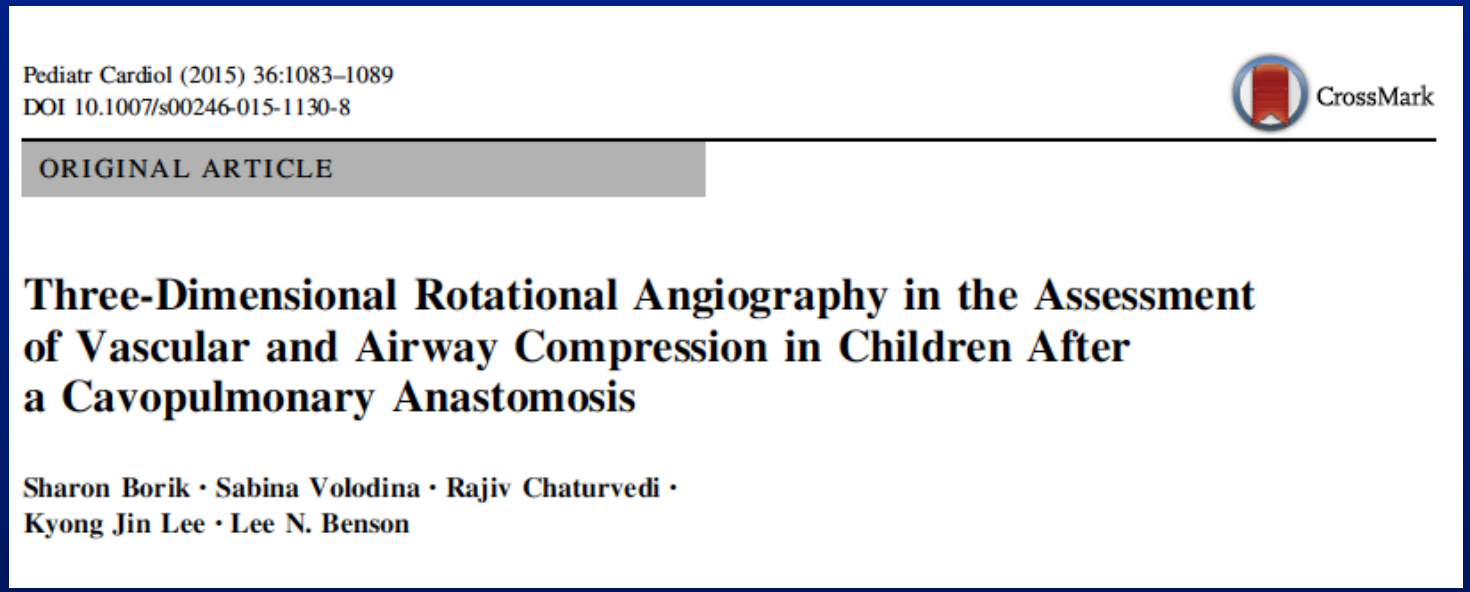


Repaired LPA Sling; Tracheal Rings

Airway and Cardiac Disease
Pulmonary Sequestration



Airway and Cardiac Disease
3DRA Multiplanar Reformat



Pediatr Cardiol (2015) 36:1083–1089
DOI 10.1007/s00246-015-1130-8

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ORIGINAL ARTICLE

Three-Dimensional Rotational Angiography in the Assessment of Vascular and Airway Compression in Children After a Cavopulmonary Anastomosis

Sharon Borik · Sabina Volodina · Rajiv Chaturvedi · Kyong Jin Lee · Lee N. Benson

- Initial qualitative evaluation of airway narrowing
- Qualitative airway narrowing: obliteration or a decrease distally of at least 50% compared to the proximal lumen
- Quantitative assessment of PA and airway diameters by MPR

Airway and Cardiac Disease
3DRA Multiplanar Reformat

- Ten cases with LPA stenosis (83%) also had bronchial stenosis
- Qualitative assessment correlated with quantitative MPR bronchial dimensions:
  - Bronchial stenosis = 4.4 ± 1.6 mm
  - Qualitatively normal bronchus 5.9 ± 1.1 (p = 0.009)
- All bronchial stenosis found on LPA
- 4 Confirmed by CT or bronchoscopy
- History of Hybrid Palliation and DKS both risk factors

Borik, *Pediatr Cardiol.* 2015 Jun;36(5):1083-9

Airway and Cardiac Disease
3DRA Multiplanar Reformat
Conclusions

- 3DRA MPR assessment of vascular / airway relationships is a useful adjunct to define airway compression
- 3DRA MPR can be used with acute vascular testing
  - Balloon angioplasty pre-stent placement
- Less invasive than intraprocedural bronchoscopy
- Radiation exposure is present but appears minimal

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