Ablation in infants and small children: Results and complications

John Papagiannis, MD, FHRS, CCDS, CEPS
Director of Electrophysiology
Children's Mercy Hospital
Kansas City, Missouri

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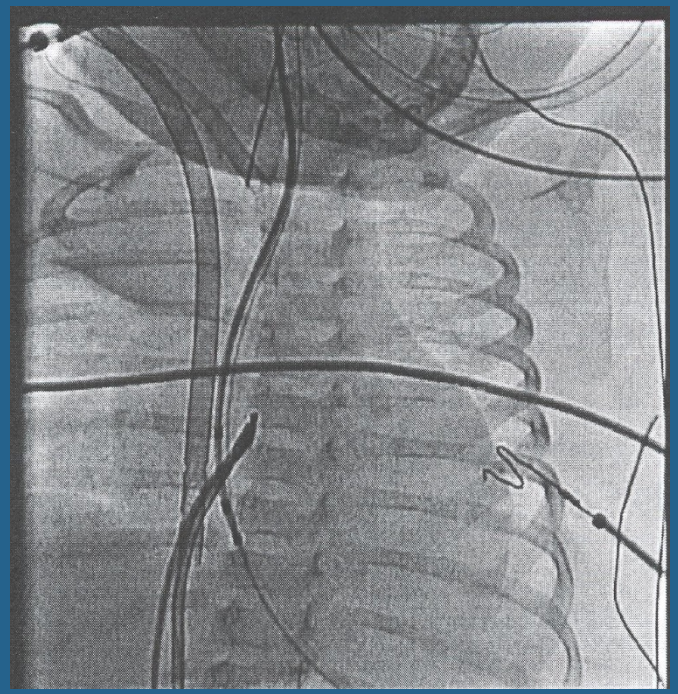
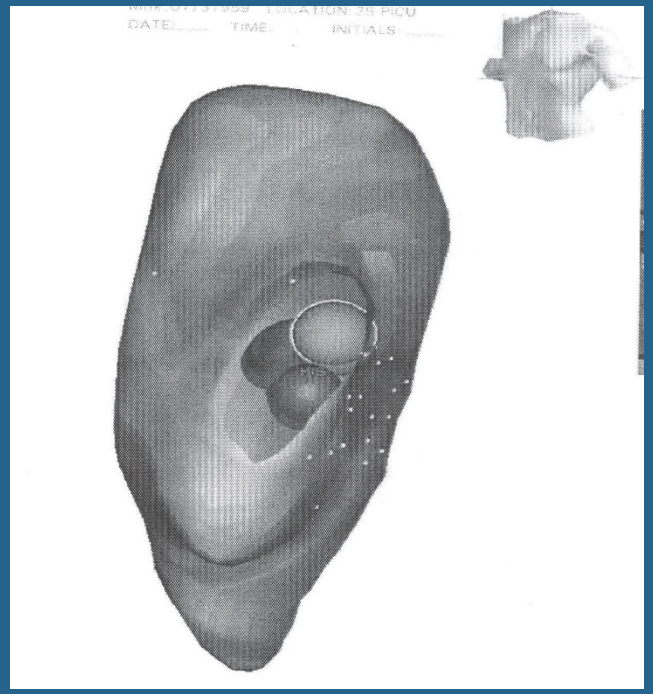
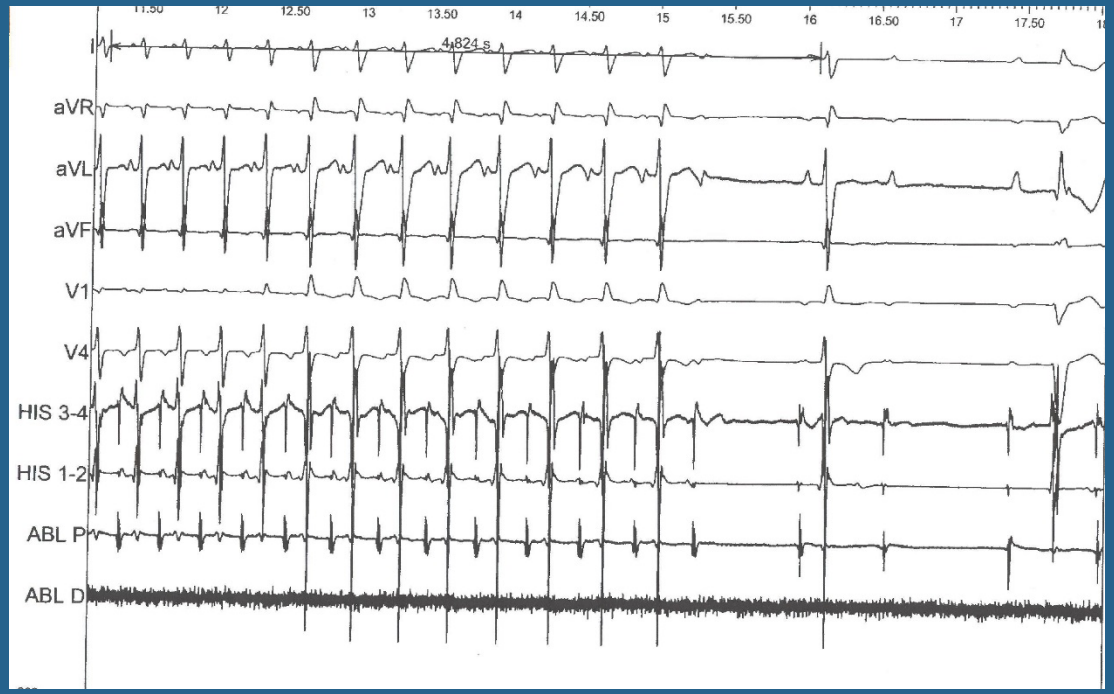
Sometimes things are tough…

- 5 month old female, incessant SVT, HR 260 bpm, LVEF 10%
- Electively intubated and amiodarone bolus given with ECMO standby
- Resistant to 3 amiodarone boluses and infusion
- Placed “electively” on ECMO in preparation for ablation
- EP study: Long RP tachycardia, inducible with extrastimuli, V-A-V response to ventricular entrainment

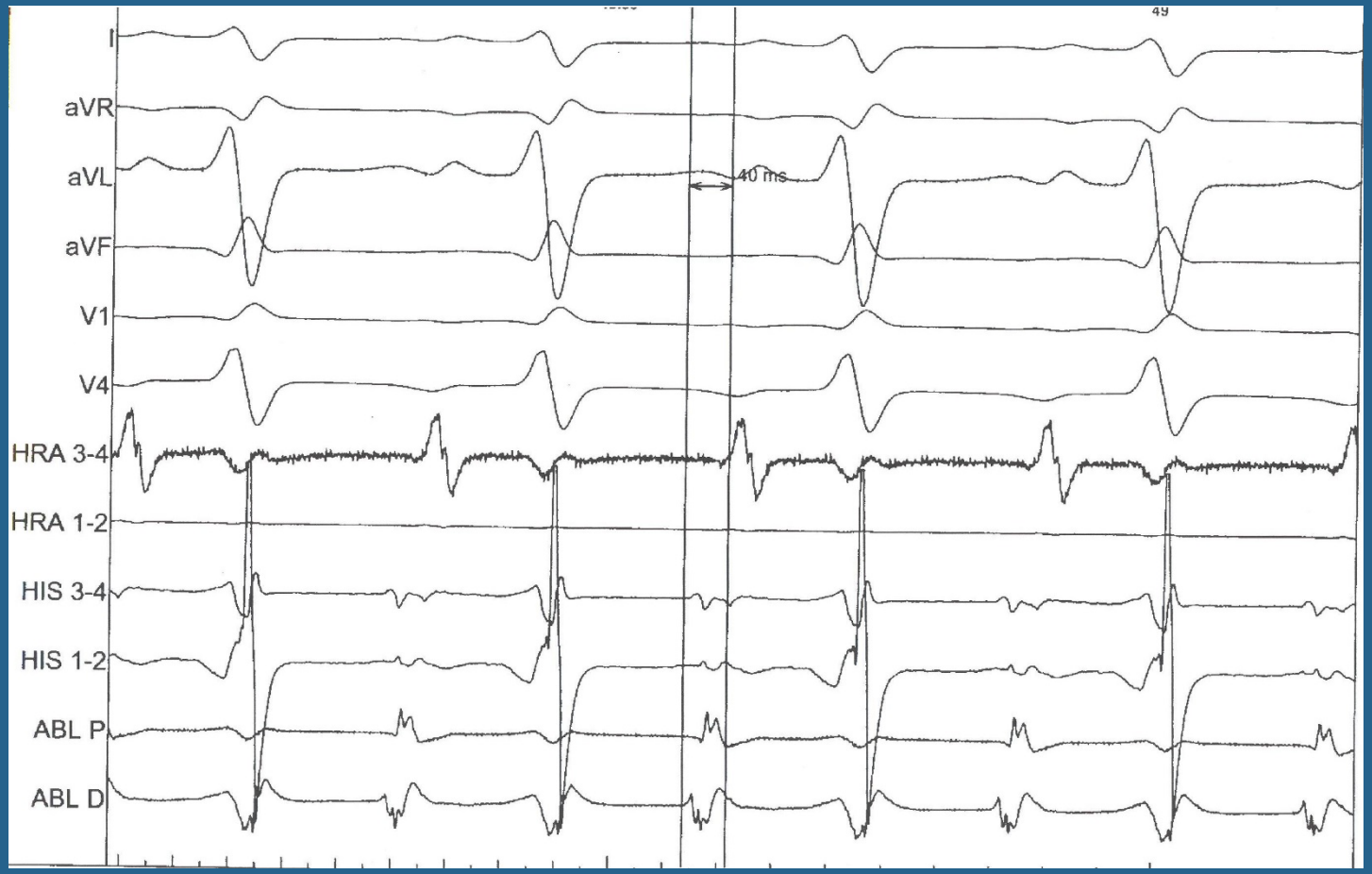
Cryoablation of parahisian pathway on ECMO
Termination of tachycardia with transient AV block



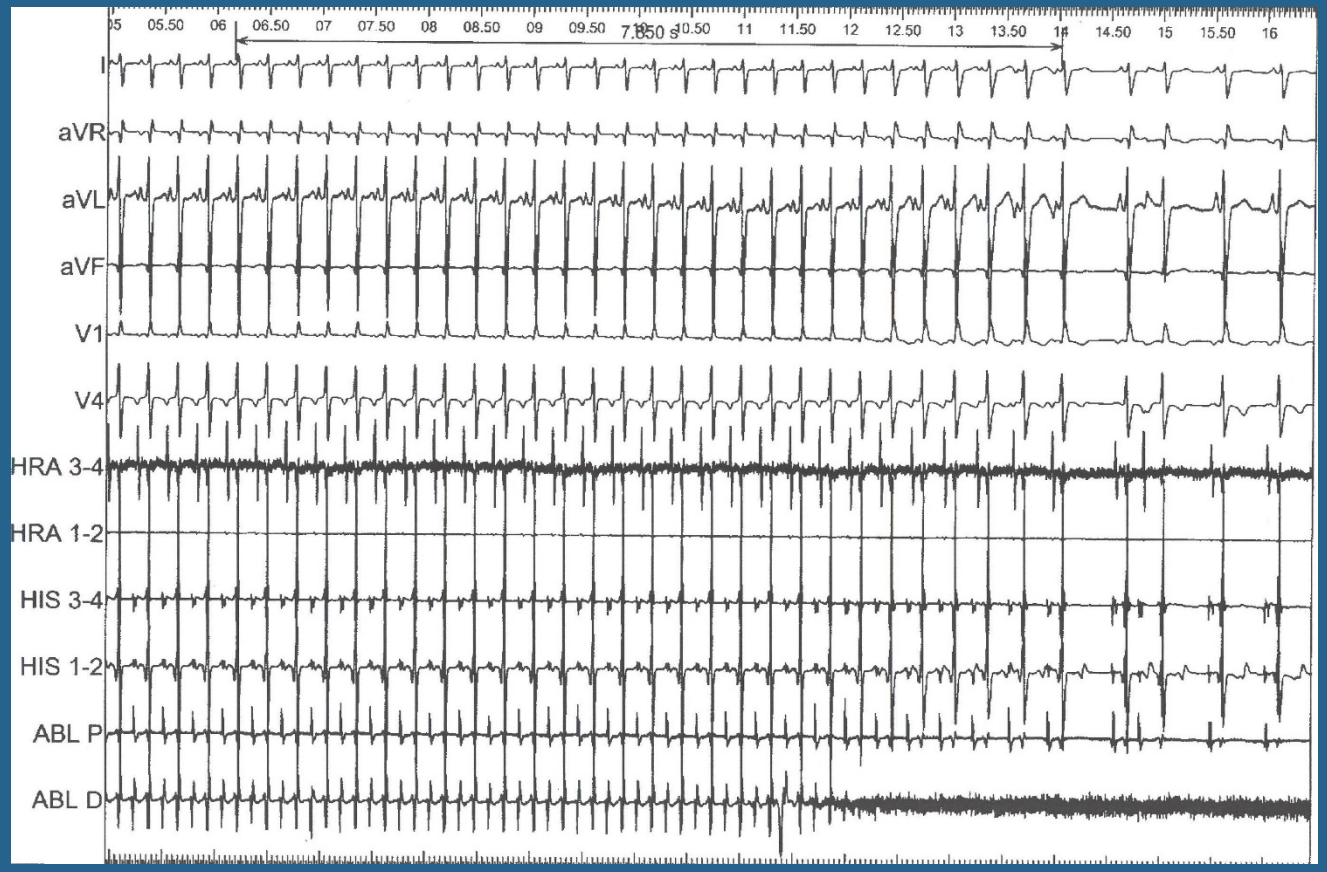




Pre-ablation signal Parahisian area



Successful cryoablation and full recovery



- Successful cryoablation
- Fluoro time 11 min
- 5 cryolesions
- F/U: return of LVEF to normal in 2 months
- No recurrence at 12 months of age

Reasons for ablation in infants/small children

- **Incessant arrhythmias leading to cardiomyopathy**
  - Ectopic atrial tachycardia
  - Permanent junctional reciprocating tachycardia
  - Junctional ectopic tachycardia
  - Incessant ventricular tachycardia
  - Dyssynchrony-induced cardiomyopathy
- **Paroxysmal arrhythmias not controlled by medications or intolerable side-effects caused by medications**
- **Congenital heart disease**
  - Anticipated effect on perioperative management
  - Access issues related to impending CHD surgery

Infants/small children are different

- Peripheral vasculature: Access issues
- Size of intracardiac structures
  - Triangle of Koch
  - Myocardial thickness
  - Distance and size of coronary arteries
- Effects of ablation on immature myocardium
- Effects of radiation on growing organisms
- Natural history of arrhythmia substrates

Natural history of tachycardia in infancy

- AVRT in infants: Spontaneous resolution in 93%

  Perry JC, Garson A Jr. J Am Coll Cardiol. 1990 Nov;16(5):1215-20

- EAT in <3 yrs of age: Spontaneous resolution in 78%

  Salerno JC, J Am Coll Cardiol. 2004 Feb 4;43(3):438-44

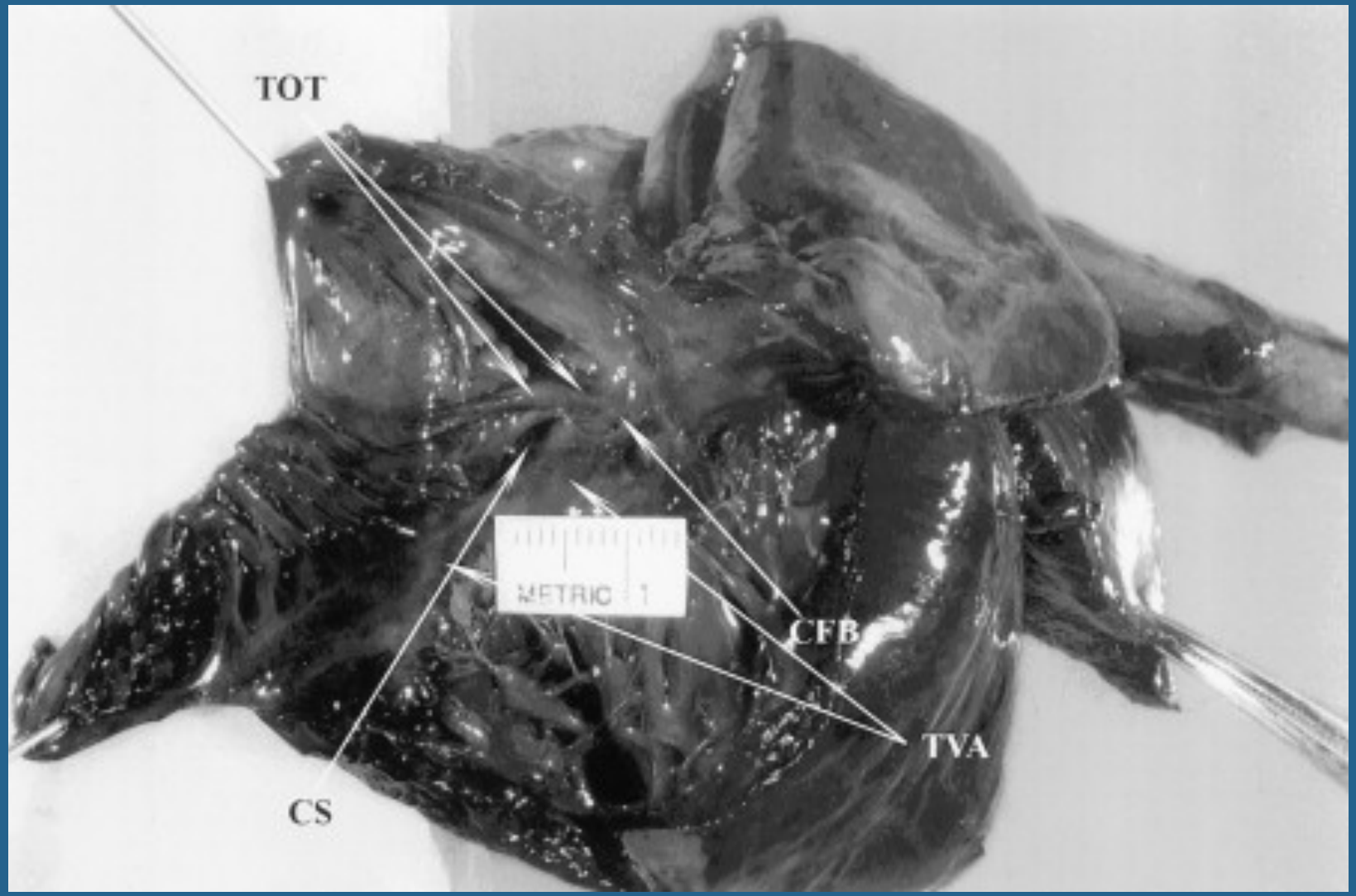
- Ventricular tachycardia in infants with structurally normal heart:

  Ventricular tachycardia resolved spontaneously in all infants
  No patient died, or received catheter ablation or device therapy

  Levin et al, Cardiol Young 2010 Dec;20(6):641-7

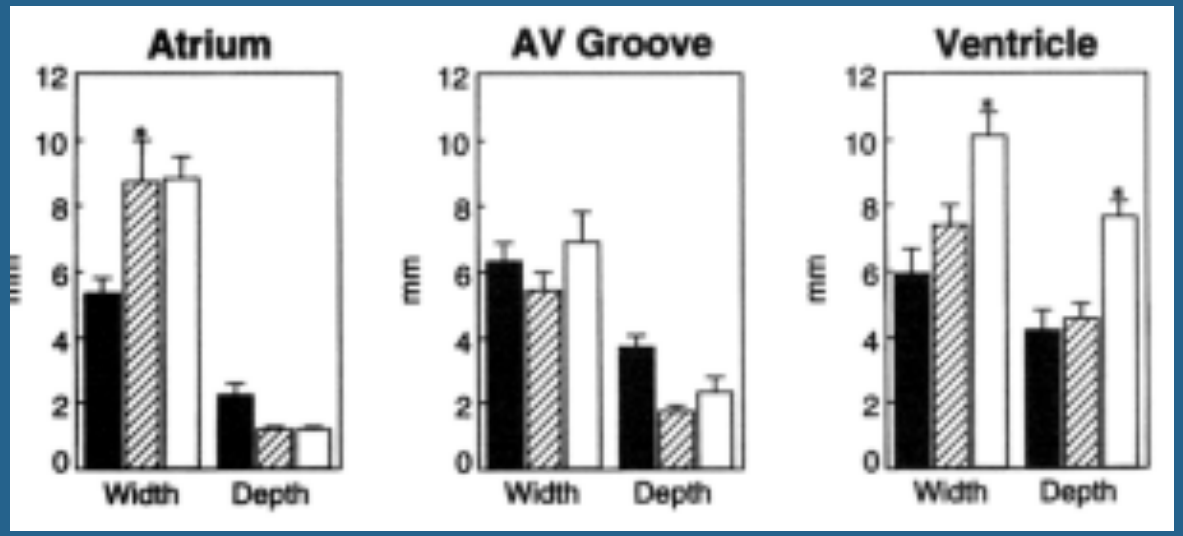
Triangle of Koch 4.5 kg infant

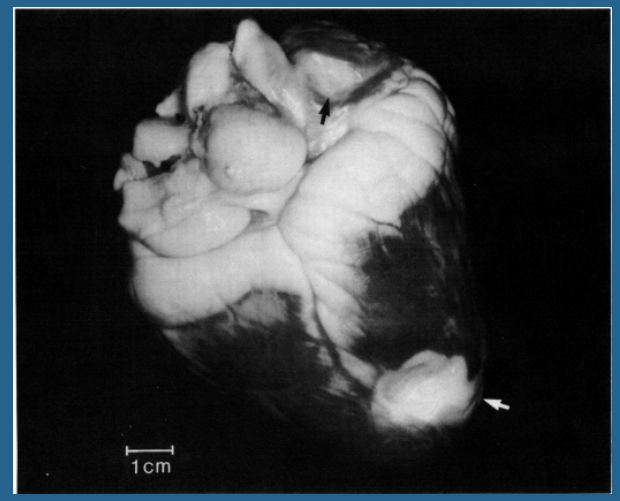
Goldberg…Dick, AJC 1999;83:117–120

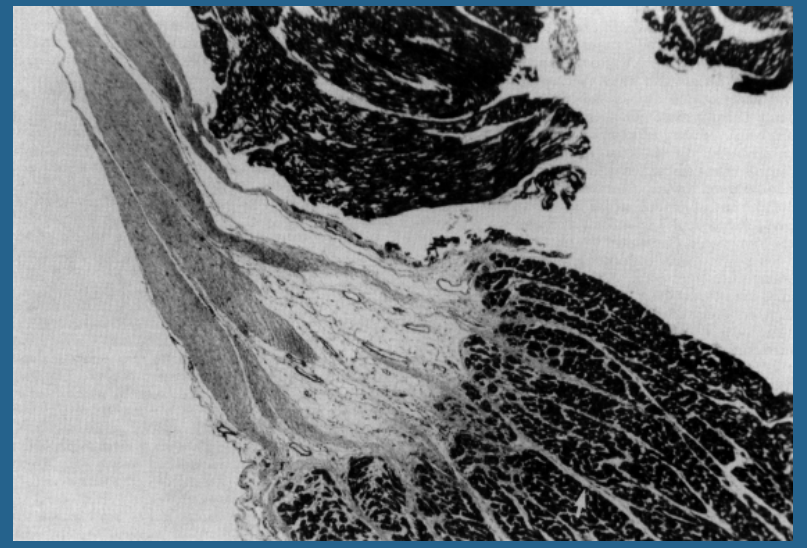


Late enlargement of radiofrequency lesions in infant lambs. Implications for ablation procedures in small children.

Saul JP et al, Circulation 1994 Jul;90(1):492-9.

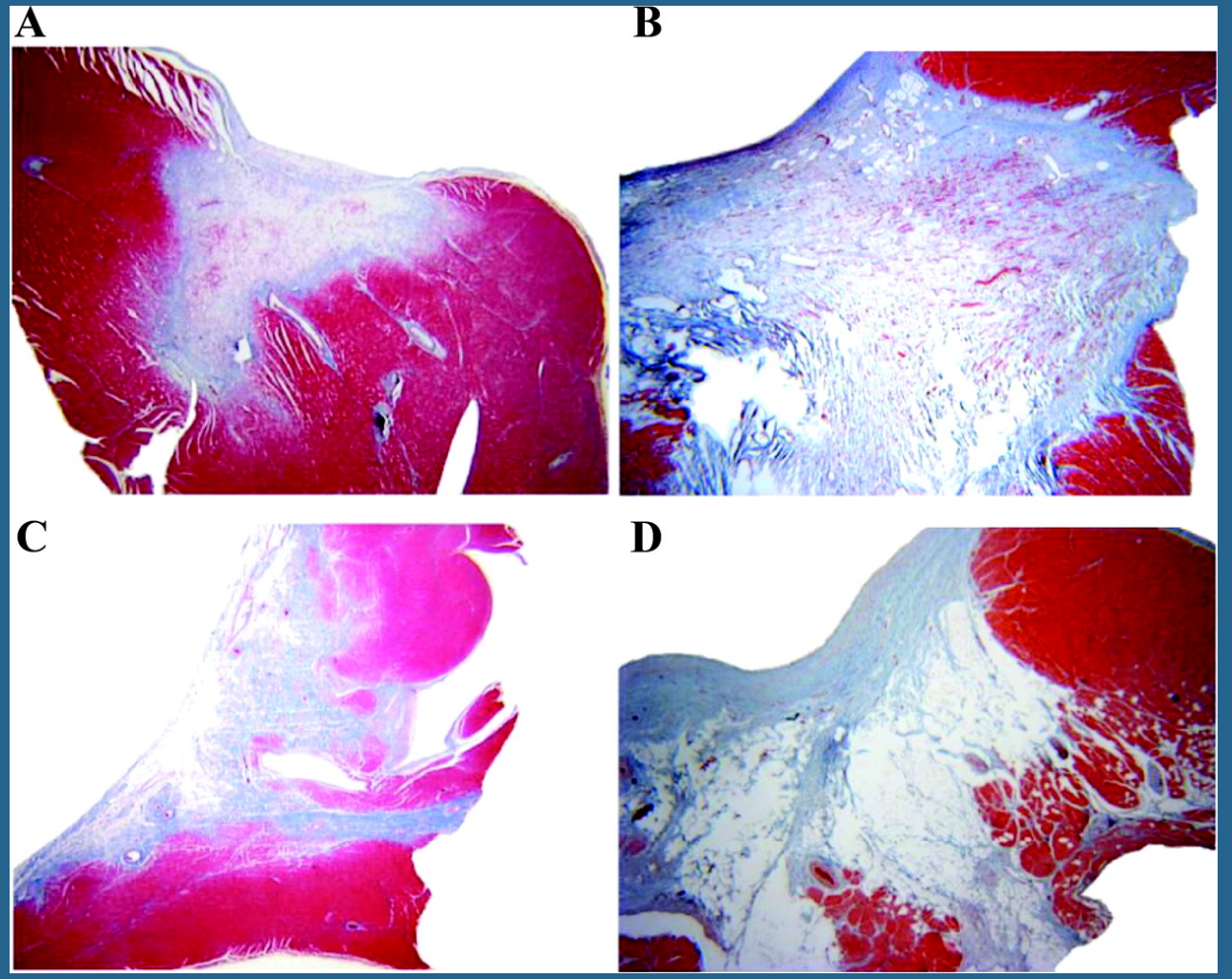






Histological characteristics of cryothermal and radiofrequency ablation lesions.

Khairy et al, Circ Arrhythm Electrophysiol 2011;4:211-217



Radiofrequency catheter ablation in infants </=18 months old: when is it done and how do they fare? short-term data from the pediatric ablation registry

Blaufox AD, Circulation 2001;104(23):2803-8.

TABLE 1. Patients

	Infants	Noninfants	*P*
Patients, n	137	5960	...
Procedures, n	152	6610	...
Substrates, n	171	7160	...
Age, y	0.7 (0.05–1.5)	13.1 (1.6–20.9)	<0.0001
Weight, kg	7.4 (1.9–14.8)	50 (8–139)	<0.0001
Structural HD, %	36%	11.2%	<0.0001

Structural HD indicates structural heart disease.

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TABLE 3. Substrates

	Infants			Noninfants		
Substrate	n	Prevalence, %	Success, %	n	Prevalence, %	Success, %
Accessory pathway	115	67.3	87.8	4731	66.1	90.9
AVNRT	7	4.1	100	1576	21.6	97
EAT	29	17.1	89.7	332	4.9	87.3
JET	6	3.5	100	13	0.3	76.9
Atrial flutter	4	2.4	50	312	4.3	76
VT	10	5.9	70	196	2.8	65.3

AVNRT indicates AV nodal reentrant tachycardia; EAT, ectopic atrial tachycardia; JET, junctional ectopic tachycardia; and VT, ventricular tachycardia.

P=NS for infants vs noninfants for success for all substrates.

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TABLE 4. Complications

Complications	n	Substrate	Heart Disease
Major			
Pericardial effusion	2	L lateral AP/P septal AP	ASD
Pneumothorax	2	A septal AP/R EAT	VSD
2° AVB	1	M septal AP	
3° AVB	1	M septal AP	
Horner's syndrome	1	L lateral AP	
Death	1	RV-VT	Ebstein's
Minor			
Transient 3° AVB	2	A septal AP/P septal AP	VSD
Hematoma	1	R EAT	
Sinus bradycardia	1	R EAT	LV dysfunction

2° AVB indicates 2nd-degree AV block; 3° AVB, 3rd-degree AVB; L lateral, left lateral; P septal, posteroseptal; A septal, anteroseptal; R EAT, right atrial ectopic atrial tachycardia; M septal, midseptal; and RV-VT, right ventricular tachycardia.

Short- and Long-Term Outcomes in Children Undergoing Radiofrequency Catheter Ablation Before Their Second Birthday

Kantoch et al, Canadian Journal of Cardiology, 2011-07-01, Volume 27, Issue 4, Pages 523.e3-523.e9

Arrhythmia substrate	Small children, age: 0.4 to 23 months (N = 31)	Older children, age: 2.6 to 18 years (N = 447)	*P* value
All arrhythmias	23 of 31 (74%)	409 of 447 (91%)	< 0.01
Atrioventricular bypass tracts	16 of 19 (84%)	361 of 392 (92%)	> 0.2
Ectopic atrial tachycardia	2 of 4 (50%)	28 of 33 (85%)	
Multifocal atrial tachycardia	3 failed	0	
Atrial flutter	1 of 1 (100%)	7 of 7 (100%)	
Junctional ectopic tachycardia	2 of 2 (100%)	0	
Ventricular tachycardia	2 of 3 (66%)	13 of 15 (87%)	

Efficacy and Safety of Radiofrequency Catheter Ablation of Tachyarrhythmias in 123 Children Under 3 Years of Age

Jiang et al, PACE 2016;39:792–796

- 123 children under 3 years of age (mean, 2.3 ± 0.8 years)
- Weight, 13.6 ± 2.8 kg)
- Indications: drug resistance, drug intolerance, or tachycardia-induced cardiomyopathy;
- 15 CHD, 27 children <1 year of age.
- 109 children had RFCA
- 76.4% AVRT, 5.7% AVNRT, 2.4% EAT, 6.5% AFL, and 4.1% ILVT
- Acute success rate: 94.5%, recurrence rate: 6.8%,
- Complications: 2 femoral vessel occlusions treated with thrombolysis
- Comment: Ablation avoided in left-sided and parahisian APs

Ablation of accessory pathways in infants and toddlers

Study	Pt no	Age (mo)	Weight (kg)	AP	CHD	Acute Success	Complications	Mortality
Blaufox, Circ 2001	137	0.3-18	1.9-14.8	67%	36%	87%	10/137 (7.8%)	-
Jiang, PACE 2016	123	4-36	4.7-19.4	75%	12%	97%	2/123 (1.6%)	-
Kantoch, Can J Card 2011	31	0.3-23	2.6-12.3	61%	13%	84%	4/31 (12.9%)	-
Chiu, Circ J 2009	27	8-70	6.6-30	59%	30%	93%	1/27 (3.7%)	-
Aiyagari, Ped Card 2005	25	33+/-22	11.9+/-3	76%	28%	96%	2/25 (8%)	-
Backhoff, Ped Card 2016	22	12-35	8.7-13.7	100%	27%	82%	3/22 (13.6%)	-
Turner, Cardiol Young 2012	17	0-22	3.7-14.6	53%	17%	81%	3/17 (17.6%)	-
Akdeniz, Cardiol J 2013	5	0.3-9.5	3.5-9.0	100%	40%	100%	0/5	-
Total	**387**	**0-70**	**1.9-30**	**73.5%**	**25.4%**	**90%**	**9,3%**	

Ablation of JET in infants

Study	No of pts	Age (mo)	RF	Cryo	Success	Complications	Follow-up
Van Hare, PACE 1990	1	10	+		+	Redo RFA: 3 AVB	2 yrs, paced VVI
Fishberger, PACE 1998	1	9	+		+	-	8mo, A&W
Berul, JICE 1998	1	0.5	+		+	-	2.5 yrs, A&W
Blaufox, Circ 2001	6		+		+	-	
Bae, PACE 2005	1	9	+		+	-	2 yrs, A&W
Shah, JCE 2007	1	12		+	+	-	6 mo, A&W
Kantoch, Can J Cardiol 2011	1	3	+		+	Transient RBBB	3.2 yrs, A&W
	1	13	+		+	Transient 3 AVB	1.4 yrs, A&W
Total	**13**	**8 mo**	**12**	**1**	**100%**	**3/13 (23%)**	**0.5-3.2 yrs** **1 paced pt**

VT ablation in infants/small children

Study	Age (mo)	Diagnosis	N	Success	Rec	Compl	Comments
Jiang, PACE 2016	35±1	ILVT	5	5/5	0	0	
Koutbi, HR 2015	11	Mitral Ann	1	1/1	0	0	ECMO, Transapical
Kornyei, EP 2014	1	RV in	1	1/1	0	0	
Abe, H&V 2014	9	PMVT (6)	1	1/1	Yes	0	Controlled with meds
Costello, CHD 2014	2	TGA s/p ASO, RVOT	1	1/1	Yes	0	Controlled with meds
Kantoch, CJC 2011	11-16	ILVT	3	2/3	Yes	0	1 pt controlled with meds
De Filippo, EP 2011	12	ILVT	1	1/1	0	0	Transseptal approach
Van Beeumen, EP 2008	21	Mitral Ann	1	1/1	0	0	Irrigated RF
Blaufox, PACE 2004	3.5-19.8	ILVT (2), PMVT, RV	4	3/4	1	0	1 pt had 4 procedures
	1-36 mo	ILVT:11, MA:2, PMVT:2, RV:3	18	16/18 (88%)	3	0	

Complications of ablation in infants

- Death: Initial series of Pediatric RF ablation Registry showed significantly higher mortality in infants: 43% of total deaths. Further series and reports did not show higher mortality

- AV block: Initial series showed higher incidence. Use of cryoablation and experience with RF have significantly decreased events

- Coronary arterial injury: Incidence unknown in infants. Series of 212 pts had 2 coronary occlusions. Schneider HE, Heart Rhythm 2009 Apr;6(4):461-7

- Cardiac perforation and effusion: From 1.3-2.2% (compare to 0.1% in general ablation procedures)

Conclusions

- The majority of arrhythmia substrates in infants tend to resolve spontaneously
- Medical therapy should be exhausted as long as it is safe
- Catheter ablation procedures can be performed successfully and safely in medically refractory cases. Consider cryoablation
- Complications may occur due to immature myocardium and small structures
- Mechanical support may be necessary in extreme cases

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