



Ablation in infants

- indications
- limitations
- challenges
- results

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SVT & RFA in neonates & infants

- ❖ Most infants & neonates "outgrow their SVT"
- ❖ PJRT & JET require ongoing Rx
- ❖ SVT resolves in 60 - 90% by 1 yr of age
- ❖ WPW disappears in 40% by 1 yr of age
- ❖ AET under age 3 has high chance of resolution

Deal BJ, Keane JF, Gillette PC, Garson A.

Wolff-Parkinson-White syndrome and supraventricular tachycardia during infancy: management and follow-up. JAm Coll Cardiol. 1983;1:130-135.

Penson WD, Dunnigan A, Benditt DG.

Follow-up evaluation of infant paroxysmal tachycardia: transesophageal study. Circulation. 1987;75:542-549.

Perry JC, Garson A.

Supraventricular tachycardia due to Wolff-Parkinson-White syndrome in children: early disappearance and late recurrence. JAm Coll Cardiol. 1991;16:1215-1220.

Salerno JC, Kertesz NJ, Friedman RA, Fenrich AL Jr.

Clinical course of atrial ectopic tachycardia is age-dependent: results and treatment in children <3 or 3 years of age J Am Coll Cardiol, 2004; 43:438-444

Death has occurred after RFA in infants



RFA in children



The NEW ENGLAND JOURNAL of MEDICINE

ORIGINAL ARTICLE

Radiofrequency Catheter Ablation for Tachyarrhythmias in Children and Adolescents

John D. Kugler, David A. Danford, Barbara J. Deal, Paul C. Gillette, James C. Perry, Michael J. Silka, George F. Van Hare, and Edward P. Walsh for the Pediatric Electrophysiology Society

N Engl J Med 1994; 330:1481-1487



RFA in children

- ❖ 1991 - 1992
- ❖ 653 patients
- ❖ Complication rate
 - ❖ Periprocedural = 3.7%
 - ❖ Late total = 4.8%
- ❖ Wt < 15 kg = significant

COMPLICATION	No. OF PROCEDURES
Procedural	19
Pericardial effusion	4
Brachial-plexus injury	3
Microemboli	3
Deep-vein thrombosis	2
Femoral arteriovenous fistula	1
Perforation	1
Horner's syndrome	1
Hemothorax	1
Occipital-nerve compression	1
Respiratory depression due to sedation	1
Death	1
Associated with application of radio-frequency	8
Atrioventricular block	5
Second-degree atrioventricular block	2
Valvular regurgitation	1
Postprocedural	8
Death	3
Pericarditis	2
Second-degree atrioventricular block	1
Pulmonary embolism	1
Valvular regurgitation	1



RFA in children

FEATURE	PATIENT 1	PATIENT 2	PATIENT 3	PATIENT 4
Age at ablation	20 mo	5 wk	3½ yr	11 yr
Complex cyanotic CHD	Yes	No†	Yes	No‡
Extracardiac disease	Renal and pulmonary disease, fever	Resolved hydrops fetalis	Hypercoagulopathy§	None
Outcome of procedure for arrhythmia	Successful ablation of left posterior septal pathway for WPW syndrome and orthodromic reciprocating tachycardia	Successful ablation of left posterior septal pathway	Successful ablation of AV-node pathway for His-bundle tachycardia	Unsuccessful ablation for atrial flutter; successful ablation of AV-node pathway for atrial flutter; successful ablation for VT
Postcatheterization thrombosis¶	No	Yes	Yes	No
Interval from ablation to death	2 hr	2 wk	56 days	10 wk
Autopsy findings	Complex CHD	Torn mitral-valve leaflet	Complex CHD, small clot in RPA	Autopsy not done



RFA in lambs

Circulation

JOURNAL OF THE AMERICAN HEART ASSOCIATION

American Heart
Association® 
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**Late enlargement of radiofrequency lesions in infant lambs. Implications for
ablation procedures in small children**

JP Saul, JE Hulse, J Papagiannis, R Van Praagh and EP Walsh

Circulation 1994, 90:492-499

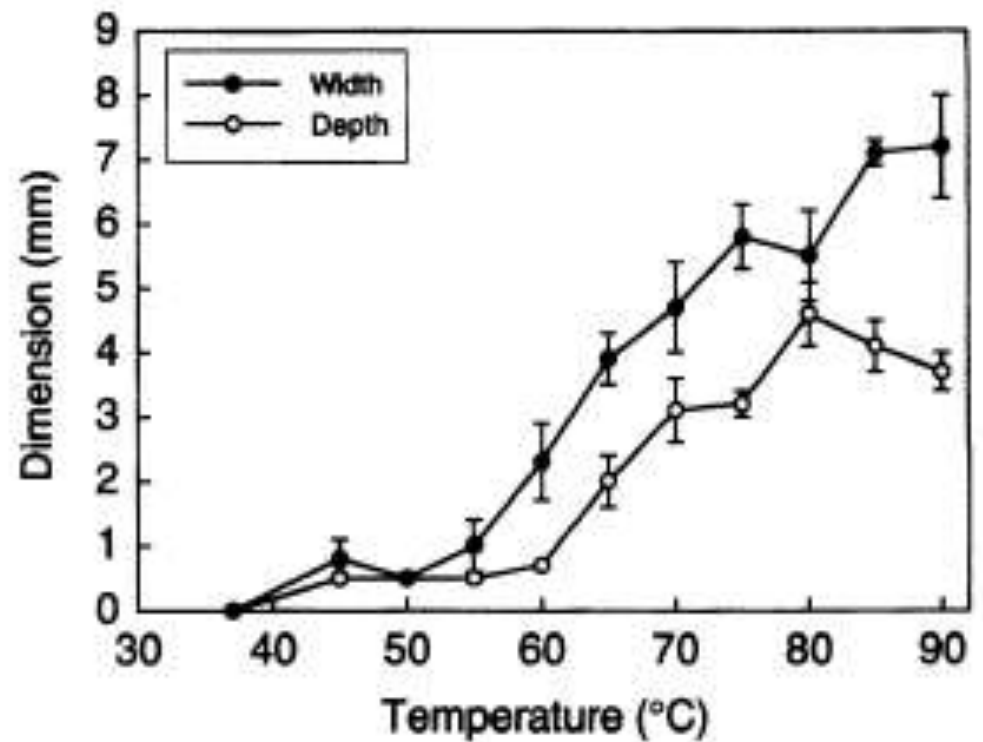
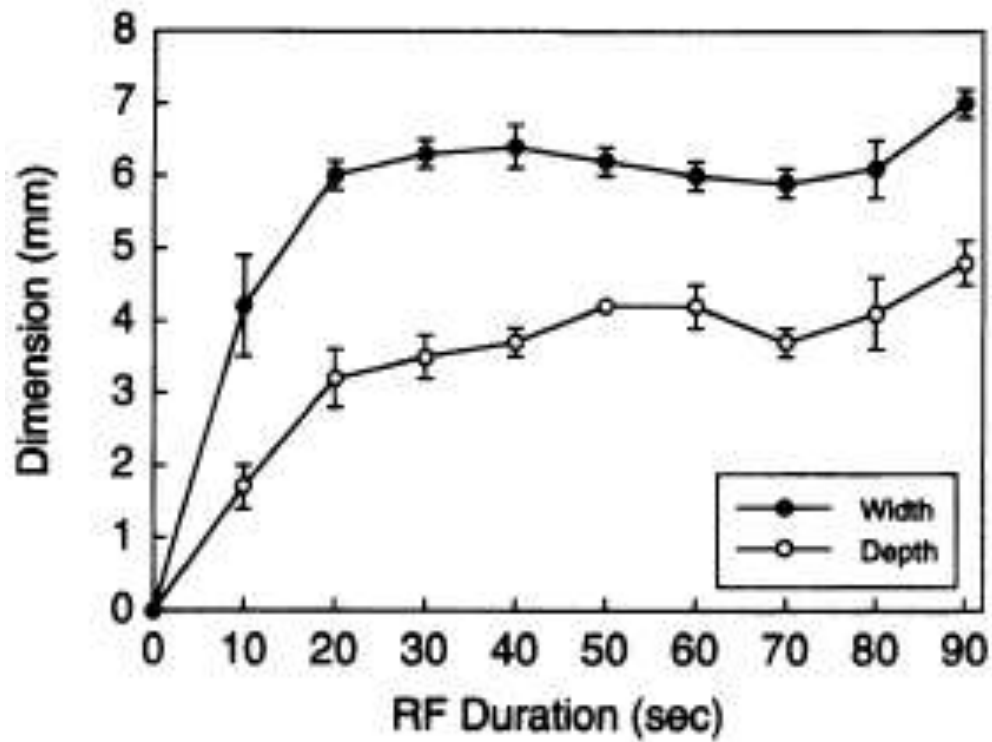


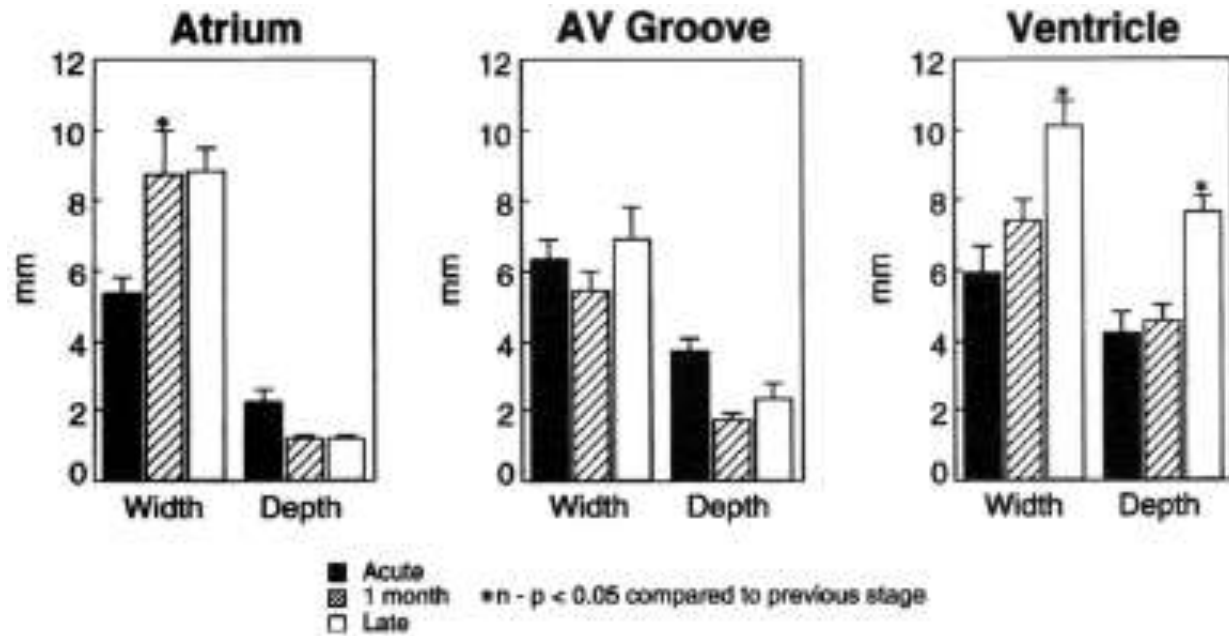
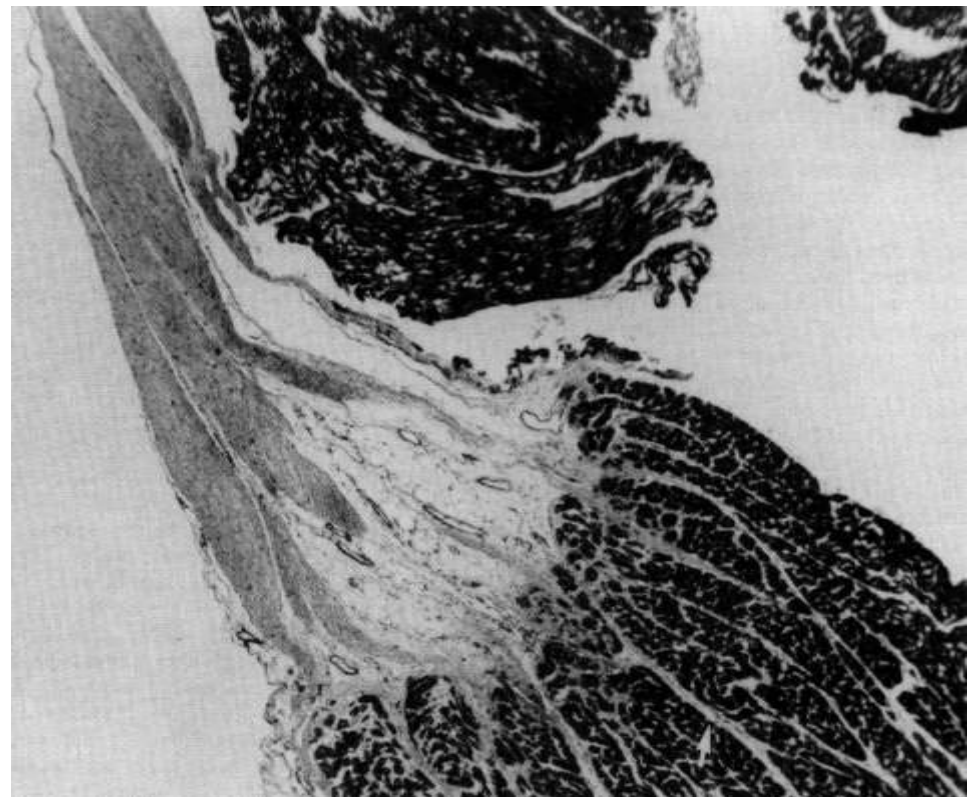
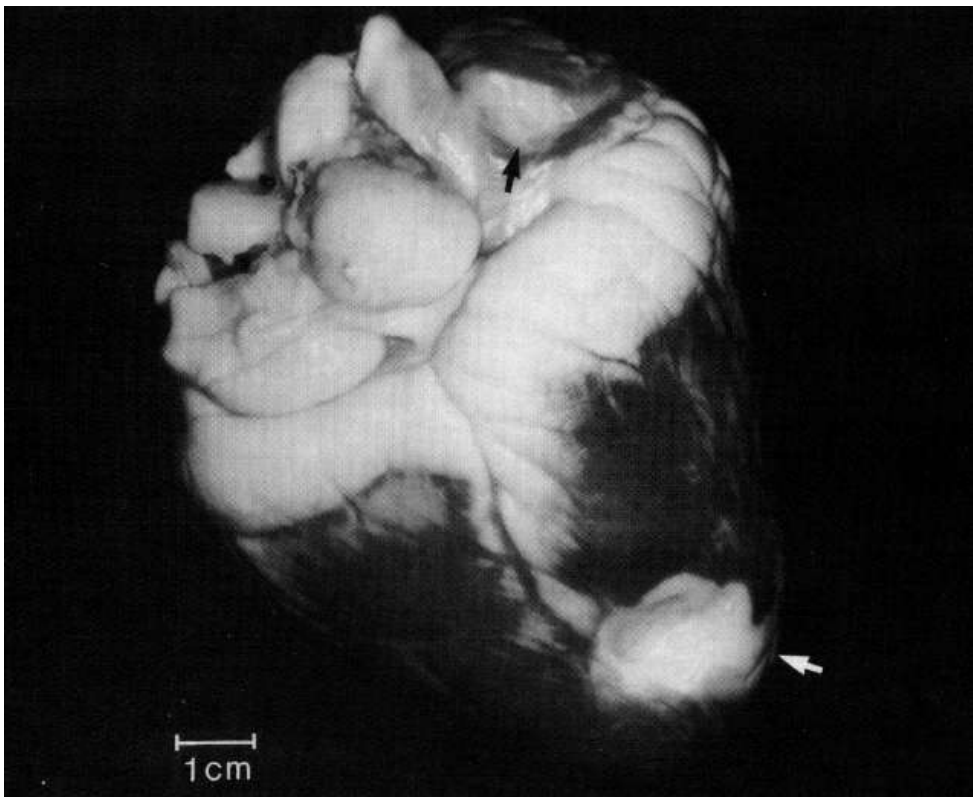
RFA in lambs

- ❖ Lambs; 8 - 12 kg
- ❖ Epicardial ablation in 15
 - ❖ Duration & temperature effect on lesion size
- ❖ Endocardial ablation
 - ❖ RFA - 7F 4 mm tip 20 W, 60 sec, 60°
 - ❖ RA, RV, LA, LV & RAV groove & LAV groove lesions
 - ❖ Sacrificed Acutely, 1 & 8.5 months



RFA in lambs







RFA in neonates & "infants"

Circulation

Clinical Investigation and Reports

Circulation.
2001;104:2803-2808

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

Andrew D. Blafox, MD; Gary L. Felix, BS; J. Philip Saul, MD; Participating Members of the Pediatric Catheter Ablation Registry*

❖ 1989 - 1999



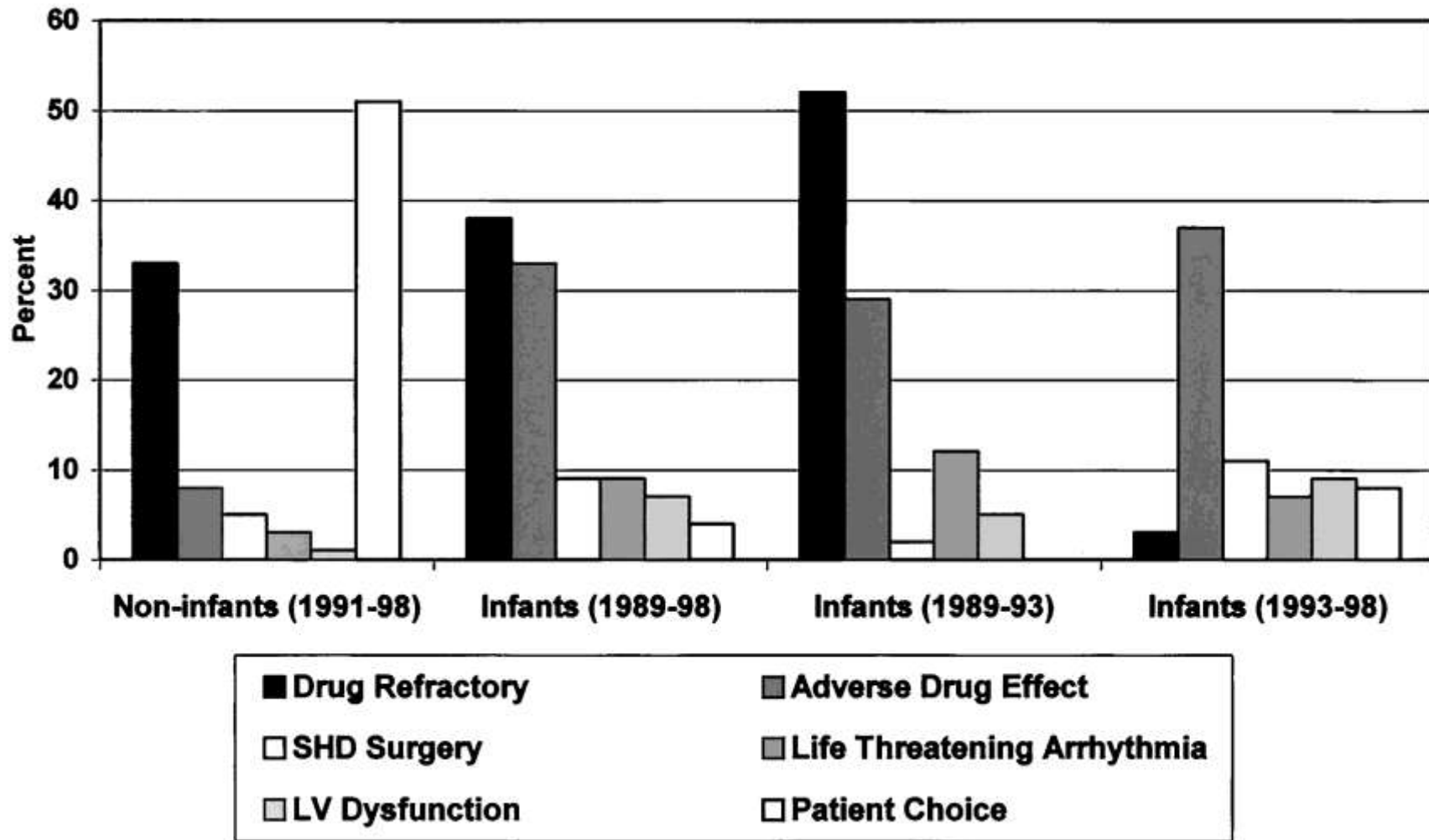
RFA in neonates & "infants"

Radiofrequency Catheter Ablation in Infants ≤ 18 Months Old

	Infants	Noninfants	<i>P</i>
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



RFA in neonates & "infants"





RFA in neonates & "infants"

Radiofrequency Catheter Ablation in Infants ≤ 18 Months Old

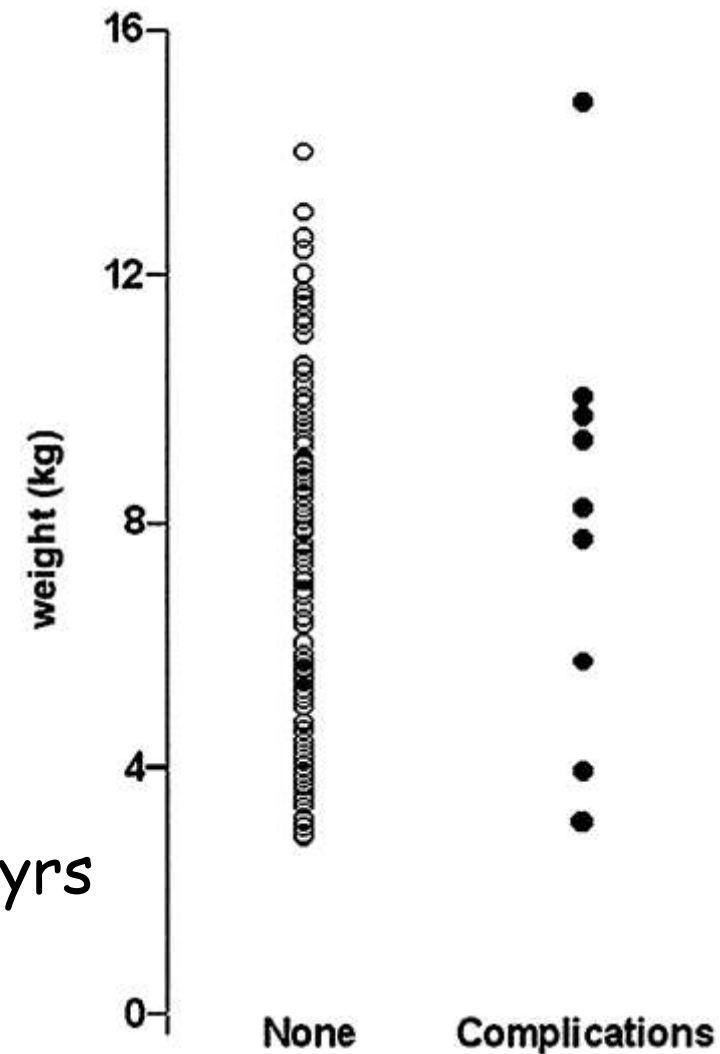
Substrate	Infants			Noninfants		
	n	Prevalence, %	Success, %	n	Prevalence, %	Success, %
Accessory pathway	115	67.3	87.8	4731	66.1	90.9
AVNRT	7	4.1	100	1576	21.6	97
EAT	29	17.1	89.7	332	4.9	87.3
JET	6	3.5	100	13	0.3	76.9
Atrial flutter	4	2.4	50	312	4.3	76
VT	10	5.9	70	196	2.8	65.3



RFA in neonates & "infants"

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

Complications



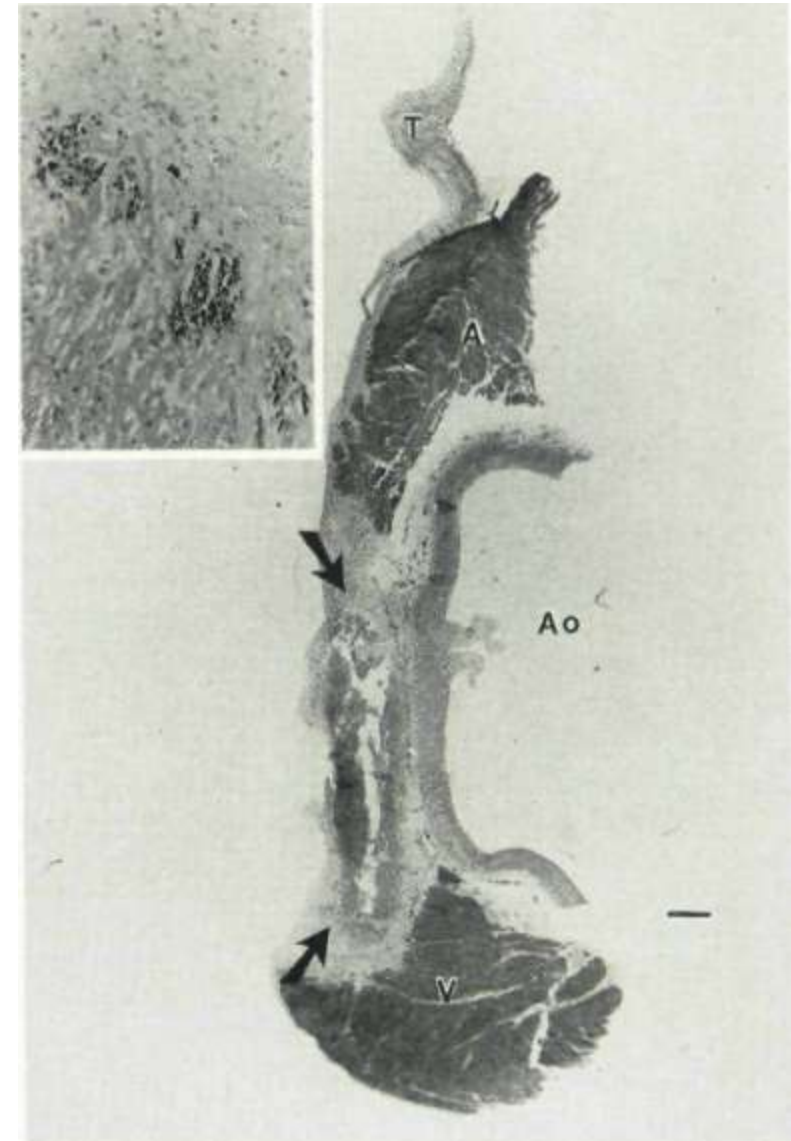
- ❖ 12 complications / 137 pats < 1.5yrs
- ❖ 17 complications / 231 pats < 15kg & > 1.5 yrs
- ❖ < 15 kg more complications than > 15kg



Emergency AV Node ablation



- ❖ 3 kg neonate - incessant SVT
- ❖ ECMO - controlled - 2nd ECMO
- ❖ Recurrent SVT
- ❖ RFA of AVN with 7F catheter
- ❖ Remained in CHB
- ❖ Pacemaker implanted
- ❖ Ventilator dependent
- ❖ Died at 2 months
 - ❖ Liver failure





RFA for JET

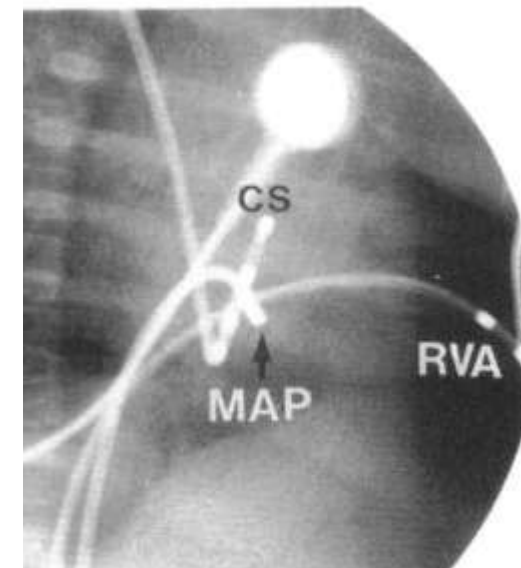
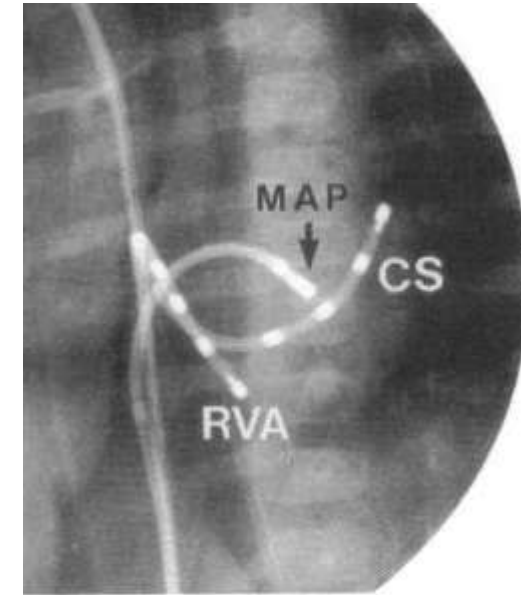
- ❖ Term gestation
- ❖ 3.1 kg
- ❖ Age 3/52
- ❖ Failed medical Rx
- ❖ 4F quad via SCV
- ❖ 5 F ablation via Umb vein
- ❖ 15 W x 20 sec & 10 W x 50 s
- ❖ SR with int CHB
- ❖ Epic DDD
- ❖ SR with RBBB





RFA in infants

- ❖ 5 infants
- ❖ 2.5 - 8 months
 - ❖ WPW with cardiac arrest x 1
 - ❖ Refractory SVT x 2
 - ❖ Tachymyopathy x 1
 - ❖ Planned cardiac surgery (DORV) x 1
- ❖ 5 F ablation catheter
- ❖ 25 W for 15 - 60 s
- ❖ ST changes in 1 - normal coronary angio
- ❖ Peric effusion in 2
- ❖ No recurrence at 18 months

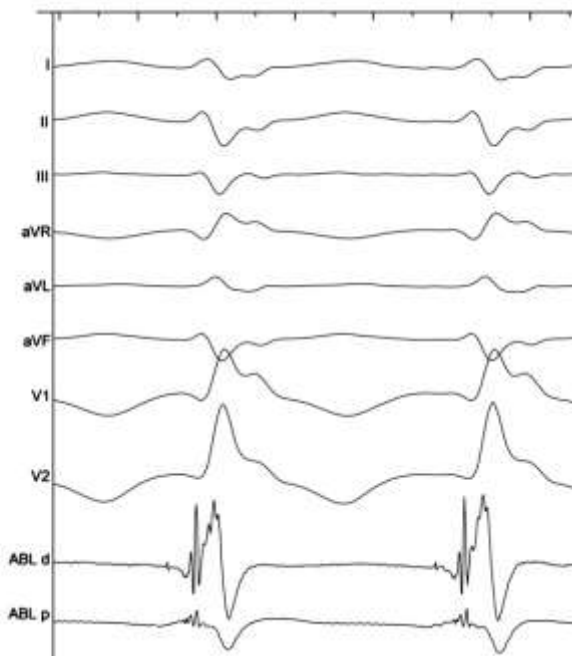
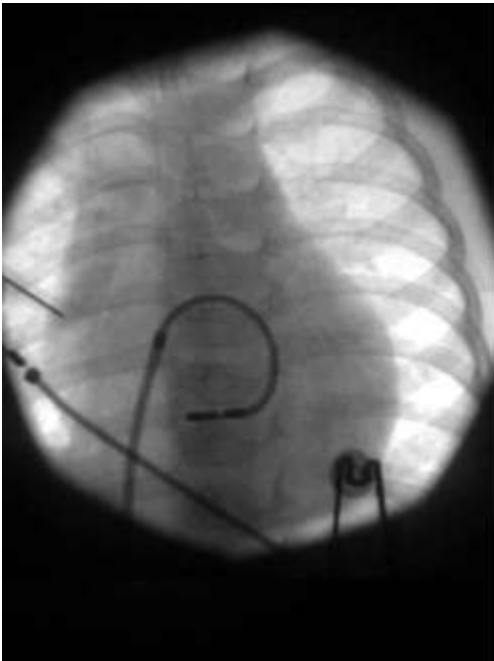
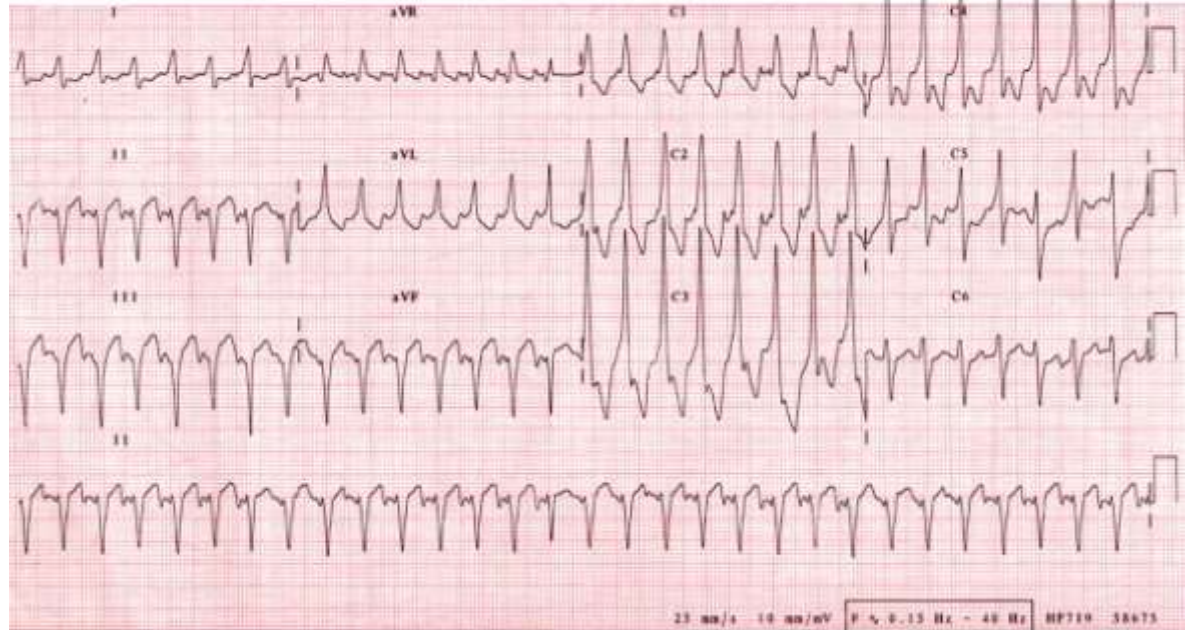




RFA for PJRT

- ❖ 4 "infants"
- ❖ 2 - 3 months in 3; 17 months in 1
- ❖ Heart failure / LV dysfunction
- ❖ Failed medical Rx
- ❖ 5 F ablation catheter
- ❖ 15 - 40 W for 10 - 40 s
- ❖ CHB in 1
 - ❖ 2.5 months at RFA
 - ❖ Pacemaker
- ❖ Recurrence in 1
 - ❖ Medical Rx for 7 months
 - ❖ 2nd ablation

Radiofrequency Ablation of Fascicular VT in 1 yr old in severe heart failure ~ 10 kg



- ❖ 1 year old
- ❖ ~ 10 kg
- ❖ Poor LV function
- ❖ Failed medical Rx
- ❖ Single catheter ? F
- ❖ Trans-septal puncture
- ❖ 30 W, 65 °C, 60 s



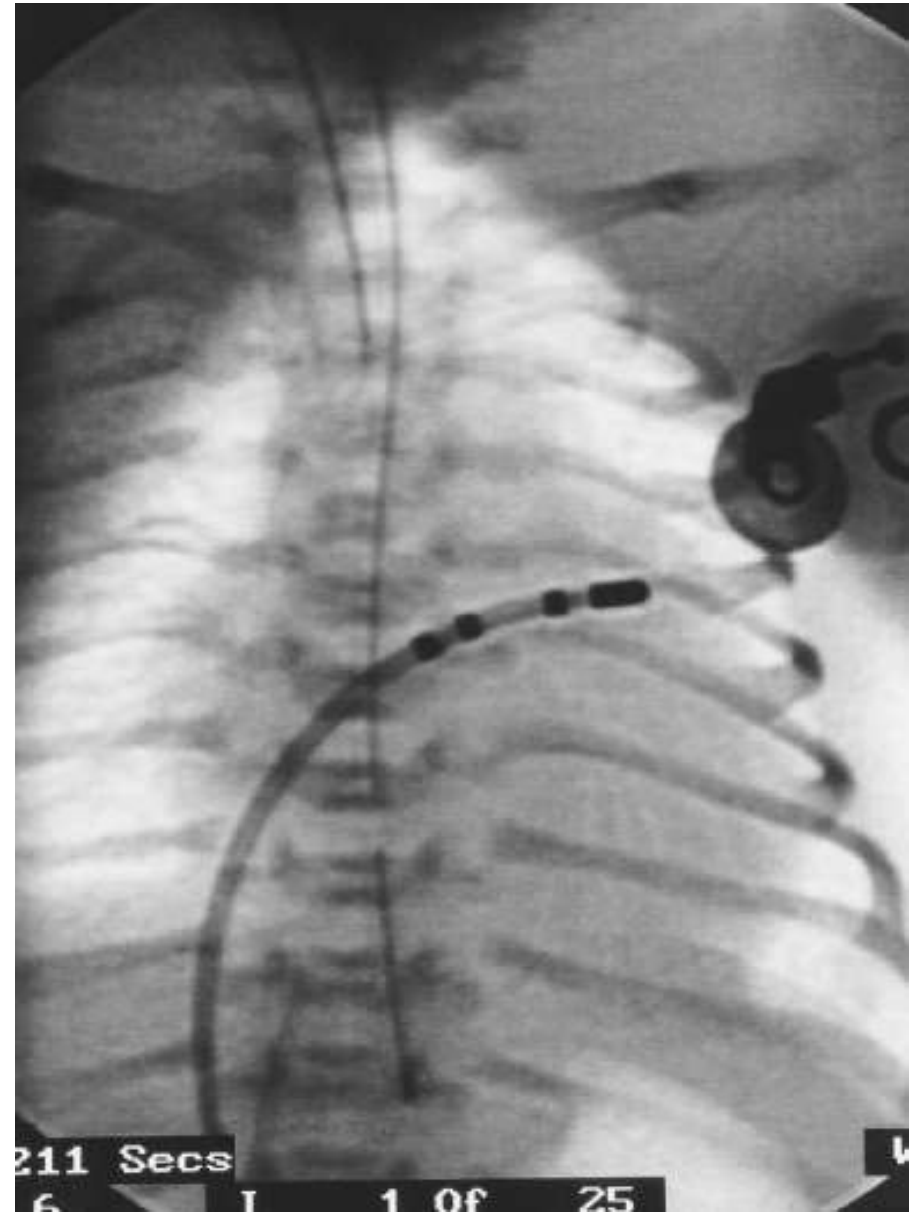
RFA at 24 hours of age

- ❖ Prem 35 weeks gestation
- ❖ 3.7 kg with hydrops
- ❖ Poor LV function
- ❖ Failed medical Rx
- ❖ RFA at 24 hours of age
- ❖ 2 x 4 F quads
- ❖ 5 F ablation via PFO
- ❖ 25 W, 60 s
- ❖ Well at 1 year



RFA at 4 days of age

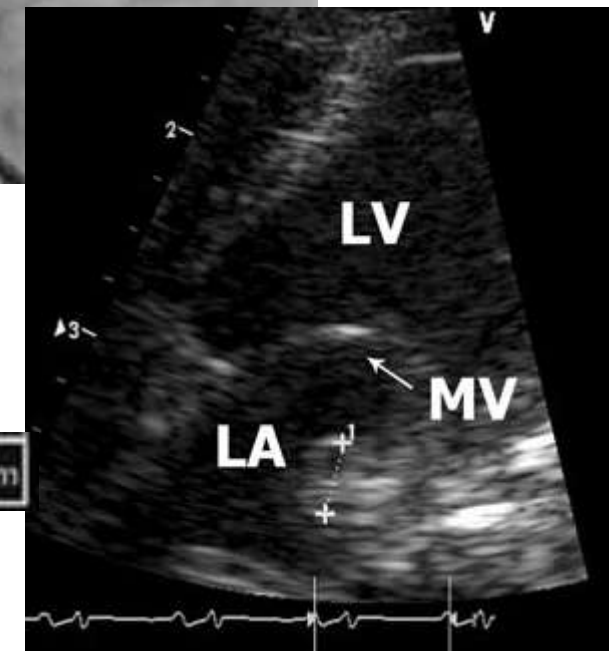
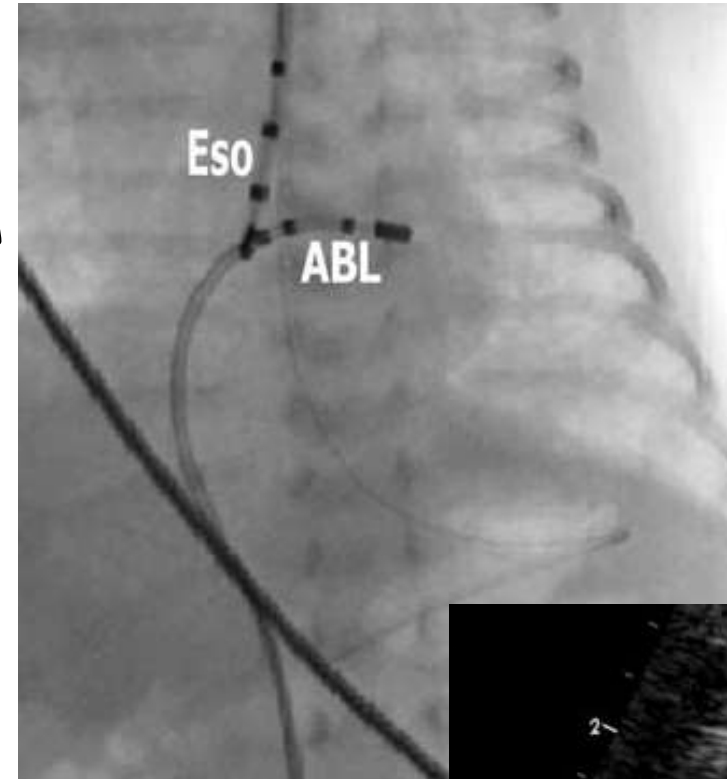
- ❖ Fetal SVT on RX
- ❖ C/S at 32 weeks gest
- ❖ 1.8 kg ventilated
- ❖ 5 F ablation via PFO
- ❖ 25 W, 50°C, 20 s x 1





RFA at 3 weeks of age

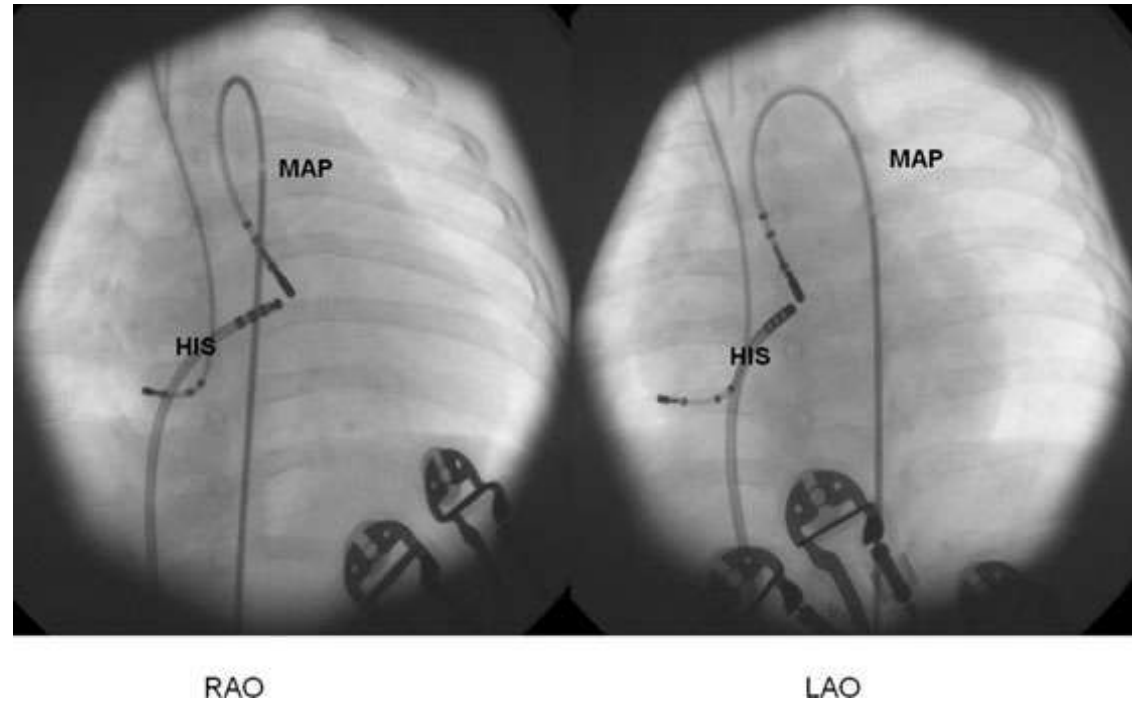
- ❖ Fetal SVT & hydrops
- ❖ Prem 32 weeks gestation
- ❖ 1.7 kg ventilated
- ❖ Age 3/52
- ❖ 2.0 kg
- ❖ TO atrial pacing
- ❖ 5 F ablation via PFO
- ❖ 25 W, 55°C, 30 s x 1
- ❖ Echodense lesion in LA
 - ❖ - resolved at 3 months
- ❖ Coronaries & LV normal on echo



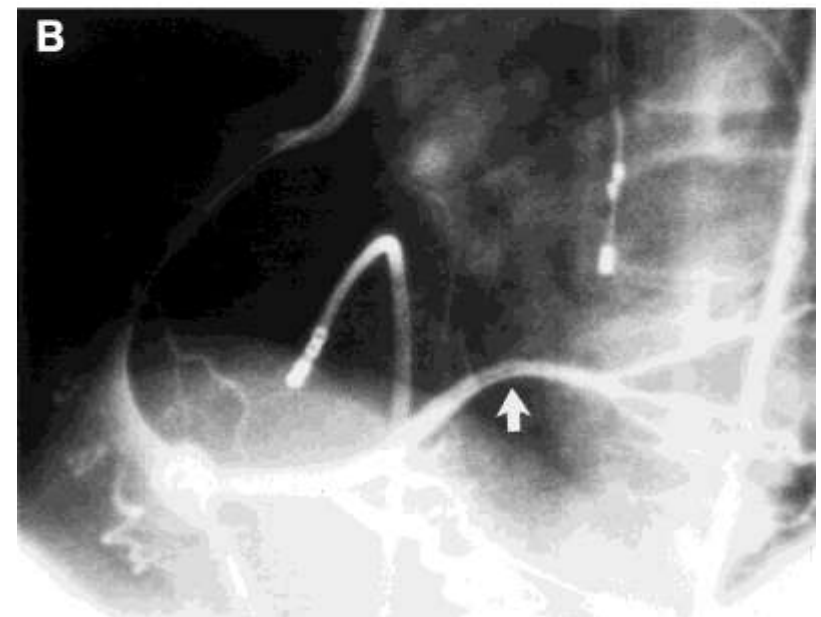
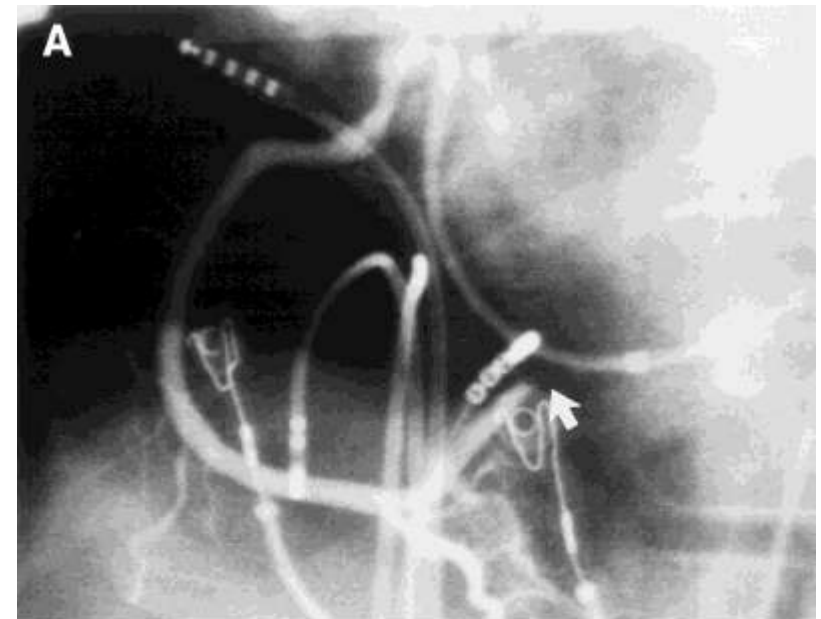
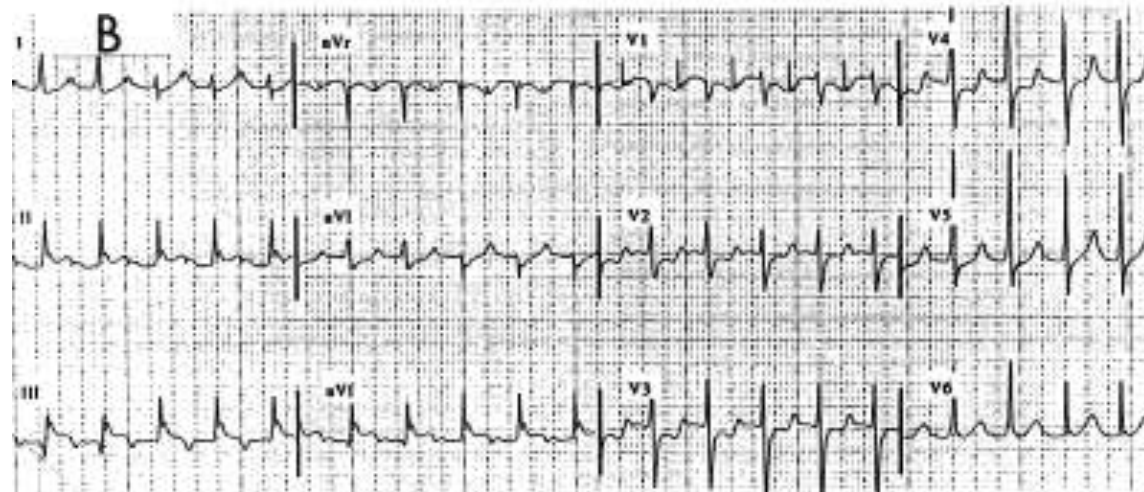
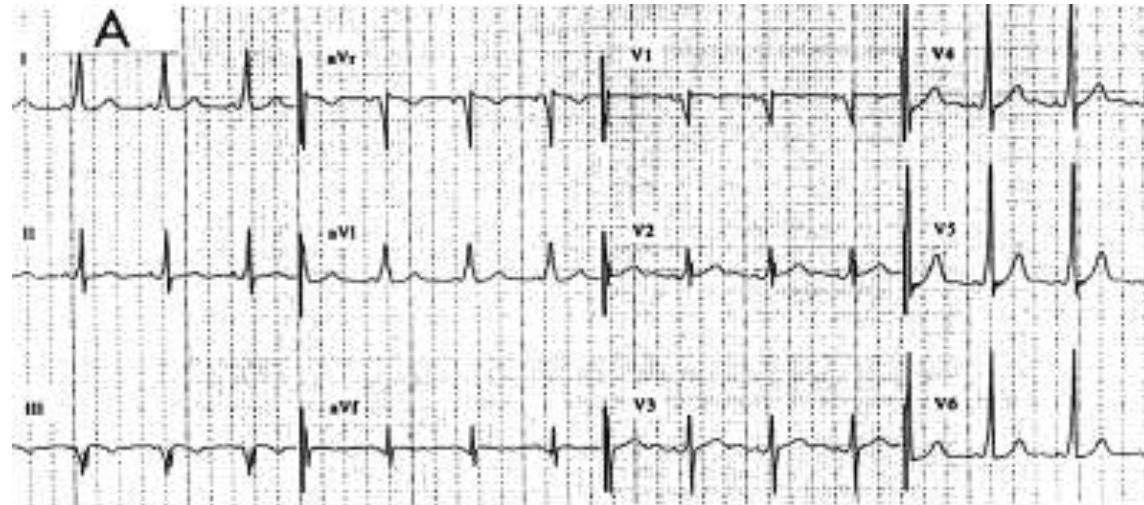


RFA via non-coronary cusp

- ❖ 4 month infant
- ❖ Incessant SVT & FTT
- ❖ Failed Mx - DC shocks
- ❖ EP
 - ❖ 5F quad via FV
 - ❖ 4F via SCV
 - ❖ 4F via FA
- ❖ Earliest VA in His
 - ❖ Earlier non-coronary cusp & a "pathway potential"
- ❖ 5 F ablation via FA; 25 W, 55°C, x 1
- ❖ Well at 12 months



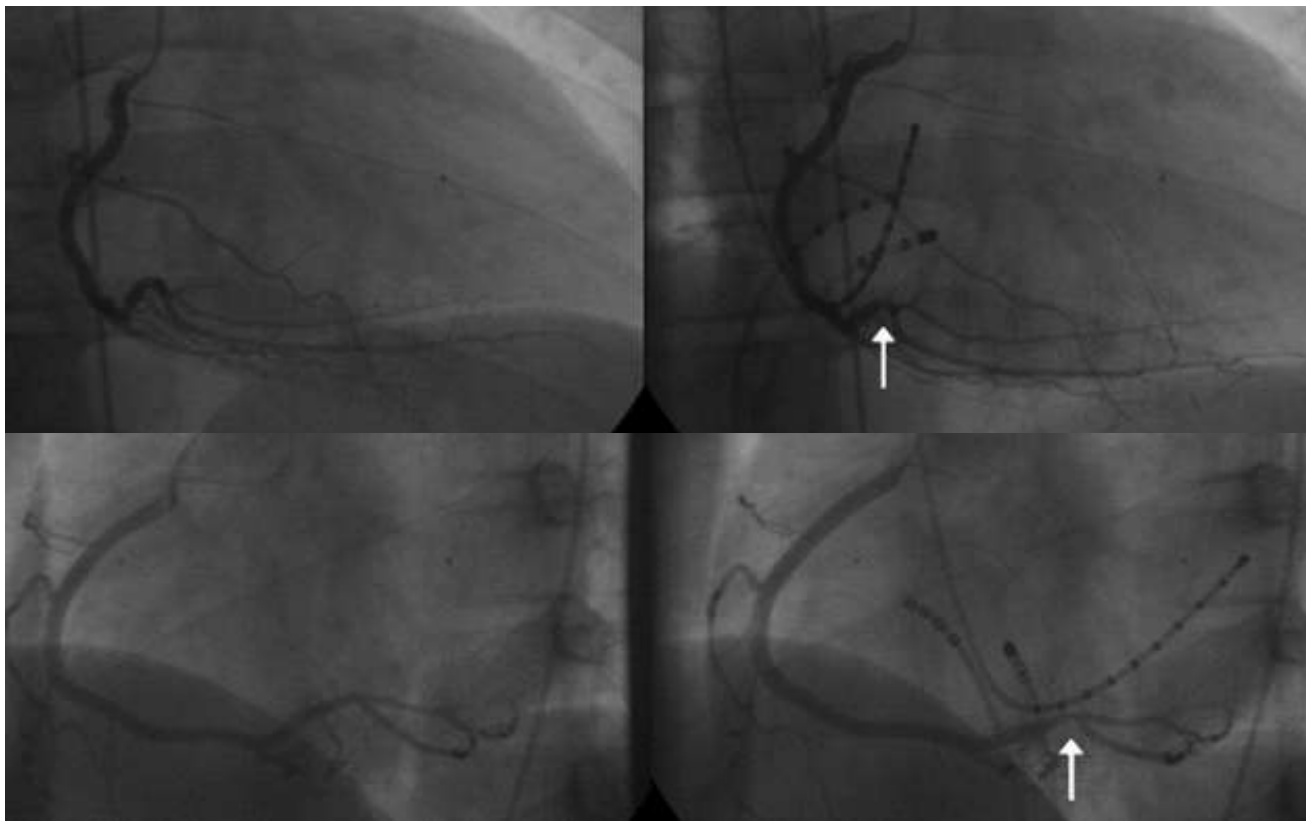
**Ablation of a Postero-Septal Accessory Pathway in a 12 yr old boy
6F catheter 4 mm tip; 4 x 30-60 sec applic at 60°**

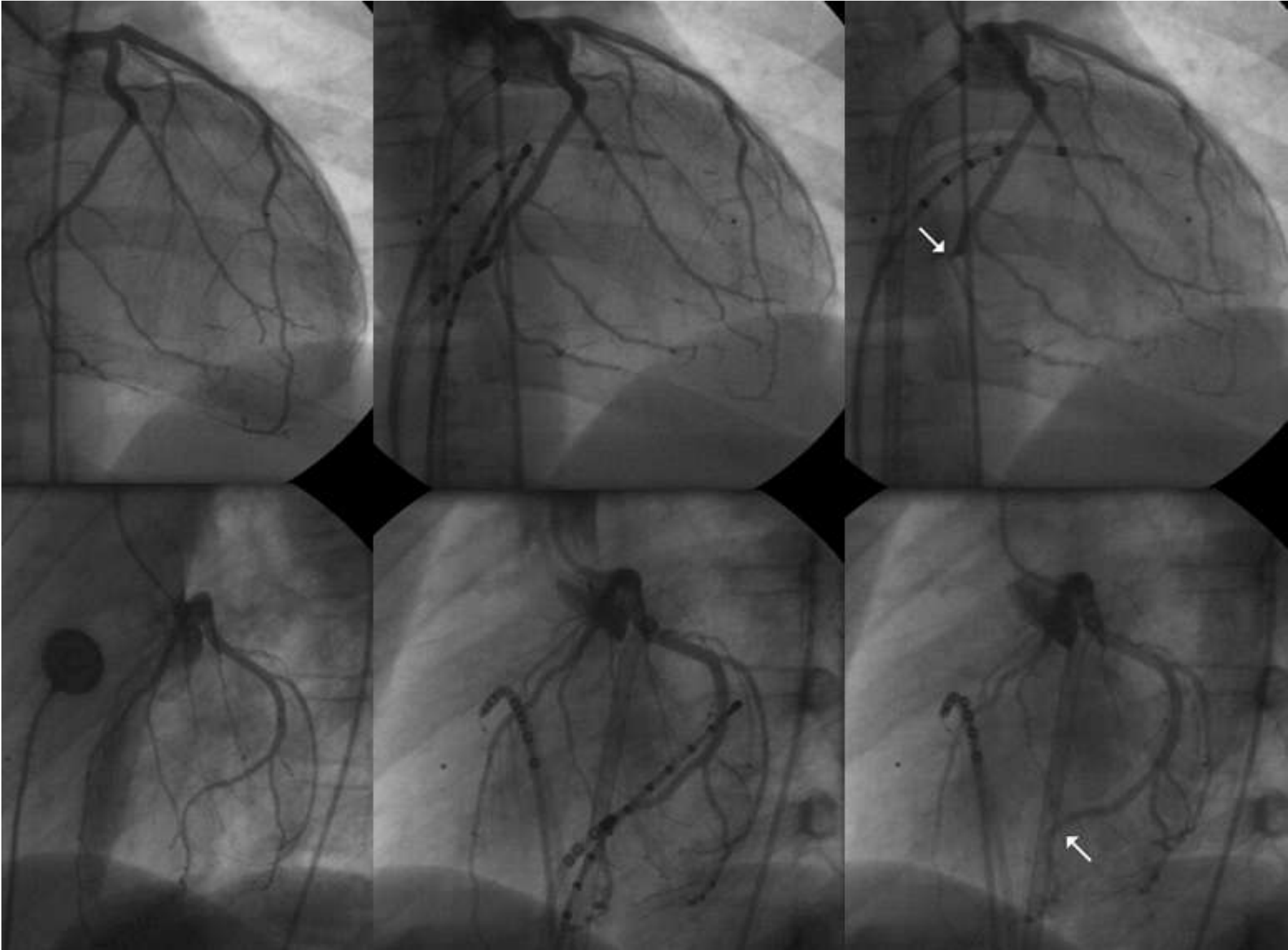




Coronary artery damage

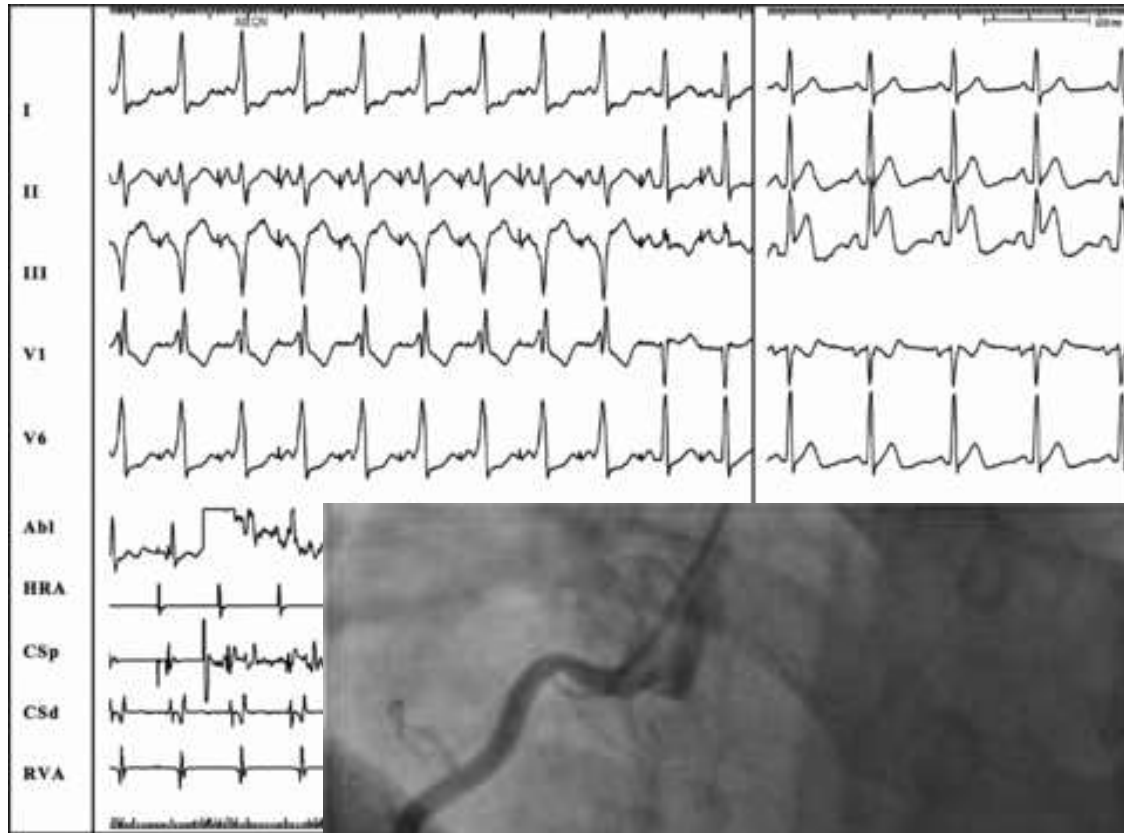
- ❖ Prospective coronary angio pre & post RFA (5.5 - 130 kg median 47)
 - ❖ Asymptomatic narrowing in 2/117 children with RFA of APs
 - ❖ Posteroseptal RFA in 12 & 9 yr old (40 & 44 kg)
 - ❖ Minor ST changes - no enzyme rises





Schneider HE, Heart Rhythm, 6 (2009), pp. 461–467.

Ablation of a Postero-Septal Accessory Pathway in a 35 yr old man Irrigated tip at 38 W & 30 deg



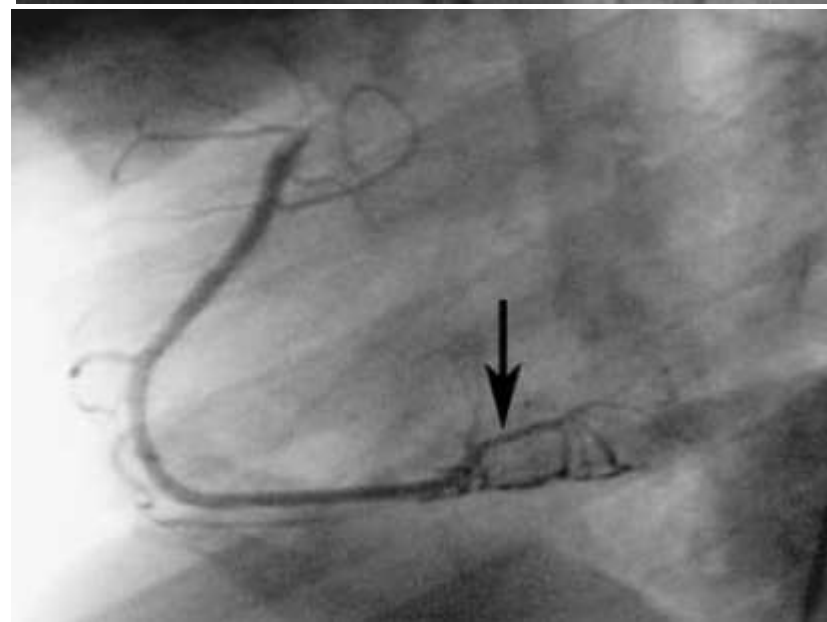
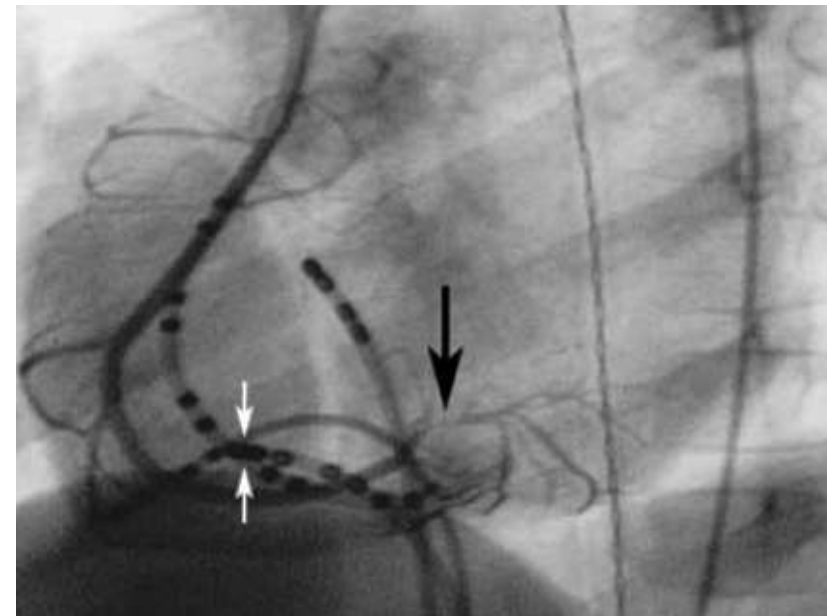
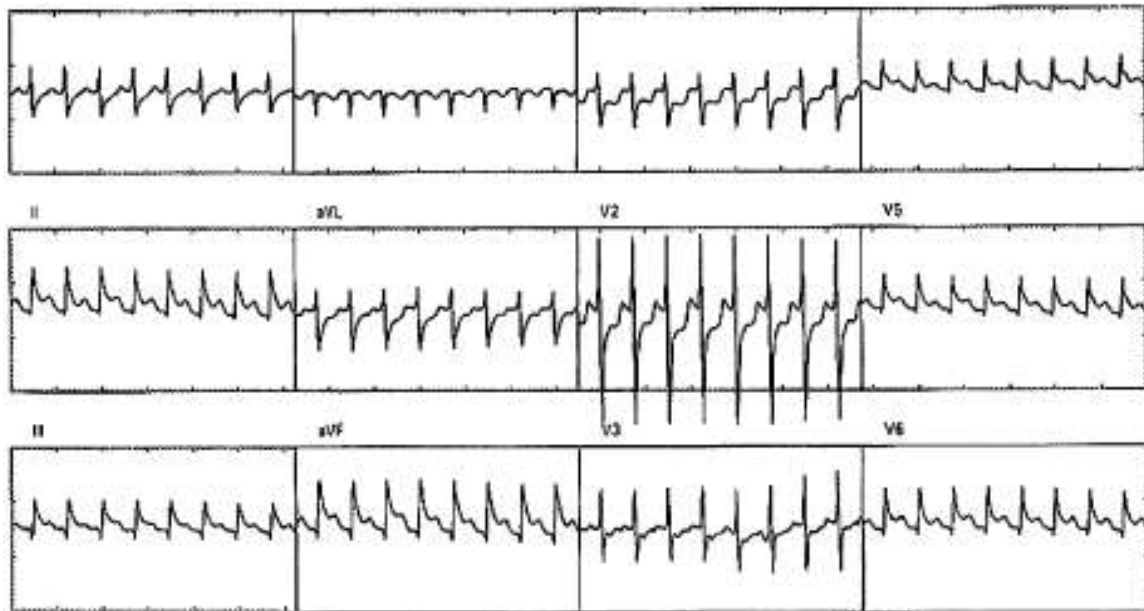


AVNRT ablation in 2.5 yr old

- ❖ 15.5 kg
- ❖ Slow pathway
- ❖ 4 applications 9, 11, 18 & 60 sec
- ❖ Temp 61 - 69°
- ❖ Power 13 - 46 W
- ❖ ST changes during non sustained AVNRT after RFA
- ❖ Coronary angio; GTN; Solumedrol
- ❖ GTN on ITU until CK & troponin had fallen
- ❖ Coronary angio at 2 days & 2 months



AVNRT ablation in 2.5 yr old



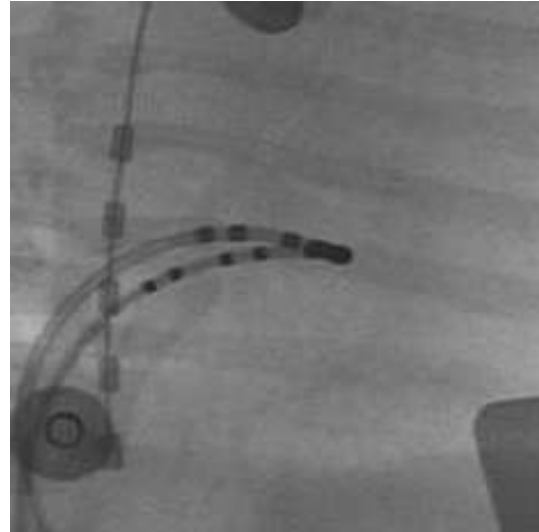


AVRT ablation in 5 week old

- ❖ 5 kg
- ❖ Cardiogenic shock with SVT
- ❖ Failed medical management
- ❖ 4 F quad to His
- ❖ 5 F ablation via PFO
- ❖ TO atrial pacing
- ❖ 11 applications at 30 W & 60°C
 - ❖ 7 test of 10 sec
 - ❖ 4 ablations for 30 sec
- ❖ ST changes - Coronary angio - GTN
- ❖ Heparin infusion
- ❖ Regional wall abnormality - MR - MVR at 2 weeks
 - ❖ Perforation of MV



AVRT ablation in 5 week old



Indications and Outcome of Radiofrequency Ablation in Infants: a Retrospective UK Multi-centre Study over 15 years



Shebani S.O. (1), De Giovanni J. (2), Macleod K. (3), Morgan J. (4), Nanapragassam J. (4), Peart I. (5), Rosenthal E. (6), Stuart G. (7), Till J. (8), Walsh K. (9), Duke C. (1).

(1) Glenfield Hospital Leicester, (2) Birmingham Children's Hospital, (3) Royal Hospital for sick children Glasgow, (4) Southampton General Hospital, (5) Liverpool Children's Hospital, (6) Guy's Hospital London, (7) Bristol Children's Hospital, (8) Royal Brompton Hospital London, (9) Royal Hospital for sick children S Ireland

Introduction and purpose

The decision to perform radiofrequency ablation (RFA) in infancy (< 1 year) is controversial as most tachycardias respond to antiarrhythmic drugs and RFA is perceived as high risk. All UK infant RFA cases over the last 15 years were retrospectively studied to identify the clinical characteristics of patients, indications for RFA and success and complication rates.

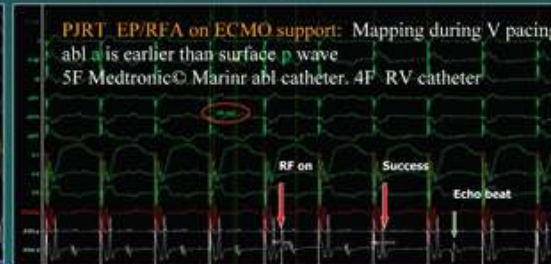
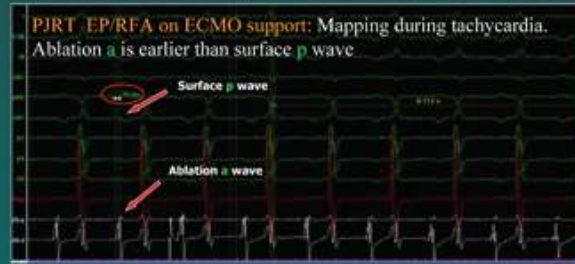


Results3: Intensive care

Haemodynamic collapse 9/19
Mean (36 days)
Tachymyopathy 10 pts duration
Mean (29 days)
Time ventilated 8/19 patient
Mean (17 days)
ECMO 4/19 (3 RFA on ECMO)
average 5.8 days of ECMO support
2 recurred post decannulation

Results4: Procedural data

Acute success 21/21 (100%)
Recurrence 7/21 (33%) mean 39days
2 redo in infancy (1 recurred)
2 redo 1-2 years old (1 recurred)



Methods1

Every UK paediatric electrophysiologist was contacted to identify ablations carried out in infancy at their institution since the inception of RFA. Patient and procedural data was collected by a single investigator visiting each centre to review medical records.

Methods2

Time period 1993-2007 (15 years)
8/13 centres have performed RFA in infancy
8 operators
19 patients
21 procedures *in total*
20 tachycardia substrates

Results1: Demographics

Age 0.9–11.9 (median 3)m
Weight 3.5-10 (median 5.2)kg
Congenital heart disease 4/19
WPW AVRT 10
Left lateral/posterior (6)
R posteroseptal (3)
R posterior (1)
PJRT 7
EAT 2
A Fib / Flutter 1

Results2: Indications

Incessant 14
Frequent recurrence 4
Tachymyopathy 10
Haemodynamic collapse 9
Resistant to drug therapy 17
Complications from drugs 5
Elective 1

Results5: Complications

NO MORTALITY
Major 4/21 (19%)
Tamponade (2) one due to Cardima 3F catheter during mapping, before ablation.
Perforated MV (moderate MR) - Left lat RFA (1)
3rd degree AV block (1)(pacemaker) – PJRT
Minor 4/21 (19%)
Transient 3rd heart block (1)
Transient 2nd heart block (1) persisted as 1st degree HB
Superficial skin burn(1)
Small effusion + MV thrombus (resolved) (1)

Function Data, Relative to t=0 Ablation Time



RFA < 1 year in UK

- ❖ 1993 - 2007
- ❖ 8/13 UK centres
- ❖ 19 children - 21 procedures
- ❖ Age .9 - 11.9 months; median 3
- ❖ Weight 3.5 - 10 kg; median 5.2
- ❖ Tachymyopathy 10, H/dynamic collapse 9
- ❖ Incessant 14, Frequent 4
- ❖ Drug resistant 17; complications 5
- ❖ Elective 1 (pre Glenn shunt)
- ❖ RFA on ECMO in 3



RFA < 1 year in UK

- ❖ Acute success in 21 procedures
- ❖ Recurrence in 7; 2 redo in infancy; 2 redo 1 - 2 yrs
- ❖ 2 re-recurrence
- ❖ No mortality
 - ❖ Tamponade 2
 - ❖ MV perforation (L lat AP) - moderate MR in 1
 - ❖ CHD (PRT) - pacemaker
 - ❖ Transient HB in 2 - 1 residual 1st °
 - ❖ Skin burn in 1
 - ❖ Effusion and MV thrombus (resolved) in 1

Impact of corticosteroids on late growth of radiofrequency lesions in infant pigs: histopathological and electroanatomical findings

Elerson Arfelli¹, Sérgio de Araujo², Mieko Okada¹, Thais Nascimento¹, Luis Felipe N. dos Santos¹, Marcello Franco², Angelo A.V. de Paola¹, and Guilherme Fenelon^{1*}

- ❖ 14 piglets; 65 days; 5 kg ; 3 control adults
- ❖ 6F catheter; lesions in RA & RV; 60°C; 60 s
- ❖ 7 in treatment group
 - ❖ 10mg/kg hydrocortisone IV
 - ❖ 1 mg/kg prednisone x 29 days
- ❖ Sacrificed at 8 months = 40 +/- 4.6 kg



Effect of Steroids on lesion size: 6F ablation catheter

Right ventricle Controls (A–C) and Steroid (D and E)

❖ Atrium

Rx 11 +/- 5 mm

unRx 13 +/- 7 mm

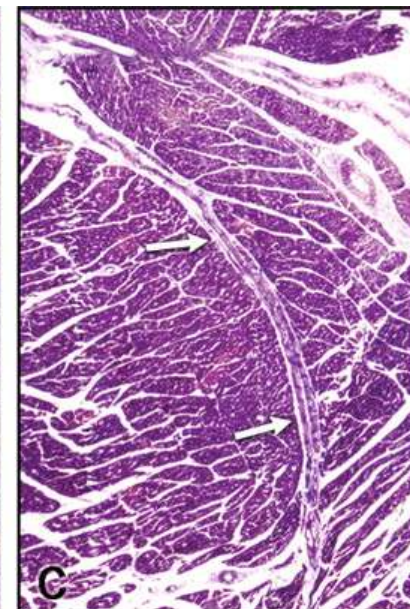
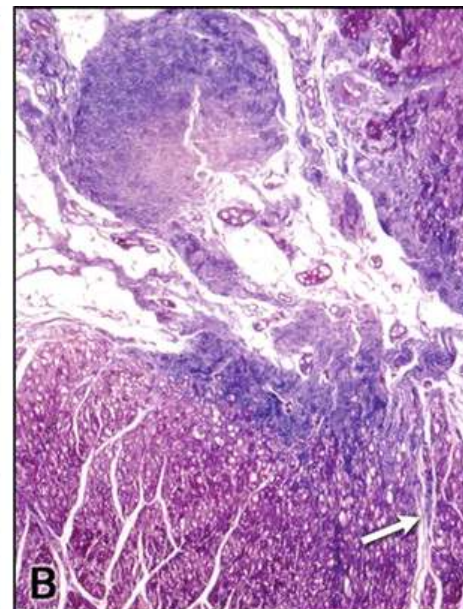
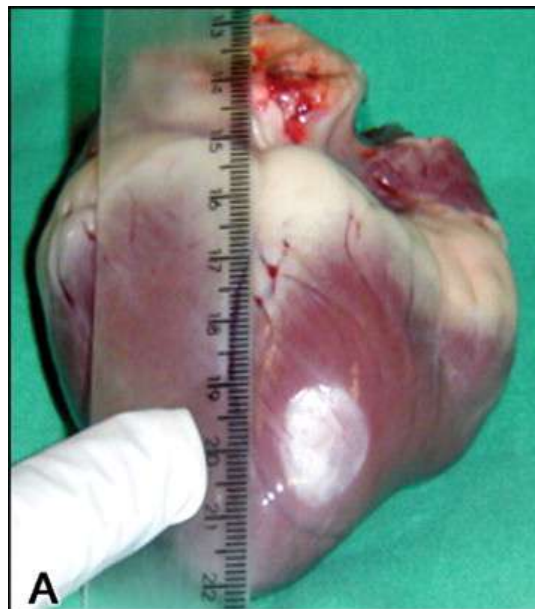
Adult 6 +/- 1 mm

❖ Ventricle

Rx 12 +/- 3 mm

unRx 11 +/- 3 mm

Adult 6 +/- 1 mm





Is Cryo better than RF ??

Circ Arrhythm Electrophysiol. 2011;4:211-217.

Enlargement of Catheter Ablation Lesions in Infant Hearts With Cryothermal Versus Radiofrequency Energy An Animal Study

Paul Khairy, MD, PhD; Peter G. Guerra, MD; Lena Rivard, MD; Jean-François Tanguay, MD;
Evelyn Landry, AHT; Marie-Claude Guertin, PhD; Laurent Macle, MD; Bernard Thibault, MD;
Jean-Claude Tardif, MD; Mario Talajic, MD; Denis Roy, MD; Marc Dubuc, MD



Cryo vs RF < 10 kg

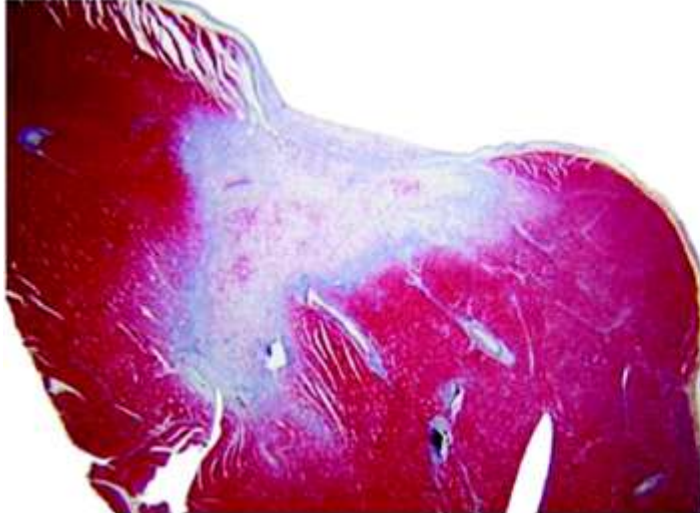
- ❖ 32 piglets
- ❖ 1 - 3 months; < 10 kg
- ❖ 2 RA, 2 RV, 2 RAV groove & 2 LAV groove lesions
- ❖ Cryo - 7F, -80° for 4 min
- ❖ RFA - 7F 40 W, 60 sec, 60°
- ❖ Sacrificed: acutely, 1, 6 & 12 months
- ❖ Weight increased to 18, 46 & 63 kg

Epicardial surface 1 year after ablation.

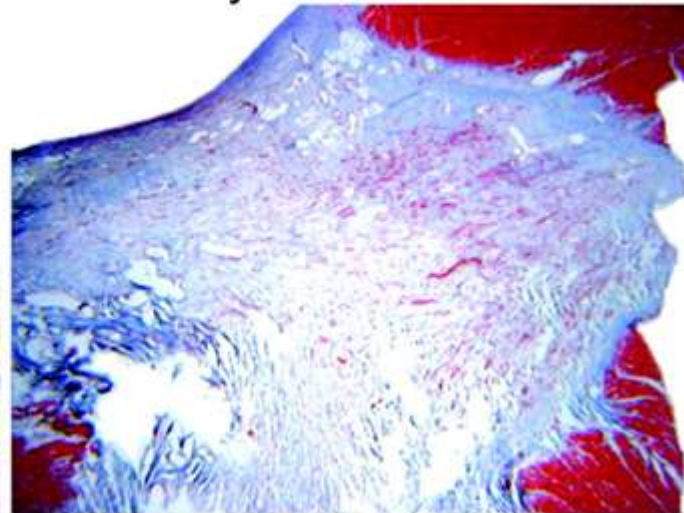


Histological characteristics of cryothermal and radiofrequency ablation lesions.

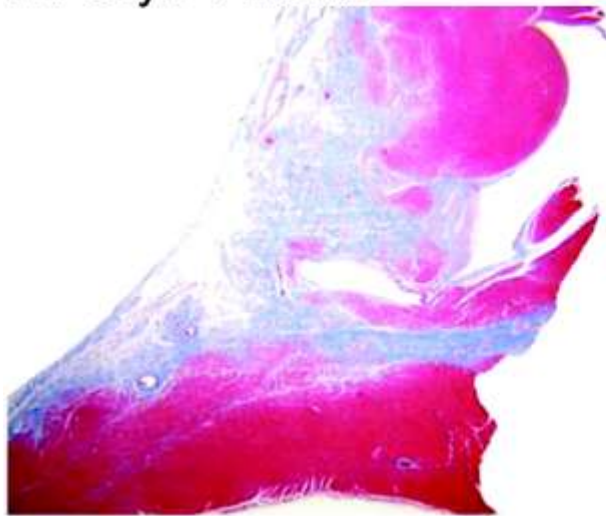
RV RFA 1 month



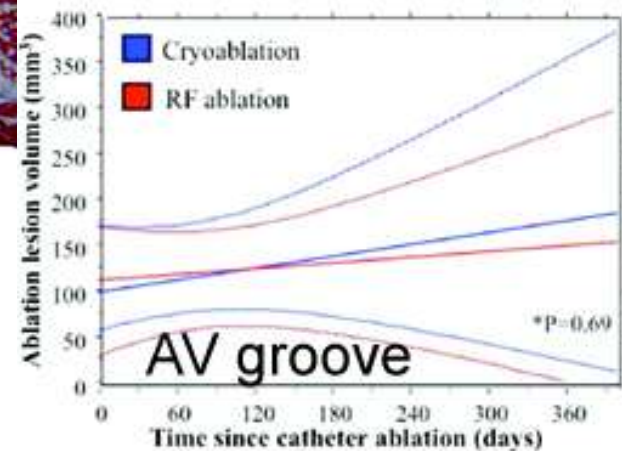
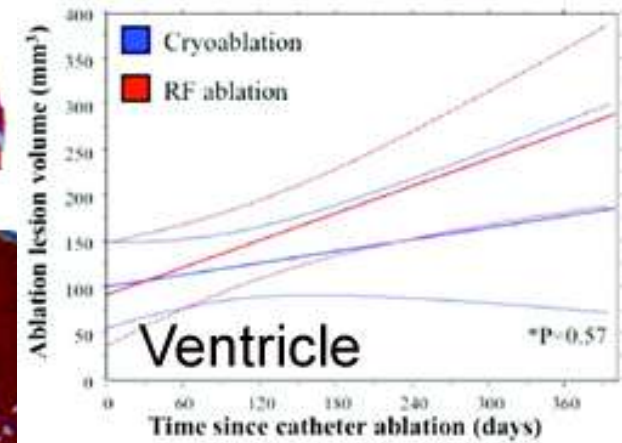
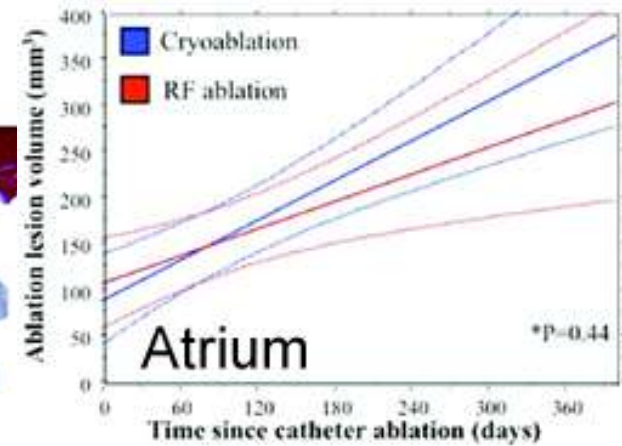
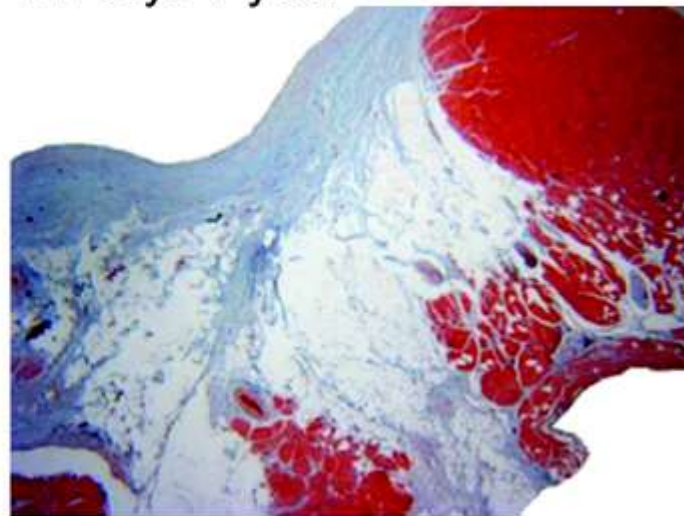
RV RFA 1 year



RV Cryo 1 month



RV Cryo 1 year





Coronary artery & Cryo

- ❖ Prospective coronary angio pre & post Cryo
- ❖ No narrowing in 10 piglets restudied
 - ❖ 5 at 48 hours
 - ❖ 5 at 3 - 6 months
- ❖ Justification for using Cryo in neonates & infants ?



Cryoablation <15kg & <5 years

- ❖ 11 centres; 61 patients; 68 procedures
- ❖ 8 days - 9.9 years; median 3.5 yrs!!
- ❖ 2.3 - 23 kg; median 15.2!!!
- ❖ No Cx in cryo only; 74 % success; 20% recurrence
 - ❖ 8/52 = transient AV block
 - ❖ (1 death at 8 days in 3.5 kg single V - incessant AVNRT from CHF & infection)
- ❖ Cx in 2/16 with additional RF; 30% recurrence
- ❖ 4 < 1 month & 6 < 1 year - refractory SVT & CHF



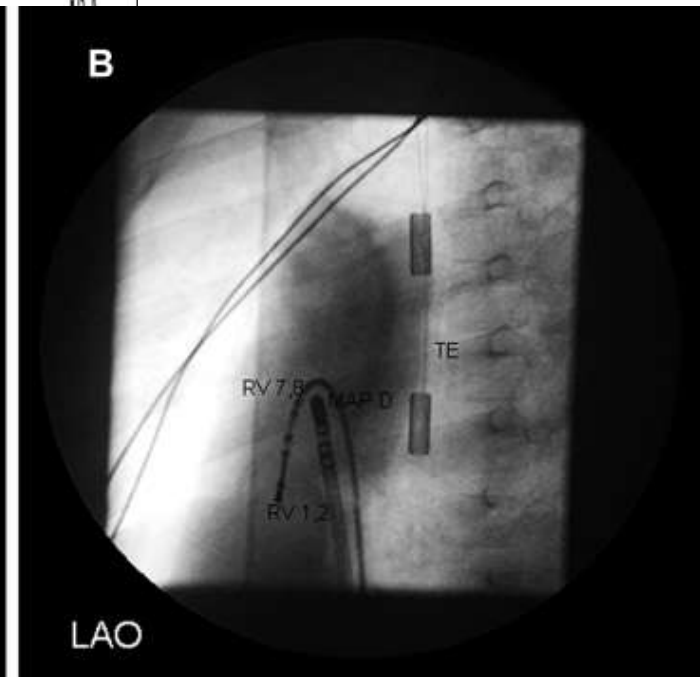
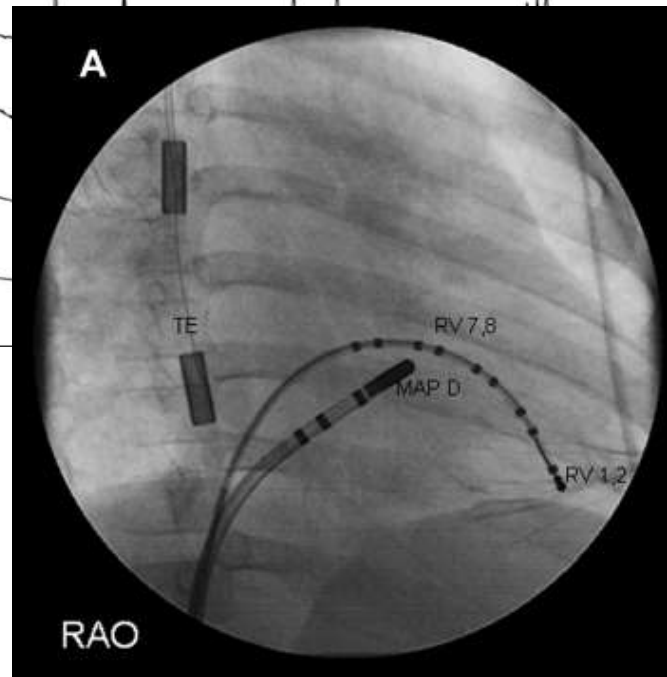
Cryoablation < 5kg & < 5 years

- ❖ 2.3 kg incessant SVT
- ❖ Pericardial effusion & arrest during procedure
- ❖ Mitral regurgitation - MVR
 - ❖ Posterior scallops macerated
 - ❖ Thermal damage on annulus; free wall necrosis
- ❖ Mediastinitis
- ❖ Subdural hemorrhage on anticoagulation
- ❖ Endocarditis
- ❖ 2nd MVR
- ❖ Weight unknown with EAT
- ❖ SVC obstruction at 2 months
- ❖ Stent implantation

Cryoablation of Congenital Familial Junctional Ectopic Tachycardia



- ❖ 1 year old
- ❖ 8 kg
- ❖ FTT
- ❖ TO Atrial pacing
- ❖ 5 F decapole
- ❖ 7 F cryocath - 4mm tip
- ❖ Esmolol & Atrial o/drive
- ❖ 6 mm tip x 4 min x 2





Conclusions

- ❖ RF Ablation in neonates & infants carries a higher risk than in children > 15 kg
 - ❖ 5F catheter is preferred
 - ❖ Power, temperature & duration should be reduced
- ❖ Cryoablation is less effective than RFA but may be slightly safer ?
 - ❖ Catheter size & stiffness are not ideal in neonates
- ❖ Ablation is appropriate and can be effective:
 - ❖ Truly drug refractory patients
 - ❖ Severe haemodynamic compromise



