Paediatric Catheter Ablation

Efficacy & Adverse Events

SÉMINAIRE DE CARDIOLOGIE
CONGÉNITALE ET PÉDIATRIQUE
NECKER, 2018

Jérôme Lacotte (ICPS) & Alice Maltret (M3C)

Disclosure Statement of Financial Interest

I currently have, or have had over the last two years, an affiliation or financial interests or interests of any order with a company or I receive compensation or fees or research grants with a commercial company :

Grant/Research Support: Ramsay GDS, EHRA/ERTC European Fellowship

Consulting Fees/Honoraria: Abbot-St Jude, Biosense, Boehringer Ingelheim,

~~Major Stock Shareholder/Equity:~~

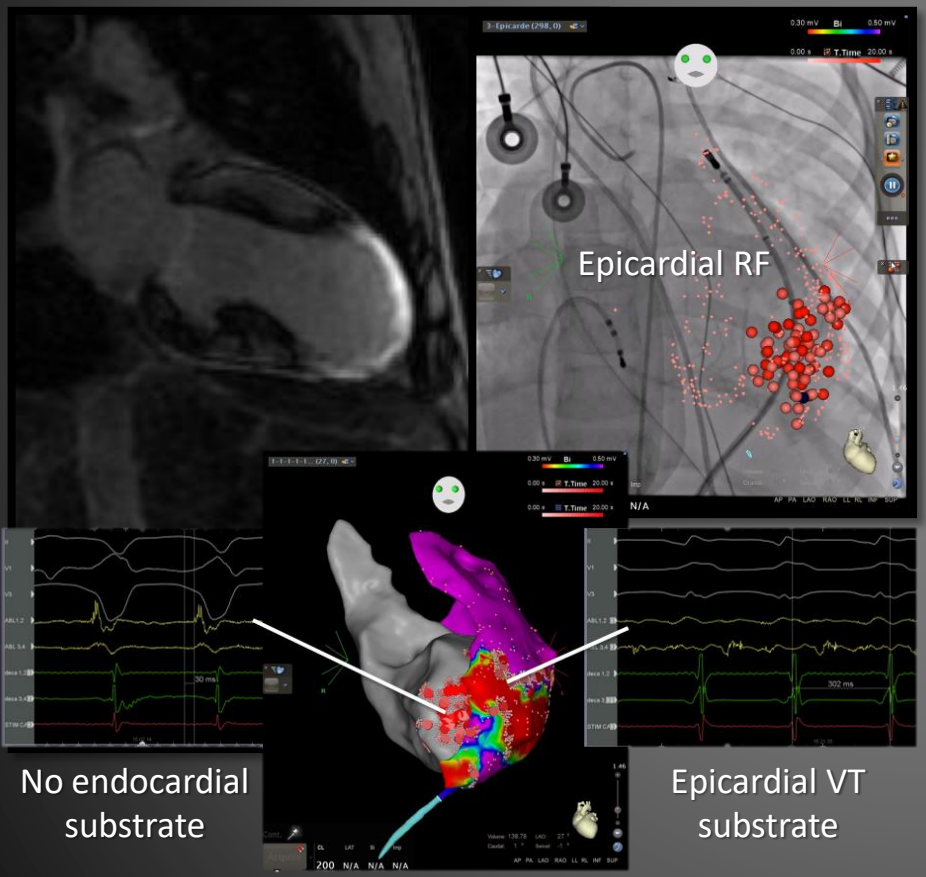
~~Royalty Income:~~

~~Ownership/Founder:~~

~~Intellectual Property Rights:~~

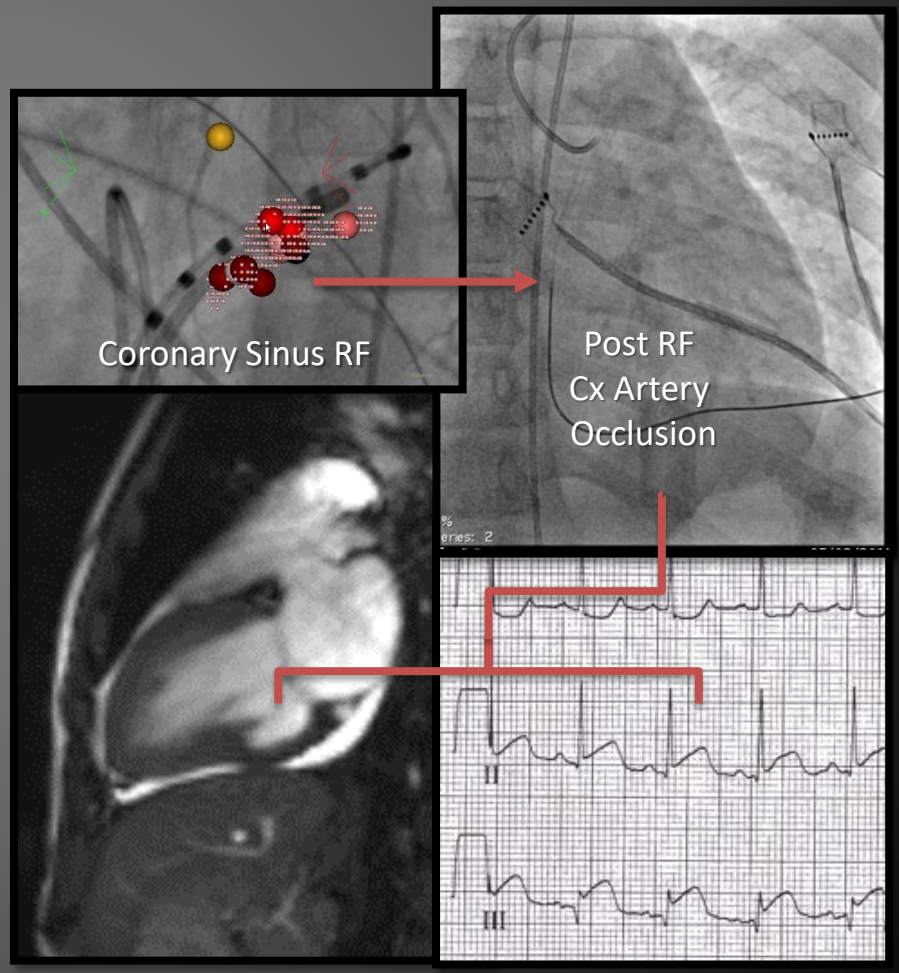
Adrien, 8 years 30 kgs

SCD / drug refractory VT storm / LV idiopathic aneuvrysm
Percutaneous epicardial LV VT RF in emergency (Feb 2016)
No more sustained VT / ICD events



Djawad, 9 years 39 kgs

Symptomatic for drug refractory PJRT
Programmed RF / Coronary Sinus (March 2015)
Posterior STEMI, preserved LVEF, no PJRT recurrence

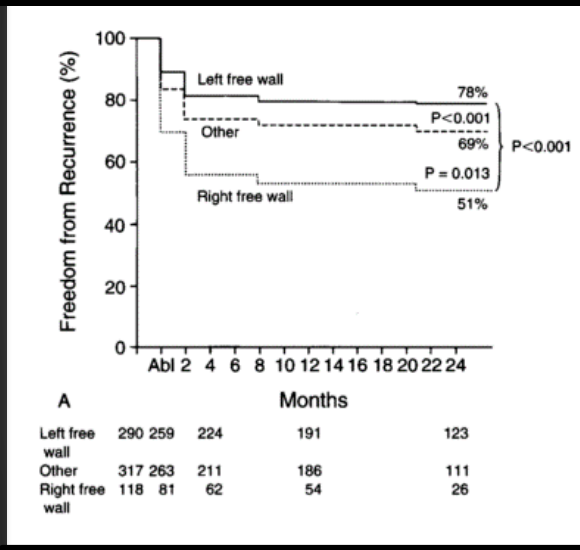


1 Who are the patients ablated ?

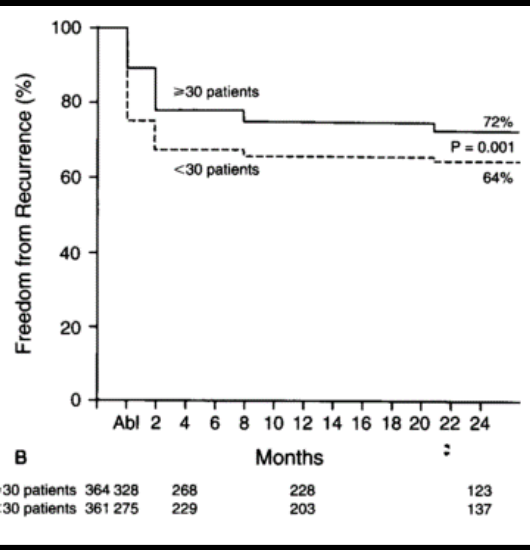
	Kugler NEJM 1994	Kugler JCE 2002		Van Hare JCE 2004	Kubus EP 2014	M3C & ICPS Registry
	1991-1992	1991-1995	1995-1999	1999-2003	2003-2010	2010-2016
Age cut off	< 21 y	< 21 y		< 21 y	< 18	< 18
Centers	24 (US)	24 (US)		24 (US)	3 (Czech Rep)	1
Patients	652			481	633	487
Prodecures	725	4193	3407	540	708	550
Energy = RF	100%	100%	100%	100%	100%	93%
Age (mean)	12,4	12,4	12,2	11,4	14,9	8,7
	11% < 5 y	6,7% < 5 y	6% < 5 y	27% < 9 y	NA	5,9% < 5 y
Weight < 15 kg	NA	NA	NA	NA	NA	2,8%
Normal Hearts	84%	NA	NA	97%	94%	88%
Acc.Pathways	82%	75%	66%	72%	61%	72%
AVN Reentry	10%	20%	29%	26%	28%	13%
Other SVTs & VTs	7%	5%	6%	0%	10%	15%
Initial Success Rate	83%	90%	95% *	96%	89%	90%
Fluoroscopy	45,9-79,6	50,9	40,1 *	38,3	14,1	8,5
Follow up	21 mo	NA	NA	NA	12 mo	12 mo
Recurrences	32%	NA	NA	NA	23%	30%
Complications	4,80%	4,20%	3,00% *	4,00%	1,40%	0,90%
Death procedural	0,15%	0,07%	0,03%	0%	0%	0,18%

Ablation outcome: independent predictive factors

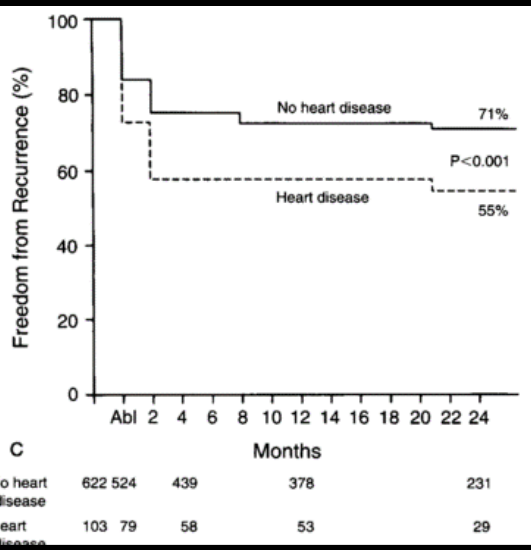
Substrate location



Experience



Heart Disease

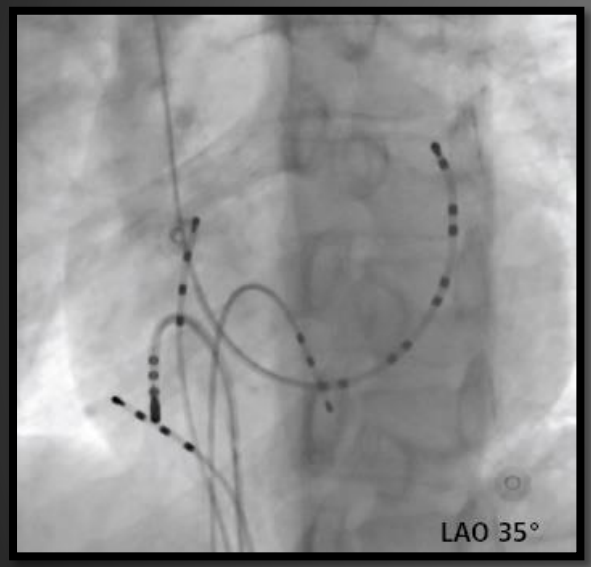


Weight : Complication rate = 4.8% (overall population) vs 10% (< 15 kg)

Kugler N. Engl. J. Med. 1994;330:1481–7

	Kugler NEJM 1994	Kugler JCE 2002		Van Hare JCE 2004	Kubus EP 2014	M3C & ICPS Registry
	1991-1992	1991-1995	1995-1999	1999-2003	2003-2010	2010-2016
Age cut off	< 21 y	< 21 y		< 21 y	< 18	< 18
Centers	24 (US)	24 (US)		24 (US)	3 (Czech Rep)	1
Patients	652			481	633	487
Prodecures	725	4193	3407	540	708	550
Energy = RF	100%	100%	100%	100%	100%	93%
Age (mean)	12,4	12,4	12,2	11,4	14,9	8,7
	11% < 5 y	6,7% < 5 y	6% < 5 y	27% < 9 y	NA	5,9% < 5 y
Weight < 15 kg	NA	NA	NA	NA	NA	2,8%
Normal Hearts	84%	NA	NA	97%	94%	88%
Acc.Pathways	82%	75%	66%	72%	61%	72%
AVN Reentry	10%	20%	29%	26%	28%	13%
Other SVTs & VTs	7%	5%	6%	0%	10%	15%
Initial Success Rate	83%	90%	95% *	96%	89%	90%
Fluoroscopy	45,9-79,6	50,9	40,1 *	38,3	14,1	8,5
Follow up	21 mo	NA	NA	NA	12 mo	12 mo
Recurrences	32%	NA	NA	NA	23%	30%
Complications	4,80%	4,20%	3,00% *	4,00%	1,40%	0,90%
Death procedural	0,15%	0,07%	0,03%	0%	0%	0,18%

Expert Centers Learning Curve



Success

Successes/Attempts

Pathway/Mechanism	Early Era All Ages	Early Era <5 Years	Early Era 5–21 Years	Late Era All Ages	Late Era <5 Years	Late Era 5–21 Years	P Value (Early vs Late) All Ages	P Value (Early vs Late) <5 Years	P Value (Early vs Late) 5–21 Years
Left free wall	1,397/1,491 (94%)	78/86 (91%)	1,319/1,405 (94%)	1,044/1,073 (97%)	57/58 (98%)	987/1,015 (97%)	<0.001	0.06	<0.001
Right free wall	564/663 (85%)	37/44 (84%)	527/619 (85%)	388/410 (95%)	31/32 (97%)	357/378 (94%)	<0.001	0.07	<0.001
Anterior septal	349/419 (83%)	39/43 (91%)	310/376 (90%)	278/322 (86%)	24/29 (83%)	254/293 (87%)	0.26	0.38	0.13
Posterior septal	500/574 (87%)	61/66 (92%)	439/508 (86%)	401/431 (93%)	47/49 (96%)	354/382 (93%)	0.002	0.44	0.003
AV nodal reentry	795/838 (95%)	17/18 (94%)	778/820 (95%)	966/977 (99%)	11/11 (100%)	955/966 (99%)	<0.001	0.43	<0.001
Atrial ectopic tachycardia	185/208 (89%)	22/24 (92%)	163/184 (89%)	168/194 (87%)	21/26 (81%)	147/168 (88%)	0.47	0.27	0.75
Total	3,790/4,193 (90%)	254/281 (90%)	3,536/3,912 (90%)	3,245/3,407 (95%)	191/205 (93%)	3,054/3,202 (95%)	<0.001	<0.001	<0.001

Fluoro

Pathway/Mechanism	Early Era All Ages	Early Era <5 Years	Early Era 5–21 Years	Late Era All Ages	Late Era <5 Years	Late Era 5–21 Years	P Value (Early vs Late) All Ages	P Value (Early vs Late) <5 Years	P Value (Early vs Late) 5–21 Years
Left free wall	50.5 ± 39.7	43.7 ± 31.9	51.0 ± 40.1	38.0 ± 35.4	39.6 ± 31.4	38.3 ± 35.7	<0.001	0.46	<0.001
Right free wall	62.6 ± 46.2	44.9 ± 21.8	63.8 ± 47.1	52.1 ± 41.3	32.4 ± 23.4	53.8 ± 42.1	<0.001	0.02	<0.001
Anterior septal	54.4 ± 43.7	46.0 ± 25.0	55.3 ± 45.2	42.5 ± 36.8	53.6 ± 71.9	41.4 ± 31.2	<0.001	0.59	<0.001
Posterior septal	55.9 ± 40.8	54.0 ± 35.9	56.1 ± 41.4	42.8 ± 38.6	33.1 ± 30.1	43.5 ± 39.5	<0.001	0.002	<0.001
AV nodal reentry	35.8 ± 26.4	41.9 ± 38.0	35.6 ± 26.1	29.3 ± 25.7	41.0 ± 13.7	29.1 ± 25.8	<0.001	0.93	<0.001
Atrial ectopic tachycardia	50.8 ± 34.8	57.8 ± 35.4	49.9 ± 34.7	50.7 ± 38.5	47.8 ± 27.9	51.1 ± 40.0	0.97	0.28	0.76
Total	50.9 ± 39.9	47.2 ± 31.2	51.2 ± 40.4	40.1 ± 35.1	40.5 ± 36.7	40.0 ± 35.0	<0.001	0.03	<0.001

Complications

Complications/Attempts

Pathway/Mechanism	Early Era All Ages	Early Era <5 Years	Early Era 5–21 Years	Late Era All Ages	Late Era <5 Years	Late Era 5–21 Years	P Value (Early vs Late) All Ages	P Value (Early vs Late) <5 Years	P Value (Early vs Late) 5–21 Years
Left free wall	62/1,491 (4%)	7/86 (8%)	55/1,405 (4%)	32/1,074 (3%)	5/58 (9%)	27/1,016 (3%)	<0.001	0.92	0.09
Right free wall	14/663 (2%)	1/44 (2%)	13/619 (2%)	8/410 (2%)	3/32 (9%)	5/378 (1%)	0.86	0.17	0.38
Anterior septal	34/419 (8%)	7/43 (16%)	27/376 (7%)	15/322 (5%)	3/29 (10%)	12/293 (4%)	0.06	0.48	0.09
Posterior septal	25/574 (4%)	3/66 (5%)	22/508 (4%)	9/431 (2%)	3/49 (6%)	6/382 (2%)	0.05	0.71	0.02
AV nodal reentry	38/838 (5%)	0/18 (0%)	38/820 (5%)	29/977 (3%)	2/11 (18%)	27/966 (3%)	0.08	0.06	0.04
Atrial ectopic tachycardia	5/208 (2%)	0/24 (0%)	5/184 (3%)	7/194 (4%)	2/26 (8%)	5/168 (3%)	0.48	0.17	0.88
Total	178/4,193 (4%)	18/281 (6%)	160/3,912 (4%)	100/3,407 (3%)	18/205 (9%)	82/3,202 (3%)	0.003	0.42	<0.001

Kugler J. Cardiovasc. Electrophysiol 2002;13:336–341

	Kugler NEJM 1994	Kugler JCE 2002		Van Hare JCE 2004	Kubus EP 2014	M3C & ICPS Registry
	1991-1992	1991-1995	1995-1999	1999-2003	2003-2010	2010-2016
Age cut off	< 21 y	< 21 y		< 21 y	< 18	< 18
Centers	24 (US)	24 (US)		24 (US)	3 (Czech Rep)	1
Patients	652			481	633	487
Prodecures	725	4193	3407	540	708	550
Energy = RF	100%	100%	100%	100%	100%	93%
Age (mean)	12,4	12,4	12,2	11,4	14,9	8,7
	11% < 5 y	6,7% < 5 y	6% < 5 y	27% < 9 y	NA	5,9% < 5 y
Weight < 15 kg	NA	NA	NA	NA	NA	2,8%
Normal Hearts	84%	NA	NA	97%	94%	88%
Acc.Pathways	82%	75%	66%	72%	61%	72%
AVN Reentry	10%	20%	29%	26%	28%	13%
Other SVTs & VTs	7%	5%	6%	0%	10%	15%
Initial Success Rate	83%	90%	95% *	96%	89%	90%
Fluoroscopy	45,9-79,6	50,9	40,1 *	38,3	14,1	8,5
Follow up	21 mo	NA	NA	NA	12 mo	12 mo
Recurrences	32%	NA	NA	NA	23%	30%
Complications	4,80%	4,20%	3,00% *	4,00%	1,40%	0,90%
Death procedural	0,15%	0,07%	0,03%	0%	0%	0,18%

Complications

	Cohort
Total participants	481
Complications of electrophysiologic study	
Hematoma at catheter entry	9 (1.9%)
Hematoma other	0 (0%)
Deep vein thrombosis	0 (0%)
Emboli, pulmonary	0 (0%)
Emboli, central nervous system	0 (0%)
Emboli, other	0 (0%)
Perforation	0 (0%)
Brachial plexus injury	0 (0%)
Death	0 (0%)
Other	11 (2.3%)
None of above	461 (96%)
Any of above	20 (4.2%)
Complications of ablation	
Chest pain	1 (0.2%)
Skin burn	1 (0.2%)
Bradycardia	0 (0%)
AV block	6 (1.2%)
Right bundle branch block	1 (0.2%)
Left bundle branch block	0 (0%)
Atrial proarrhythmia	0 (0%)
Ventricular proarrhythmia	0 (0%)
Intracardiac thrombosis	1 (0.2%)
Other thrombosis	1 (0.2%)
Valvular regurgitation	5 (1.0%)
Other complications	5 (1.0%)
None of above	462 (96%)
Any of the above	19 (4.0%)

	Cohort
Total substrates	540
Diagnosis	
Manifest accessory pathway	2/234 (0.9%)
Concealed accessory pathway	1/145 (0.7%)
Paroxysmal junctional reciprocating tachycardia	0/14 (0%)
AV nodal reentrant tachycardia	3/142 (2.1%)
Atrial fibrillation	0/0 (0%)
Atrial flutter	0/1 (0%)
Ectopic atrial tachycardia	0/2 (0%)
Junctional ectopic tachycardia	0/0 (0%)
Ventricular tachycardia	0/0 (0%)
Other	0/2 (0%)
Missing	0/0 (0%)
Total	6/540 (1.1%)
Pathway location	
Right anterior	0/12 (0%)
Right lateral	0/34 (0%)
Right posterior	0/19 (0%)
Right posteroseptal	2/55 (3.6%)
Right intermediate septal	0/13 (0%)
Anteroseptal	0/12 (0%)
Left intermediate septal	0/1 (0%)
Left posterior paraseptal	1/21 (4.8%)
Left posterior	0/48 (0%)
Left lateral	0/166 (0%)
Left anterolateral	0/12 (0%)
Missing	0/0 (0%)
Total	3/393 (0.8%)

Van Hare J. Cardiovasc. Electrophysiol 2004;15:759–770

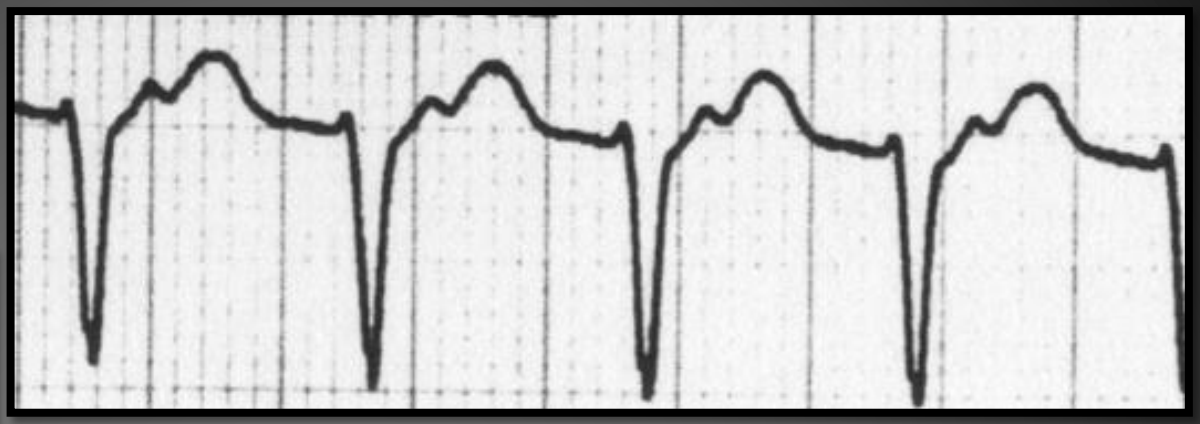
Outcomes depend on:

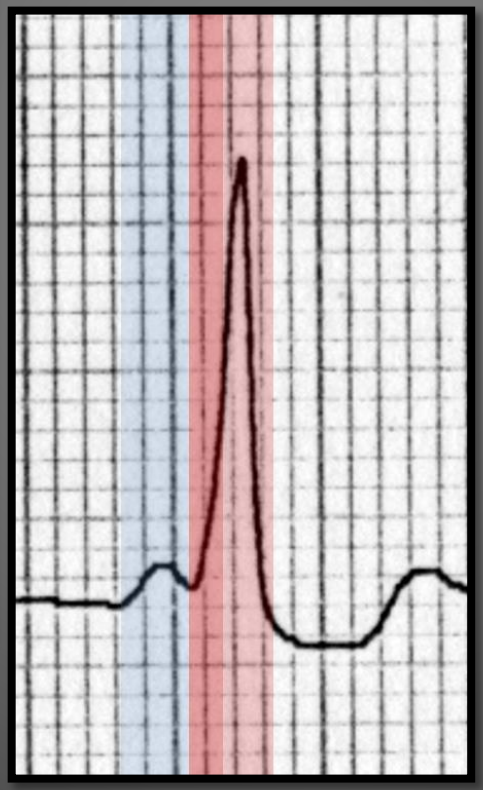
- Patient weight (<>15 kg) ~~vs age~~
- Underlying heart disease / heart failure
- Arrhythmic substrate / location / vascular approach

- Emergency vs programmed intervention
- Ablation energy used (RF vs Cryo)
- Physician experience (pediatric/adult EP) and EP lab standards (imaging integration, 3D navigation)

:'(	:)
< 15 kgs Heart Defect / Heart Failure Atypical / Multiple substrate Perinodal or Epicardial target (PJRT, Posterosept. WPW)	Teenagers Normal heart Typical SVT Left sided accessory pathway
# 20-25% recurrences (but easier to manage) serious adverse events # 1-2%	Programmed Ablation 1st RF success > 95% serious adverse events # 0%

2 My young patient has a WPW





+ AF = VF

Back to basics

SVT

AVN Reentrant Tach

AV Reentrant Tach

Retrograde Conduction

Dual AV Node Slow/Fast pathways

Accessory Pathway

Anterograde Conduction

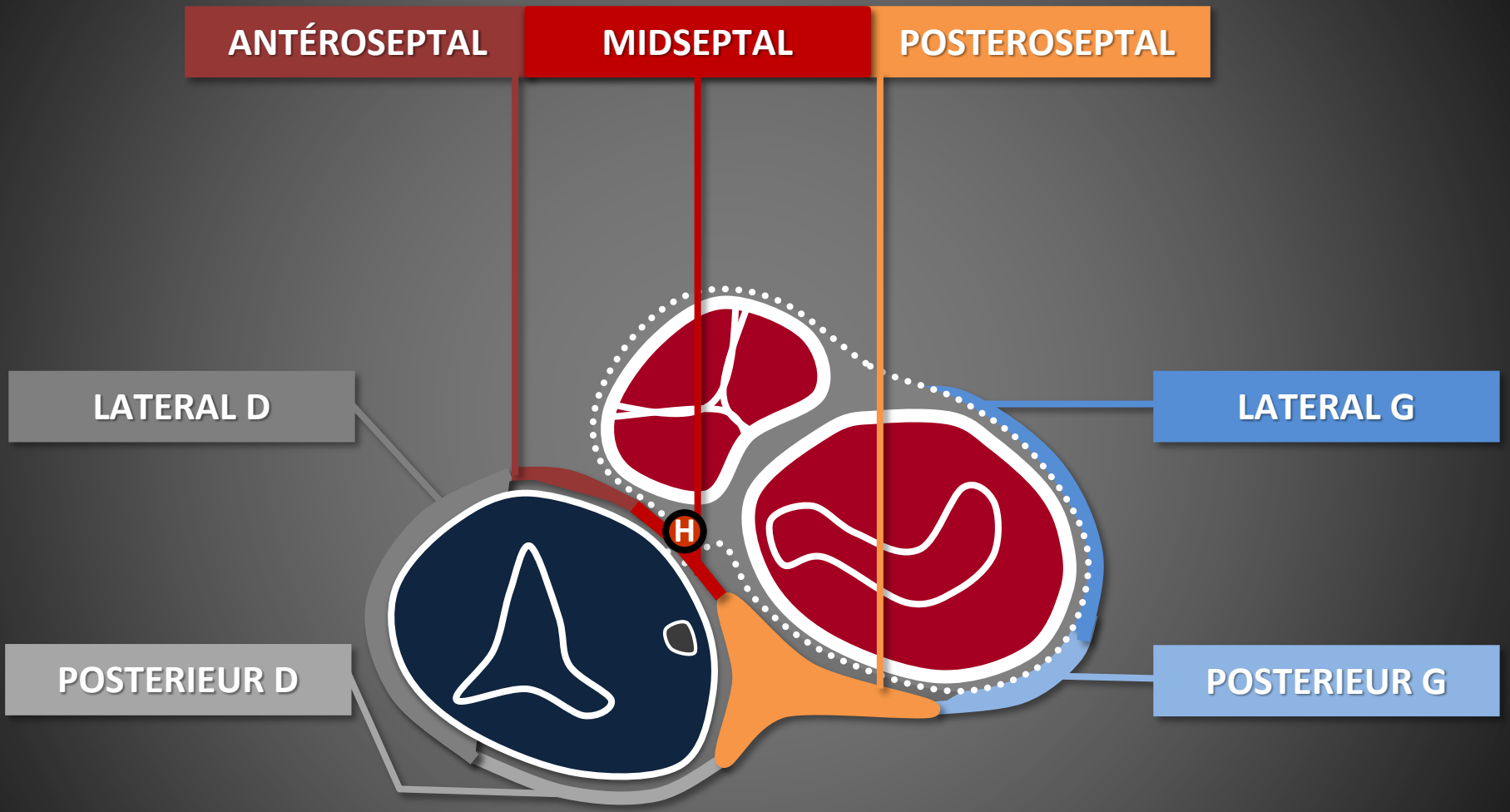
WPW Pattern SCD Risk if AF induices VF

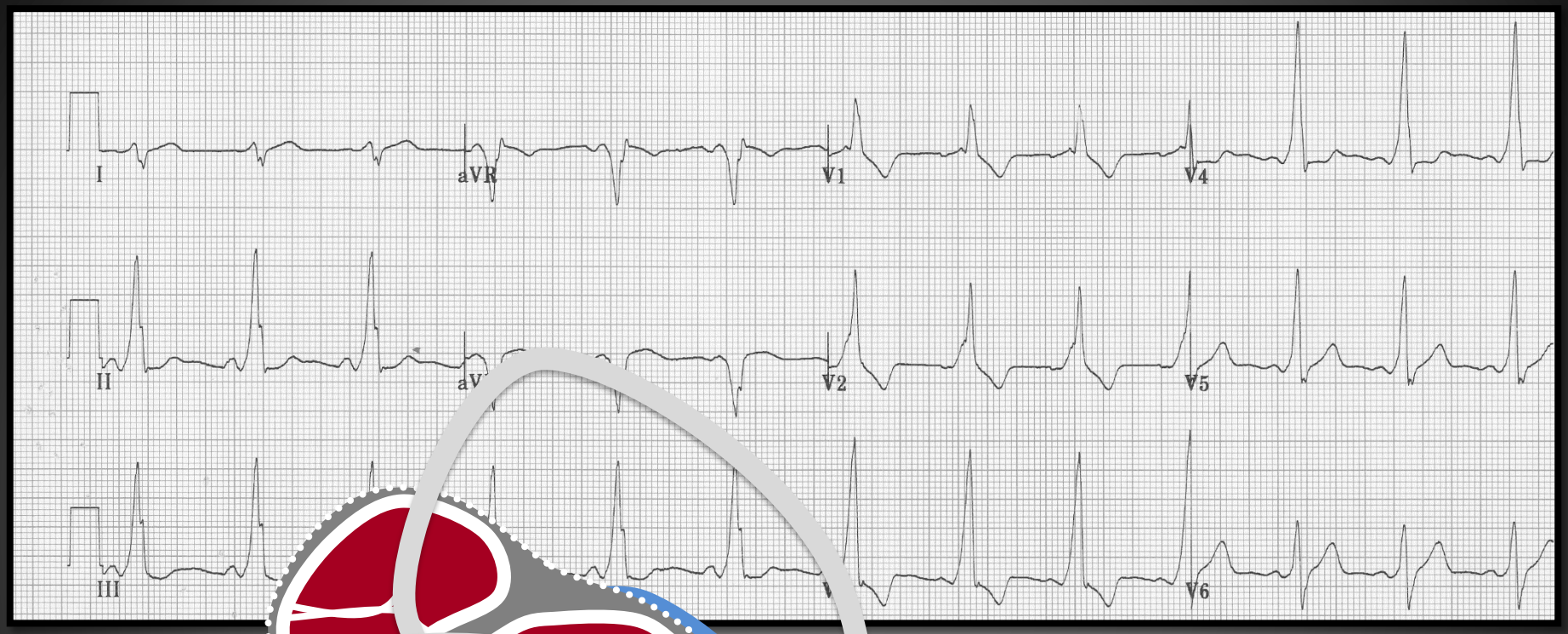
20-30%

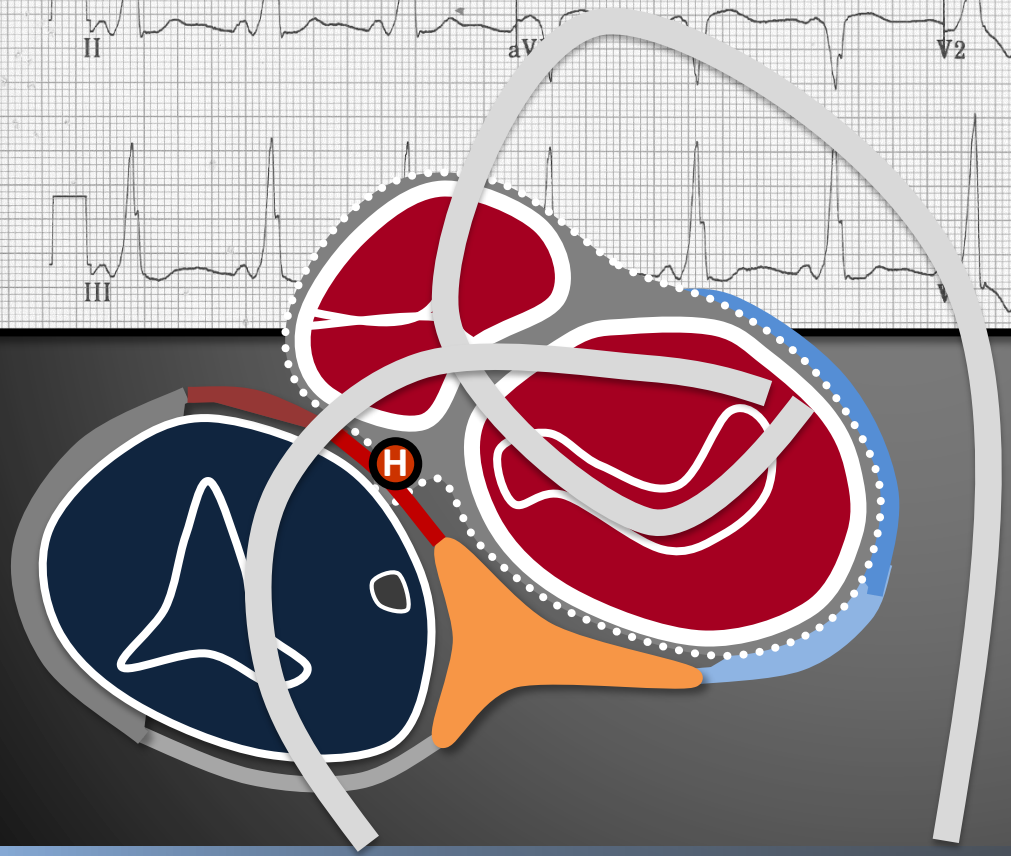
30-40% concealed

70-80%

60-70% manifest


ANTÉROSEPTAL
MIDSEPTAL
POSTEROSEPTAL
LATERAL D
LATERAL G
H
POSTERIEUR D
POSTERIEUR G





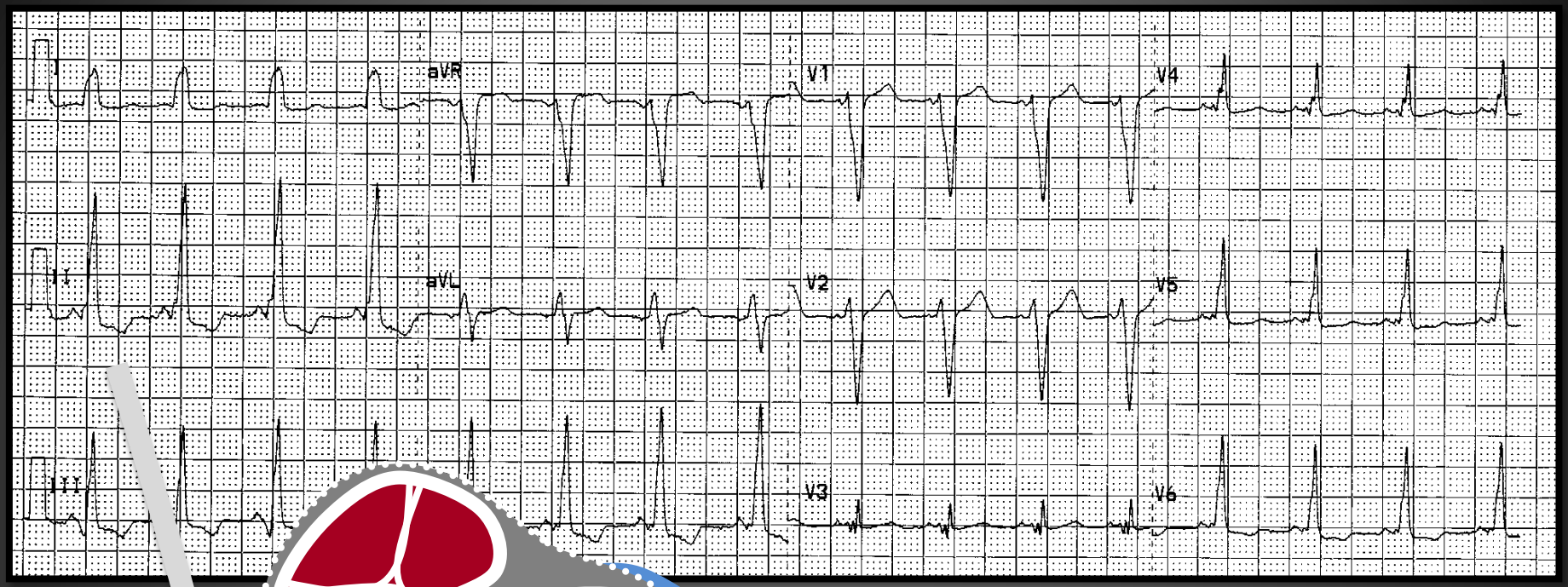
Left sided RF ablation
Retro Transaortic or Transeptal
Low risk intervention
Specific risks :
- Femoral/Aortic
- Tamponade (transeptal)
- Stroke
- Mitral Regurgitation

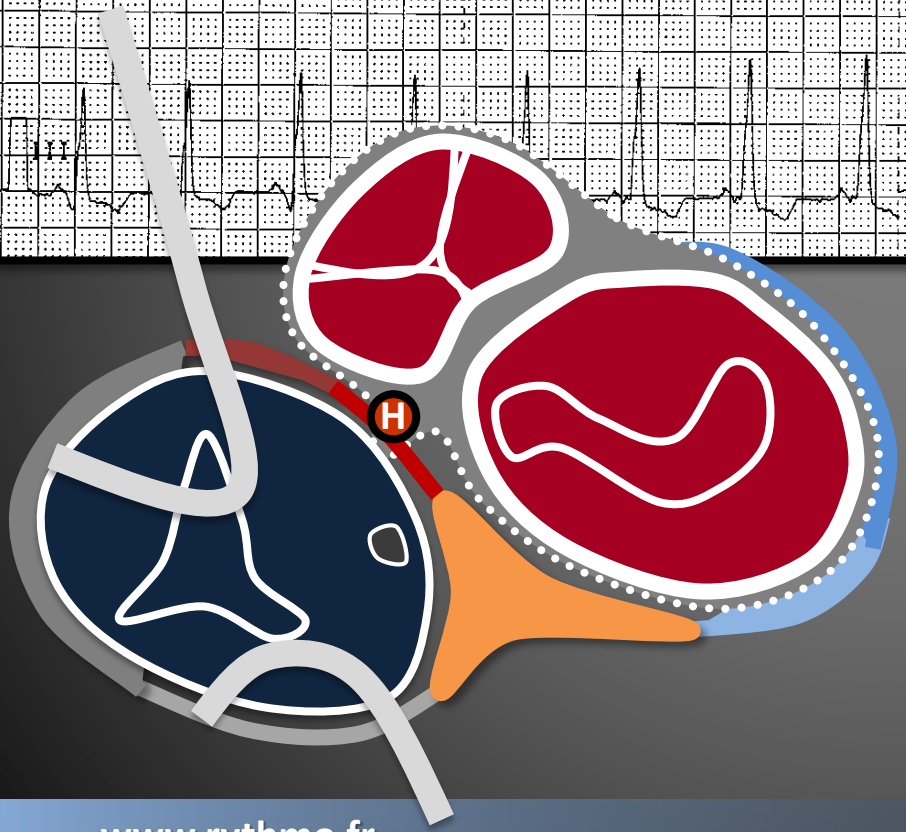
High success rate > 95%

	Transaortic	Transseptal
Pro	Simple Conventional Approach	Easy to navigate in LA Venous puncture
Cons	Arterial puncture (7-8F KT) - Leg ischemia, Fistula, Groin Hematoma - Aortic / Coronary dissection Aortic & Mitral valve regurgitation Hard to reach LA in some patients	Tamponade Air embolism / Transseptal Sheath Lack of experience

ICPS/M3C strategy

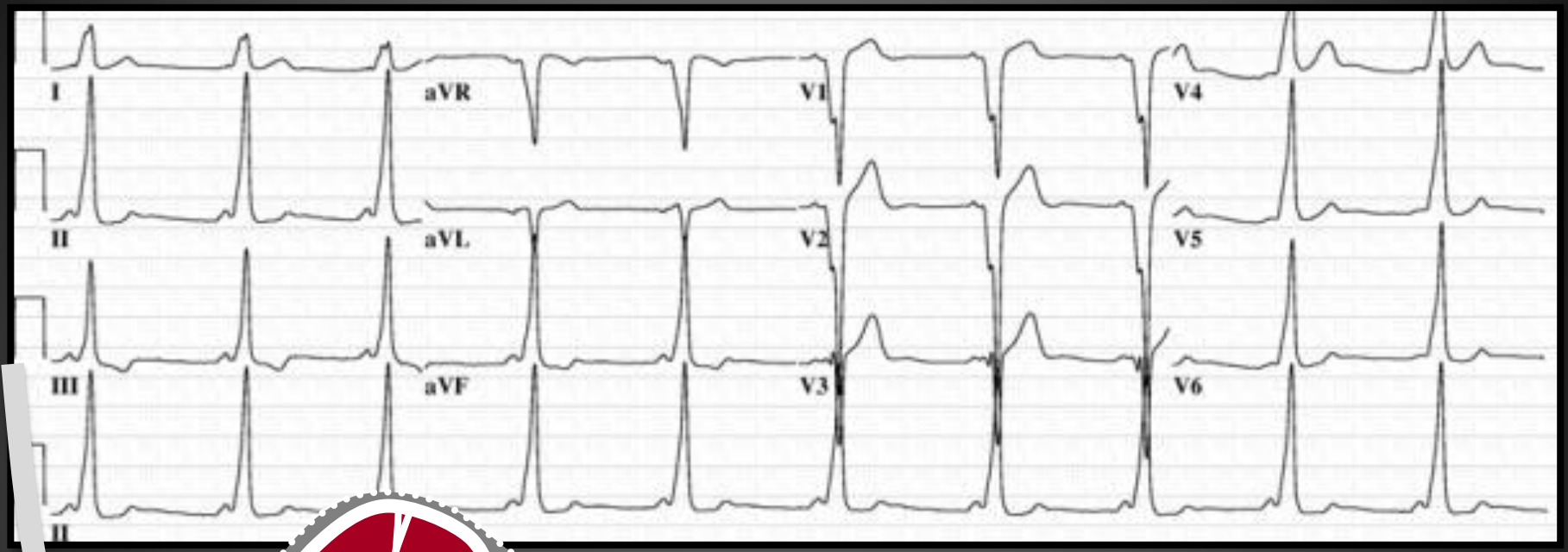
Stepwise Approach	1. Is there a PFO / ASD ? 2. Transseptal (25%) under TEE if: - Patients < 30 kgs to prevent femoral / aortic injury - Redos / failure of transaortic approach 3. Transaortic (75%) + Stroke prevention in every case (heparin, AAP 1 month)
Outcomes	Transeptal: no failure / no complication, 1% headache Transoartic : 1 reversible leg ischemia, 2 TIA, benign groin hematoma = 5-7%

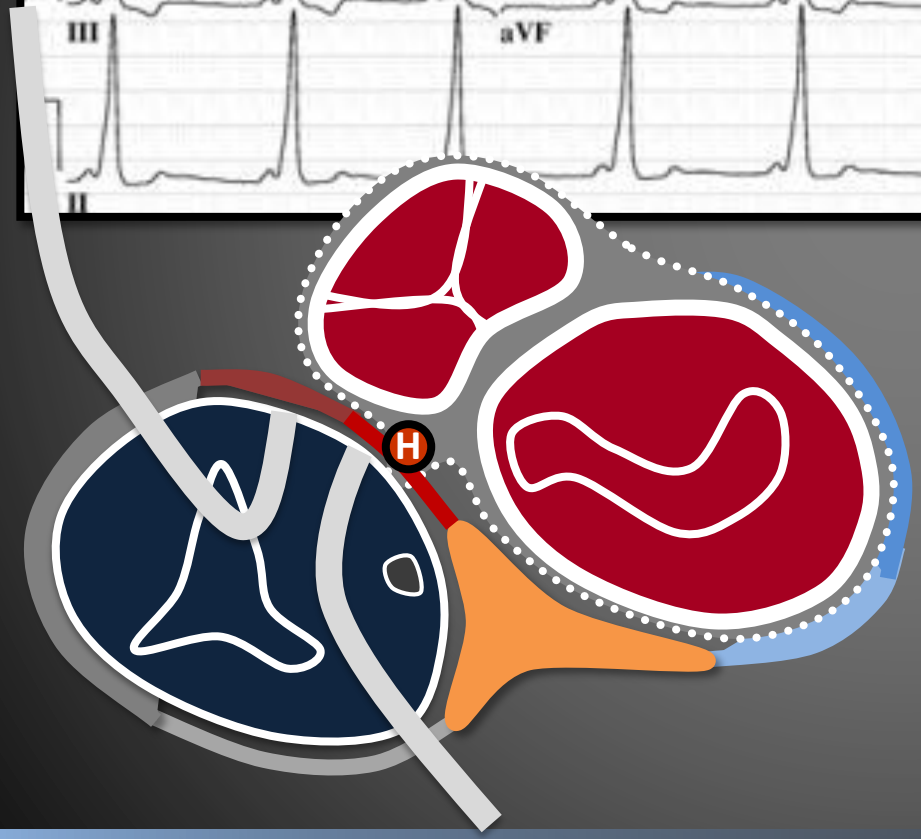




Right sided RF ablation
IVC / SVC (jugular) approach
Specific risks :
- Failure (unstable RF cath)
- Long lasting / Rx procedure
- Multiple APs (Ebstein)

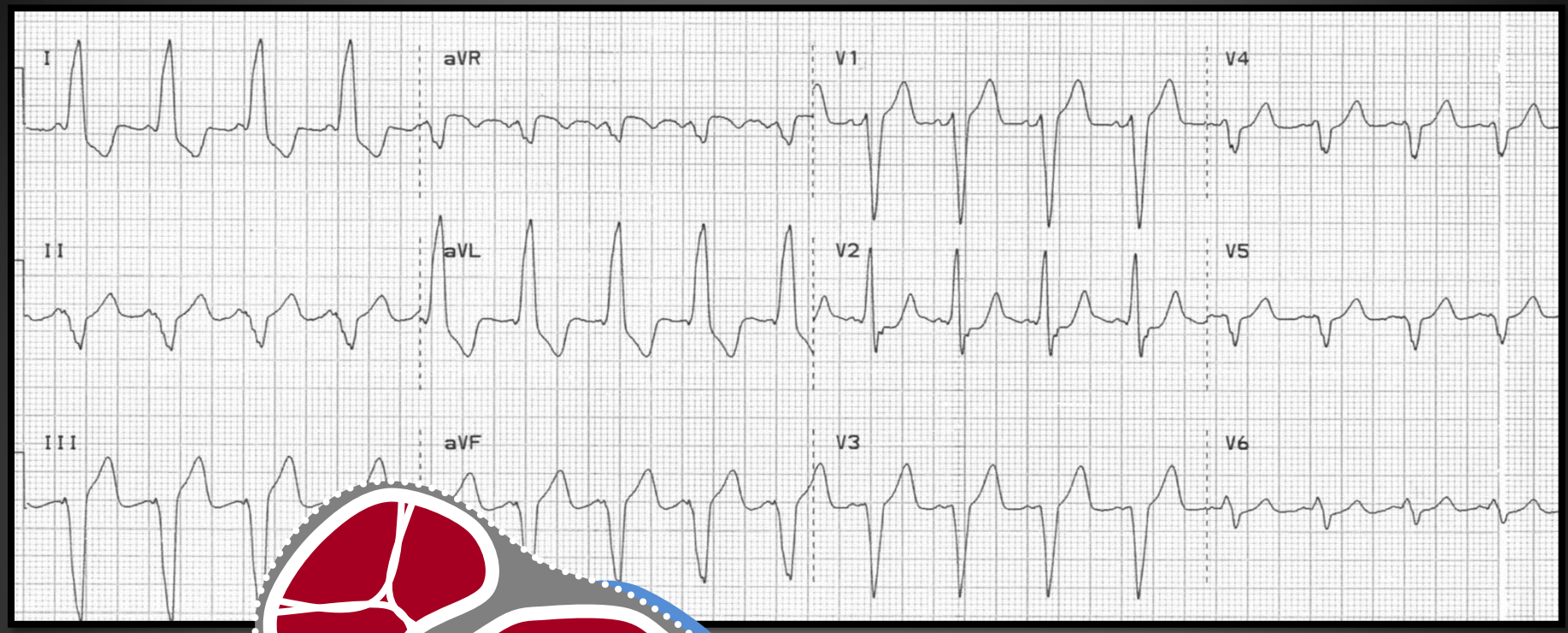
Success rate # 75%

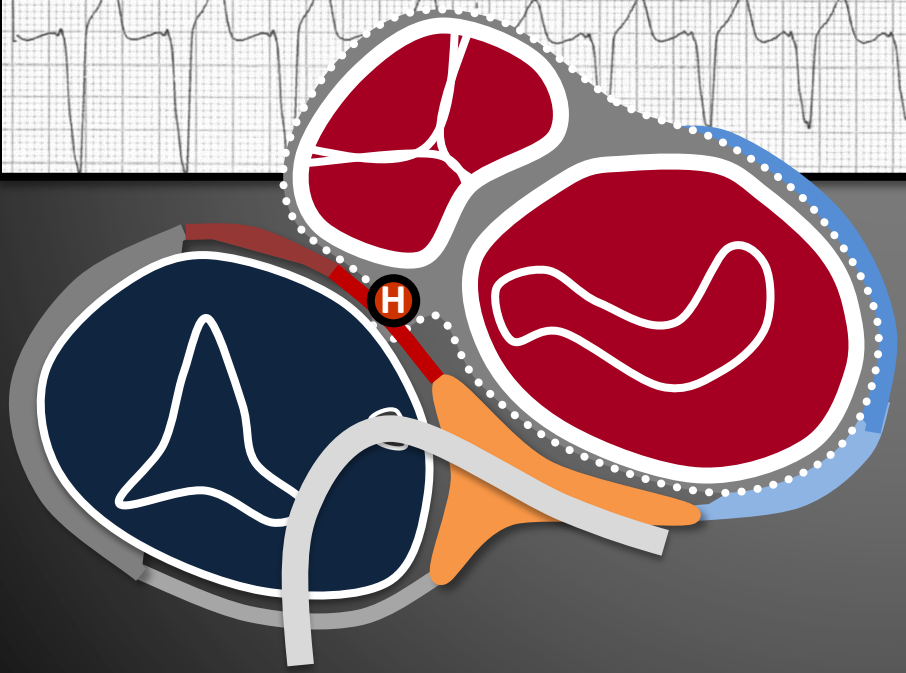




Right sided RF or Cryo ablation
IVC / SVC (jugular) approach
Specific risks :
- AV block (1-3%)
- Long lasting / Rx procedure
- Failure (AVB risk)

Success rate # 75%





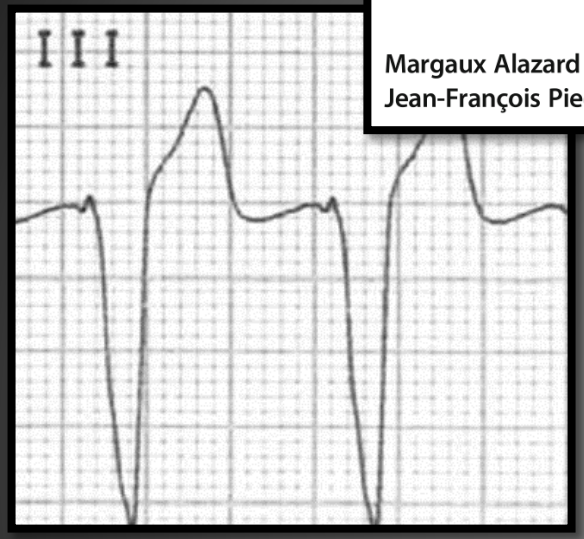
Right sided RF or Cryo ablation
Epicardial Coronary Sinus approach
Specific risks :

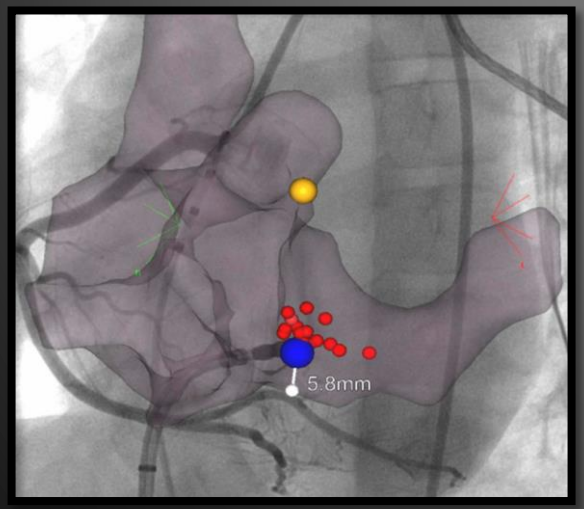
- Coronary Art Injury
- Long lasting / Rx procedure
- Failure

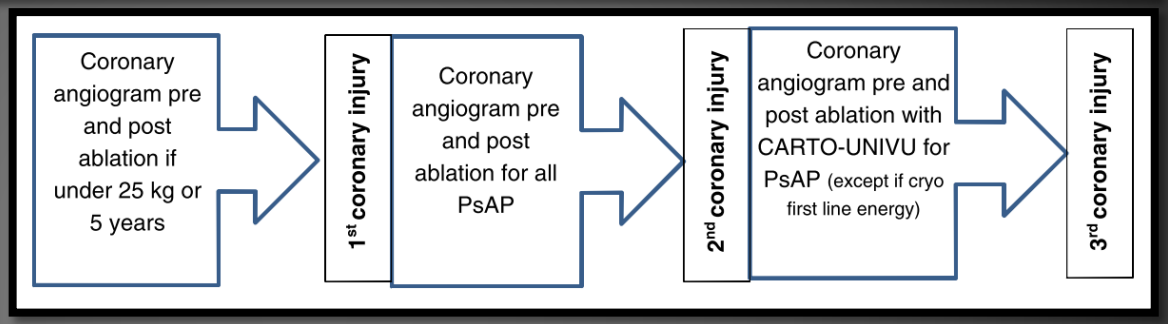
Success rate # 75%

Preventing the risk of coronary injury in posteroseptal accessory pathway ablation in children: different strategies and advantages of fluoroscopy integrated 3D-mapping system (CARTO-UNIVU™)

Margaux Alazard[1] · Jérôme Lacotte[1] · Jérôme Horvilleur[1] · Mina Ait-Said[1] · Fiorella Salerno[1] · Vladimir Manenti[1] · Jean-François Piechaud[1] · Jérôme Garot[1] · Damien Bonnet[2] · Alice Maltret[1,2]







68 patients
Coronary Injury = 4% (No LV dysfunction or Death)
1 year recurrence = 20%

	Safety margin ≤5 mm $n = 18$	Safety margin >5 mm $n = 12$	p
Typical APs (n)	10 (55.6%)	8 (66.7%)	0.189
Male (n)	11 (61.1%)	8 (66.7%)	0.091
Age (years)	10.4 ± 4.2	9.77 ± 2.7	0.640
Weight (kg)	37 ± 17	35 ± 13	0.758
Height (cm)	139 ± 24	142 ± 18	0.704
BSA (m^2)	1.18 ± 0.38	1.17 ± 0.29	0.933

Alazard J. Interv. Card. Electrophysiol 2018

3 My young patient is symptomatic for SVT (without WPW pattern)

Back to basics

SVT

AVN Reentrant Tach

AV Reentrant Tach

30-40% concealed

Retrograde Conduction

20-30%

Dual AV Node Slow/Fast pathways

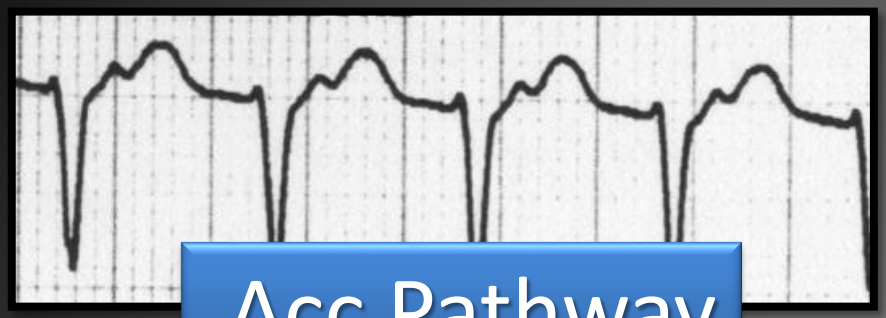
Accessory Pathway

70-80%

Anterograde Conduction

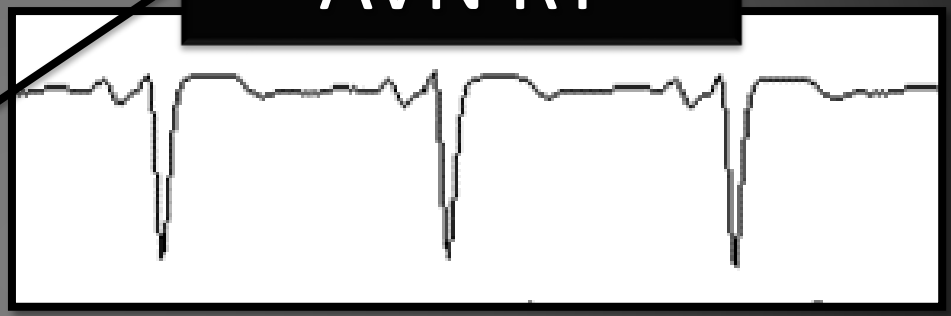
WPW Pattern SCD Risk if AF induices VF

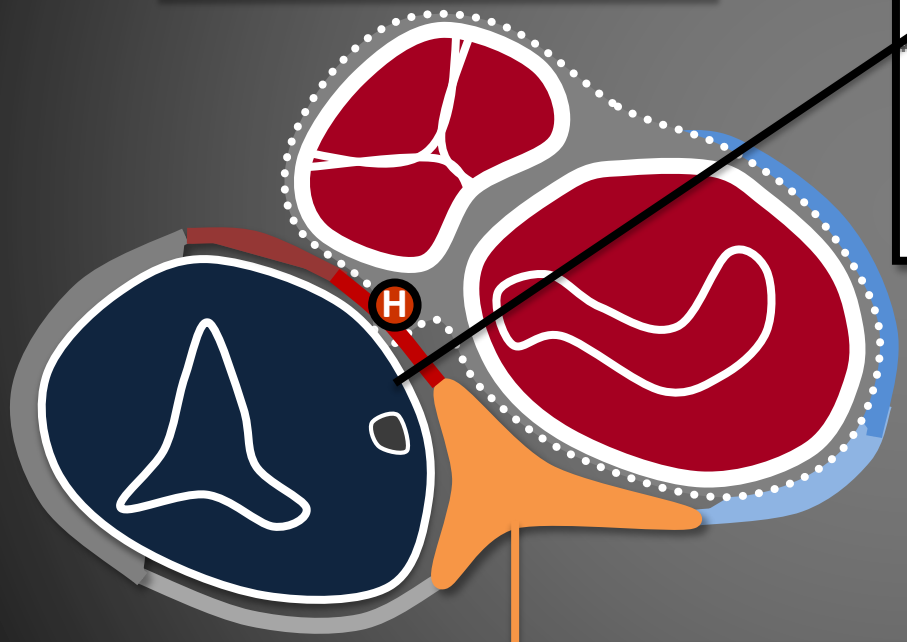
60-70% manifest



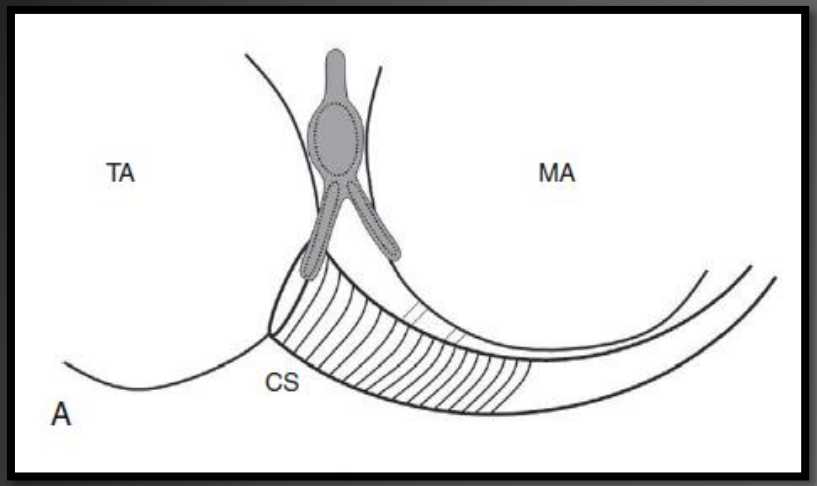
Acc Pathway

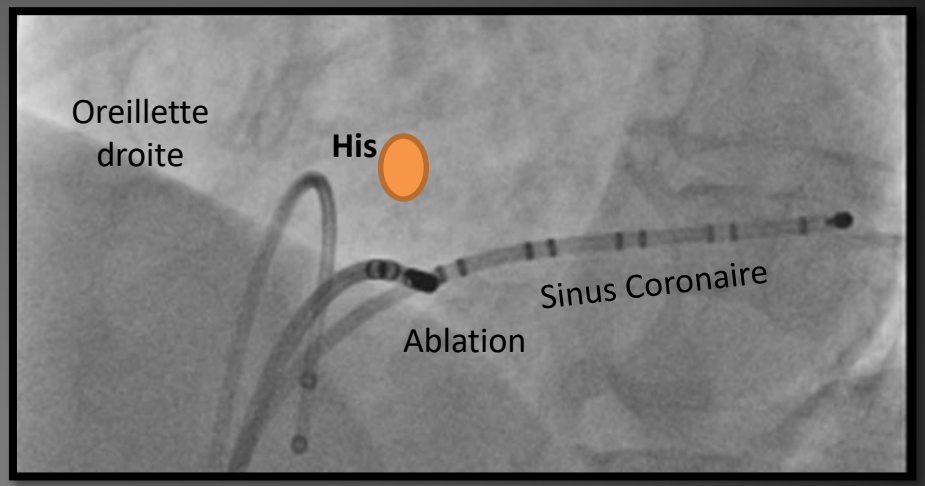
AVN RT

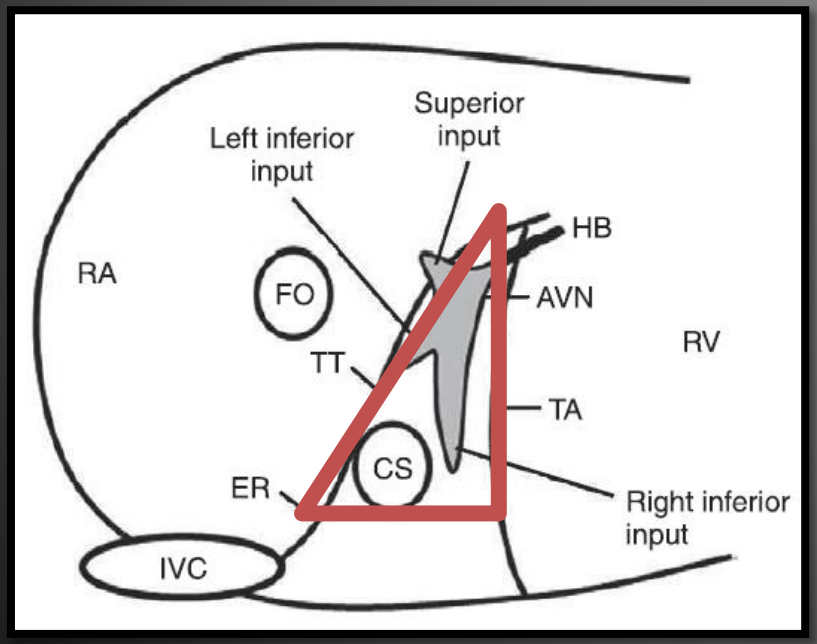




PJRT

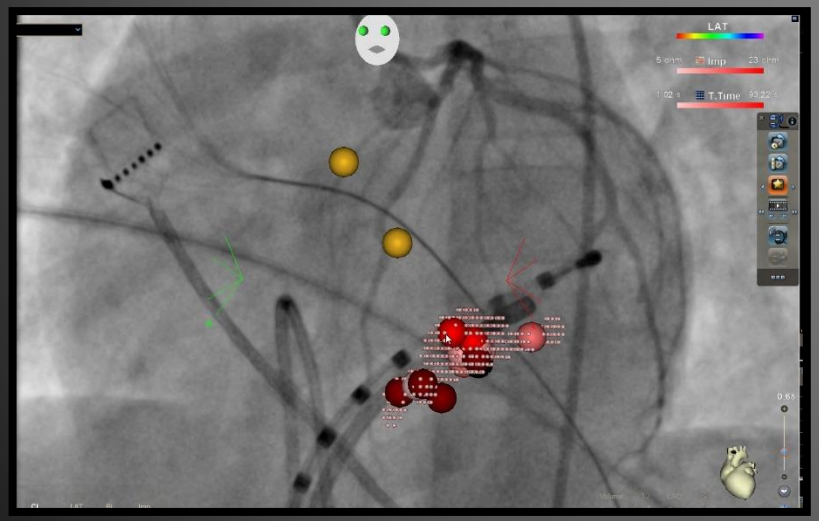

TA
MA
CS
A


Oreillette droite
His
Sinus Coronaire
Ablation

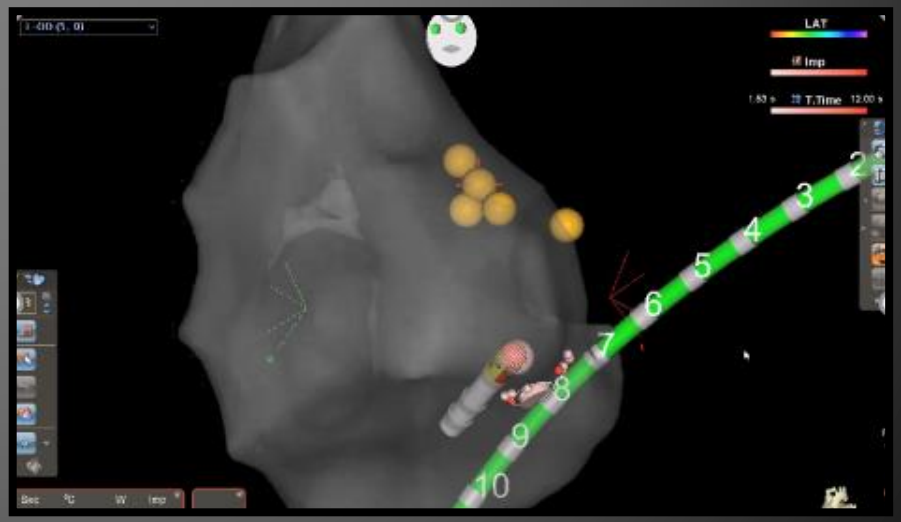

Left inferior input
Superior input
HB
RA
FO
AVN
RV
TT
TA
CS
ER
Right inferior input
IVC


Study
Map
Point
Catheter
ECG
Display
Imaging
Window
Tools
Help
Setup
Mapping
Ablation
Verification
Routed channel: Quad 1-2
LAT
Imp
T.Time
3
4
5
6
7
8
9
10
Acquire

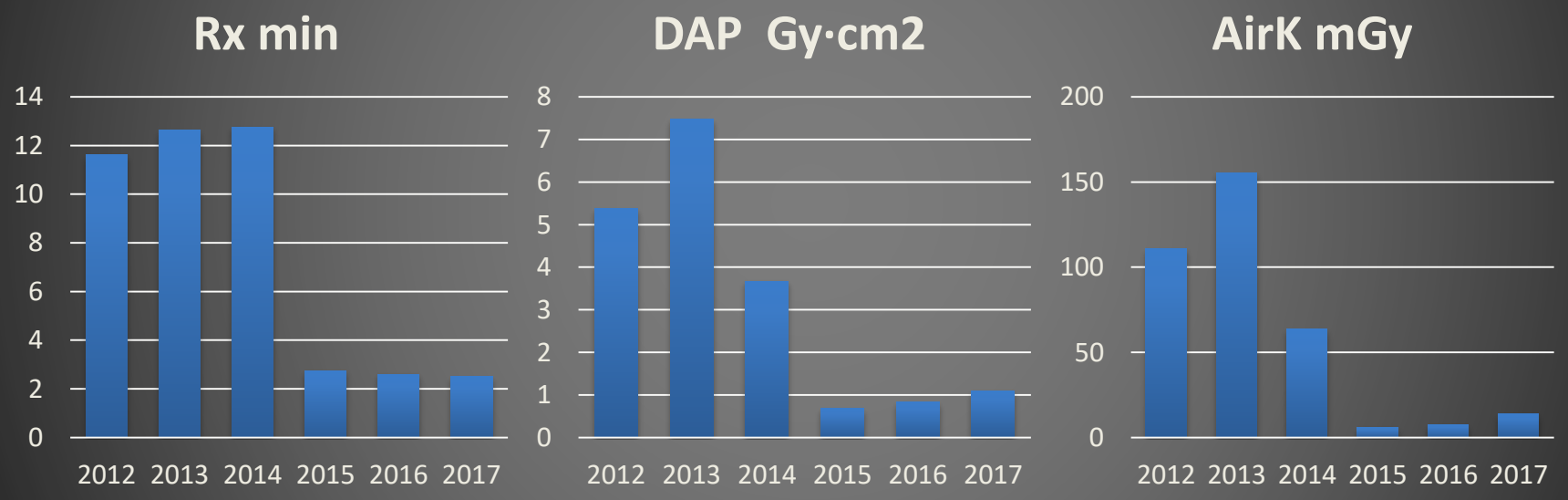
UNIVU



TSV 3D



ICPS xRay 2012-2017



	RF	Cryo
Pro	Recurrence Rate < 5% 3D xRay free: 100% compatible	AVB requiring PM # 0% No coronary injury
Cons	AVB requiring PM 0,3-1% Coronary injury (SC RF) : 4-8%	Recurrence Rate 10-15% Poor handling properties 3D xRay free: partially compatible

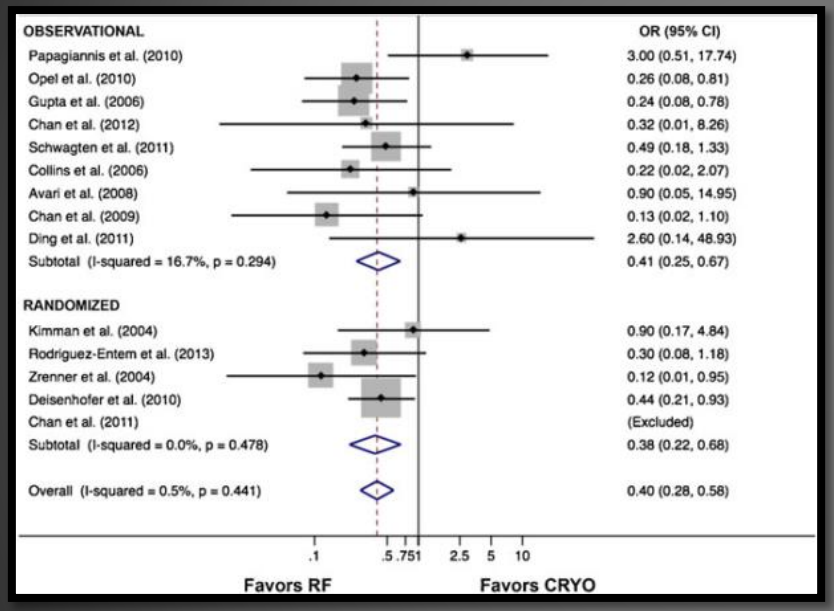
ICPS/M3C strategy

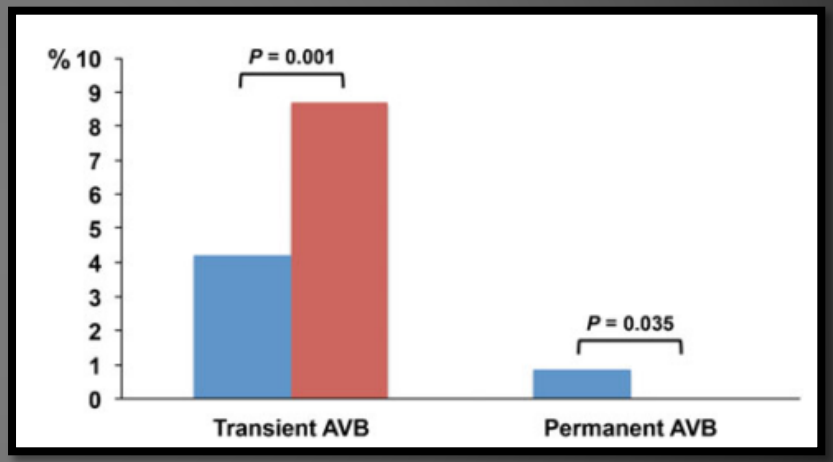
1. Cryoablation (10%) if:
   - AVNRT patients < 15 kgs
   - Parahisian Acc. Pathways
   - Epicardial / Coronary Sinus ablation with limited safety margin
2. Radiofrequency (75%)

+ 3D mapping with “As Low As Reasonably Achievable” xRay exposure

Outcomes	Cryo: 0% AVBlock, recurrences 20-30% RF : 2 AVBlocks (Cryo refractory malignant WPW), recurrences 5-15%

Meta-analysis
2340 adults AVNRT ablation





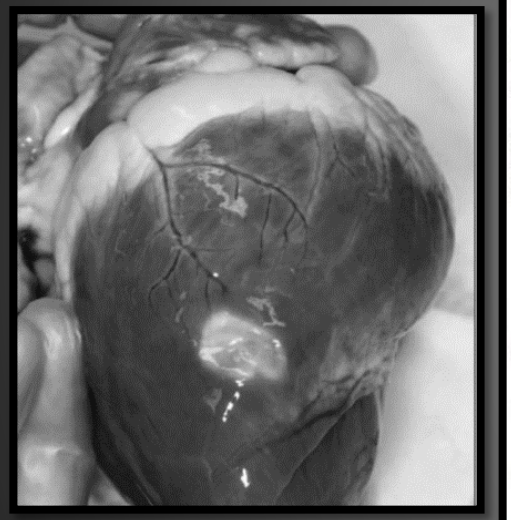
Efficacy
96,5% RF vs 90,9% Cryo
p<0.001

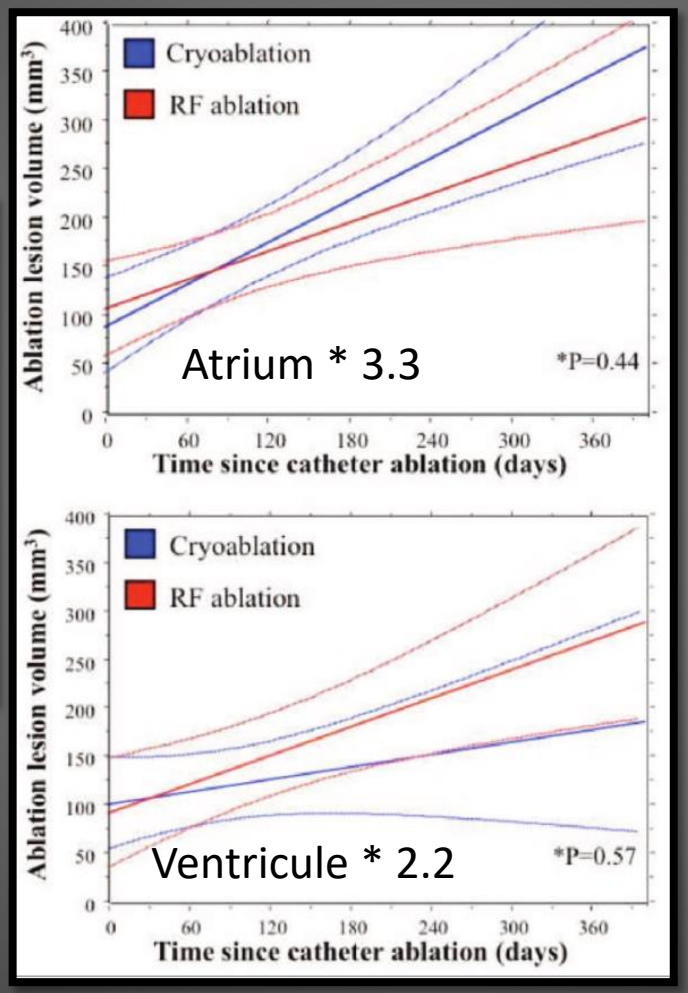
AV block
0,87% RF vs 0% Cryo
p=0.035

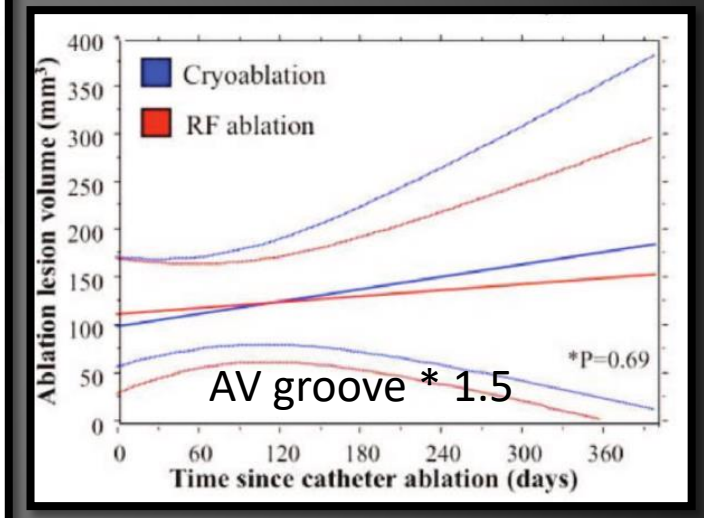
Santangeli P, JICE;39(2):111–9

4 Delayed adverse events

Will lesions grow with the patient ?







Khairy Circ. Arrhythmia Electrophysiol. 2011;4: 211–217

Is there a risk of delayed AV block ?

- European Retac Multicentric Registry
- 1043 adults with RF AVNRT ablation
- Mean age = 52 years
- Acute AVB / PM implant = 0,9%
- Delayed AVB (mean FU = 40 mo) = 1%

30 years after RF or Cryo pediatric AVNRT ablation, how many patients will require early PM implant ?

Kowsar, P5-51, Heart Rhythm, Vol 2, No 5, May Supplement 2005

xRay exposure reduction

	Adult		Paediatric		Toddler	
	3D Ablation (Y/N)		3D Ablation (Y/N)		3D Ablation (Y/N)	
	No	Yes	No	Yes	No	Yes
	Mean	Mean	Mean	Mean	Mean	Mean
Fluoro Duration (min)	10,56	2,22	15,24	3,07	13,42	5,07
Fluoro DAP (cGy.cm²)	8,15	0,86	2,95	0,73	0,87	0,49
Fluoro Air Kerma (mGy)	137,56	7,79	58,88	8,94	22,43	6,28
Procedure Duration (min)	90	84	97	98	96	123
Ablation Duration (sec)	490	485	526	448	385	427

xRay and Lifetime Cancer Risk

NIH NATIONAL CANCER INSTITUTE
Division of Cancer Epidemiology & Genetics

Radiation Risk Assessment Tool - Lifetime Cancer Risk from Ionizing Radiation

HOME | ABOUT | TUTORIALS [PDF – 2 MB]

RadRAT version 4.1.1

Enter the inputs in the form below or upload an input file.

Demographic Information

Gender:	Female
Birth Year:	2003
Population:	France 2003-2007

Exposure Information

An exposure event may result in doses to one or more organs. All doses associated with the same event should be indicated by entering the same number in the "Exposure Event" column and the same year in the "Exposure Year" column. Refer to Guidance for Entering Exposure Information.

Each organ dose may be entered as a value with no related uncertainty by selecting "Fixed Value" from the Distribution Type menu and typing the value into the "Parameter 1" column. The organ dose may also be entered as an uncertain quantity by selecting one of the probability distributions from the Distribution Type menu. The corresponding distribution parameters should be entered into columns 1, 2, and/or 3.

No.	Exposure Event	Exposure Year	Organ	Exposure Rate	Organ Dose mGy — Distribution Type	Parameters 1,2,3		
1	1	2017	Apply dose to all organs	acute	Fixed Value(value)	097	0	0

Add Exposure Event

Lifetime attributable risks of all cancers mortality and incidence

	Typical AVNRT	
	3D Ablation (Y/N)	
	No	Yes
	Mean	Mean
Fluoro Duration (min)	8,57	1,84
Fluoro DAP (cGy.cm²)	5,12	0,79
Fluoro Air Kerma (mGy)	97,49	6,81
Procedure Duration (min)	83	79
Ablation Duration (sec)	567	479
Risk cancer if ablation performed at:		
• 15 y	0,33%	0,010%
• 40 y	0,12%	0,005%
• 65 y	0,06%	0,002%

Messages

- Major technologic improvements
- Increasing experience
- High success rate, very low complication rate
- Avoid extensive lesions and xRay, prefer 3D
- RF or Cryo to prevent AVB or coronary injury
- If possible, wait > 15 kg
- ECG helps to identify substrate and to predict outcomes