Catheter Ablation for Atrial Fibrillation in Adult CHD

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Catheter ablation in adult congenital heart disease on uninterrupted oral anticoagulation: Is it safe? Data from a large single-center study

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BACKGROUND Catheter ablation in adult congenital heart disease (ACHD) patients is a critical treatment strategy for complex arrhythmias including atrial fibrillation (AF) and atrial tachycardia (AT). In addition to vitamin K antagonists (VKAs), direct oral anticoagulants (DOACs) are increasingly used in this patient population.

OBJECTIVE The purpose of this study was to assess the safety of catheter ablation in ACHD patients on uninterrupted oral anticoagulation with VKA or DOAC, examining thromboembolic, bleeding, and vascular access complications.

METHODS Retrospective analysis of 234 ACHD patients with simple (n = 83), moderate (n = 66), or complex (n = 85) CHD (mean age 46 years) undergoing 368 ablation procedures on uninterrupted oral anticoagulation with VKA (45.4%) or DOAC (54.6%) was undertaken. Arrhythmias were AF in 97, right AT in 181, left AT in 65, or a combination of AF and AT in 25.

RESULTS No thromboembolic complications occurred. Major complications occurred in 4 patients (1.1%; 1 VKA, 3 DOAC), including retroperitoneal hematoma in 2 and arteriovenous (AV) fistula requiring surgical treatment in 2. Minor bleeding or vascular access complications occurred in 46 cases (12.5%), including hematomas >5 cm in 26, AV fistulas (not requiring surgical intervention) in 13, and pseudoaneurysms in 7 (thrombin injection in 3/7). Overall, no significant difference was found between DOAC (14.9%) and VKA groups (12.0%; $P = .411$).

CONCLUSION Catheter ablation in ACHD patients on uninterrupted oral anticoagulation with VKA or DOAC is feasible and safe. No thromboembolic events occurred, and major bleeding or vascular access complications were rare. No significant differences regarding minor bleeding or vascular access complications between patients on DOAC or VKA were found.

KEYWORDS Adult congenital heart disease; Atrial fibrillation; Catheter ablation; Direct oral anticoagulant; Oral anticoagulation

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Periprocedural Anticoagulation in CHD

Table 6 Peri/postprocedural thromboembolic, bleeding, and vascular access complications

Complications	Total (N = 368)	VKA (n = 167)	DOAC (n = 201)	*P* value
Intra/periprocedural thromboembolic complications	0			
Major: Retroperitoneal hematoma	2 (0.5)	0	2 (1)	.196
Major: AV fistula (surgical intervention)	2 (0.5)	1 (0.6)	1 (0.5)	.097
Minor: Pseudoaneurysm (thrombin injection)	3 (0.8)	0	3 (1.5)	.280
Minor: Pseudoaneurysm (manual compression)	4 (1)	2 (1.2	2 (1)	.367
Minor: AV fistula (conservative)	13 (3.5)	2 (1.2)	11 (5.5)	.062
Minor: Hematoma >5 cm	26 (7)	15 (9)	11 (5.5)	.223

Periprocedural anticoagulation with uninterrupted VKA & NOAC are feasible and safe in patients with CHD.

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ESC European Society of Cardiology

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Efficacy of catheter ablation for atrial fibrillation in patients with congenital heart disease

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Aims Advances in surgical techniques allow an increasing number of children with congenital heart disease (CHD) to reach adulthood. As patients grow older, atrial fibrillation (AF) is evolving into a major clinical concern and can be difficult to manage medically. Primary AF catheter ablation may, therefore, have a role in this setting but few reports have evaluated its efficacy in CHD patients.

Methods and results We retrospectively reviewed 58 consecutive patients [median age 51, interquartile range (IQR) 44–63 years, 57% male] with AF (45% paroxysmal) who underwent 122 ablation procedures in our tertiary centre in the last decade. The majority had CHD of moderate or severe complexity (57%, Bethesda Class 2 or 3) with a dilated left atrium (LA) (81%) and/or right atrium (86%). At 1-year from the first ablation, 32.8% of patients remained in sinus rhythm. Multiple procedures were required in 35 (60%) patients. Freedom from AF at 1-year after the 2nd and 3rd ablation was 40.9% and 36.5%, respectively. Multivariable predictors of AF recurrence were underlying anatomic complexity [hazard ratio (HR) in Bethesda 3 1.98, $P = 0.006$], type of AF (HR for persistent 1.87, $P = 0.004$), and indexed LA dimensions (HR for cm^2/m^2 1.06, $P = 0.03$).

Conclusion While ablation may be a valid option for the treatment of AF in CHD patients, multiple procedures are likely to be

Table 2 Details of congenital heart diseases anatomic complexity

Anatomic complexity	*n* (%)
Bethesda 1/simple lesions	25 (43%)
ASD/PFO	22 (36.2%)
VSD	1 (1.7%)
Bicuspid aortic valve	1 (1.7%)
Cor triatriatum	1 (1.7%)
Bethesda 2/moderate lesions	20 (34.4%)
AVSD	3 (5.1%)
Aortic coarctation	7 (12%)
Ebstein's anomaly	3 (5.1%)
RVOTO	1 (1.7%)
Pulmonary valve disease	1 (1.7%)
Sinus venosus ASD	2 (3.4%)
Subaortic stenosis	1 (1.7%)
VSD and associated lesions	1 (1.7%)
ALCAPA	1 (1.7%)
Bethesda 3/complex lesions	13 (22.4%)
Double outlet right ventricle	1 (1.7%)
Pulmonary atresia and MAPCA	1 (1.7%)
TCPC/Fontan	2 (3.4%)
AVSD and pulmonary stenosis	1 (1.7%)
Tricuspid atresia (Waterstone shunt)	2 (3.4%)
LA isomerism, AVSD repaired	2 (3.4%)
Criss-cross heart(repaired TOF)	1 (1.7%)
Double inlet left ventricle	2 (3.4%)
Truncus arteriosus (Rastelli procedure)	1 (1.7%)

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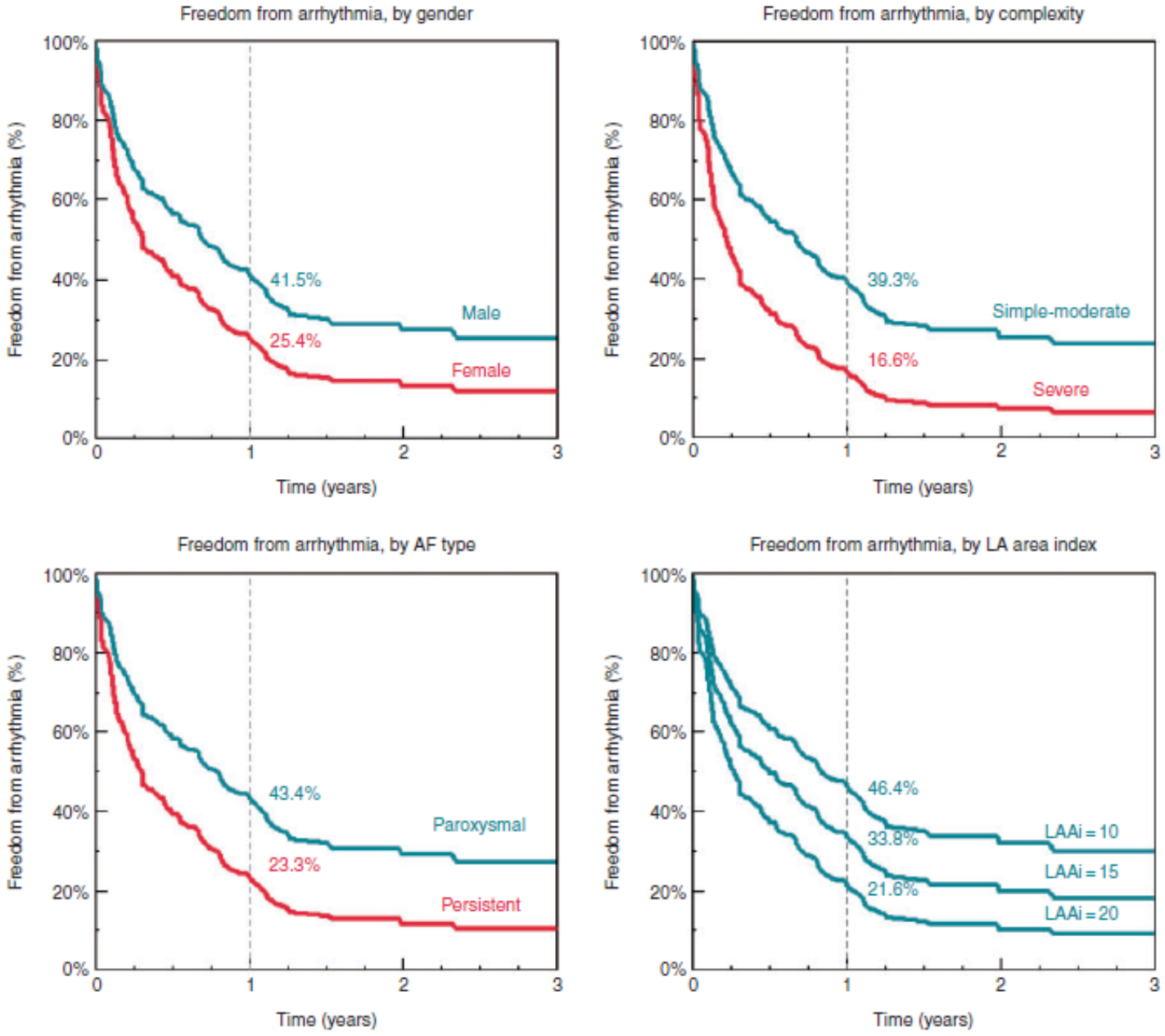

Figure 4 Adjusted survival curves for Cox model by parameters significant in the univariable model (gender, anatomy complexity, AF type, LA area index). AF, atrial fibrillation.

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Predictors of Recurrence after RFCA

Table 4 Multivariable analysis using a stepwise Cox proportional hazards model

	Multivariable analysis		
	HR	CI	*P*-value
Type (persistent)	1.87	1.22–2.89	0.004
Bethesda = 3	1.98	1.22–3.22	0.006
LA area index (cm^2/m^2)	1.06	1.01–1.12	0.03

CI, confidence interval; HR, hazard ratio; LA, left atrial.

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Safety and outcomes of catheter ablation for atrial fibrillation in adults with congenital heart disease: A multicenter registry study

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BACKGROUND An increasing number of adults with congenital heart disease (CHD) are undergoing catheter ablation for atrial fibrillation (AF). Data on ablation strategy and outcomes in CHD are limited. Rhythm control is often believed to be of greater importance among patients with complex CHD.

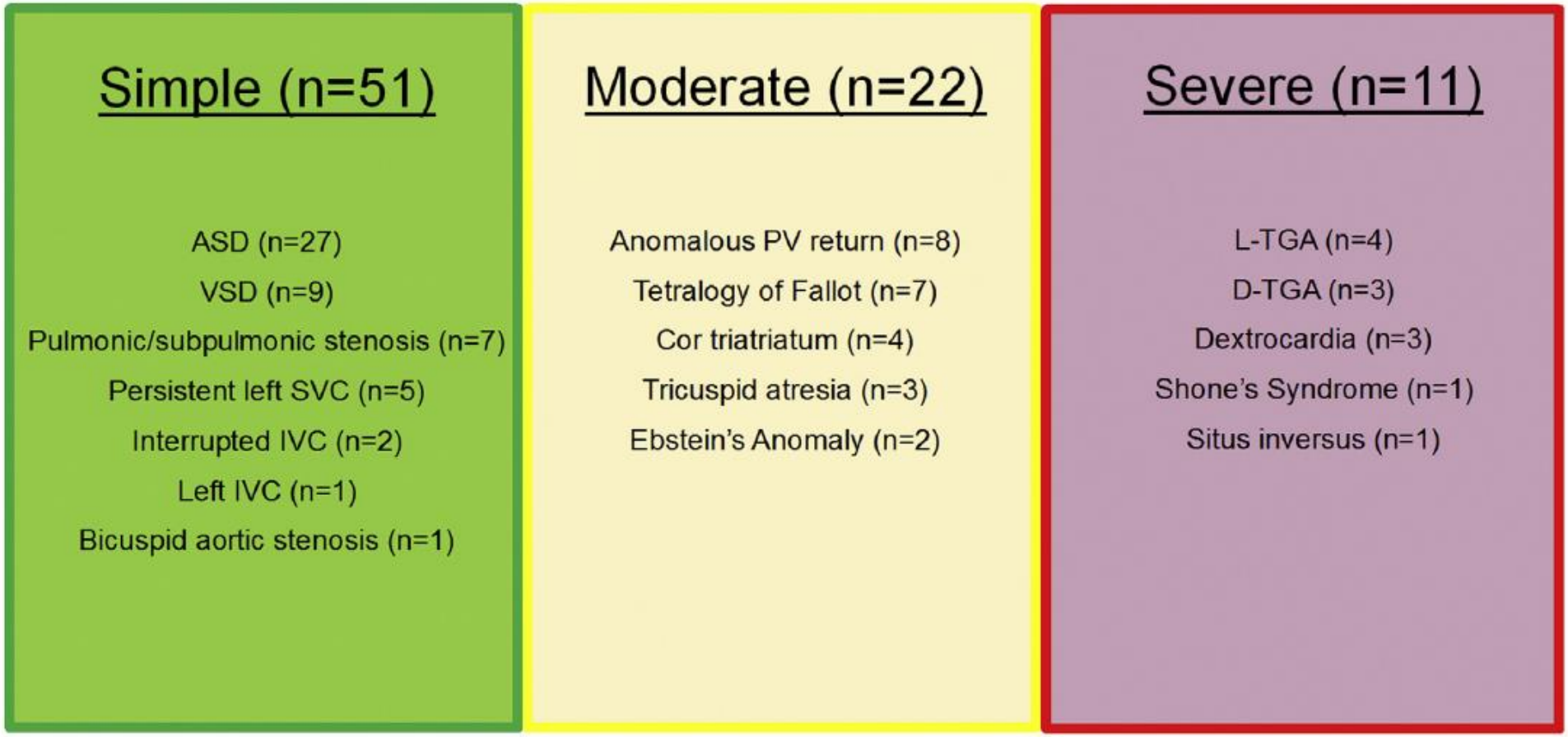
OBJECTIVE The purpose of this study was to examine the safety and efficacy of AF ablation in adult patients with CHD.

METHODS A multicenter retrospective analysis was performed of CHD patients undergoing AF ablation. Clinical data were collected, including AF and CHD type, procedural data, and outcomes. Patients were divided into 3 groups (simple, moderate, and severe) based on CHD complexity, as defined by the 2014 PACES/HRS (Pediatric and Congenital Electrophysiology Soci-

RESULTS Overall, 84 CHD patients (mean age 51.5 ± 12.1 years; 65.5% male; 45.2% with paroxysmal AF) undergoing AF ablation (51 simple, 22 moderate, 11 severe complexity) were included. Pulmonary vein isolation was performed in 80 (95.2%), of whom 30 (35.7%) underwent pulmonary vein isolation alone. Overall, complete and complete/partial freedom was achieved at 1 year in 53.1% and 71.6%, respectively, with no significant differences between those with simple, moderate, or severe complexity. There were no major complications and 7 minor complications, and 2 patients died during follow-up.

CONCLUSION There are dramatic differences in the degree of CHD complexity among patients referred for AF ablation. When performed at experienced centers, AF ablation is safe and effective even among patients with the most complex forms of CHD.

Population & Their CHD



**Patients with multiple CHD abnormalities were classified based on most complex abnormality*

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	Overall (N = 84)	Simple (n = 51)	Intermediate (n = 22)	Severe (n = 11)	*P* value
Total procedure time (min)	299.1 ± 111.5	275.9 ± 99.2	328.0 ± 122.8	342.8 ± 125.3	.07
Total fluoroscopy time (min)	51.3 ± 28.5	48.7 ± 27.1	49.6 ± 33.4	63.9 ± 23.5	.27
Ablation strategy					
Any RA ablation	40 (47.6)	22 (43.1)	14 (63.6)	4 (36.4)	.06
Any LA ablation	82 (97.6)	51 (100)	20 (90.9)	11 (100)	.06
PVI	80 (95.2)	49 (96.1)	20 (90.9)	11 (100)	.46
PVI alone	30 (35.7)	18 (35.3)	7 (31.8)	5 (45.5)	.74
CFAE (RA or LA)	16 (19.1)	9 (17.6)	6 (27.3)	1 (9.1)	.37
Roof line	20 (23.8)	12 (23.5)	5 (22.7)	3 (27.3)	.97
Mitral annular line (anterior or septal)	12 (14.3)	11 (23.9)	1 (4.5)	0 (0.0)	.05
Mitral annular line (lateral)	5 (6.0)	3 (6.5)	2 (9.1)	0 (0.0)	.55
CTI line	31 (36.9)	20 (41.7)	9 (40.9)	4 (36.4)	.93
RA atriotomy ablation	4 (4.8)	0 (0.0)	3 (13.6)	1 (9.1)	.02
Other RA flutter ablation	13 (15)	10 (19.6)	3 (13.6)	0 (0.0)	.26
Other LA flutter ablation	4 (4.8)	3 (5.8)	1 (4.5)	0 (0.0)	.71
Focal impulse or rotor ablation	3 (3.6)	2 (7.8)	1 (4.5)	0 (0.0)	.72
Non-PV triggers (RA or LA)	38 (45.2)	24 (47.1)	11 (50.0)	3 (27.3)	.43
Non-PV trigger sites					
Crista terminalis or eustachian ridge	8 (9.5)	4 (7.8)	3 (13.6)	1 (9.1)	.74
SVC (including persistent left SVC)	14 (16.7)	8 (15.7)	5 (22.7)	1 (9.1)	.53
Coronary sinus	7 (8.3)	4 (7.8)	1 (4.5)	2 (18.2)	.46
LA roof	8 (9.5)	6 (11.8)	2 (9.1)	0 (0.0)	.47
Anterior LA	10 (11.9)	10 (19.6)	0 (0.0)	0 (0.0)	.02
LA septum	7 (8.3)	5 (9.8)	1 (4.5)	1 (9.1)	.74
LA appendage	3 (3.6)	2 (3.9)	1 (4.5)	0 (0.0)	.92
Complications					
Major	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	—
Minor	7 (8.3)	1 (2.0)	4 (18.2)	2 (18.2)	.05
Outcomes					
1-year complete freedom	43 (53.1)	27 (54.0)	12 (57.1)	4 (40.0)	.66
1-year complete or partial freedom	58/81 (71.6)	35 (70.0)	17 (81.0)	6/10 (60.0)	.44

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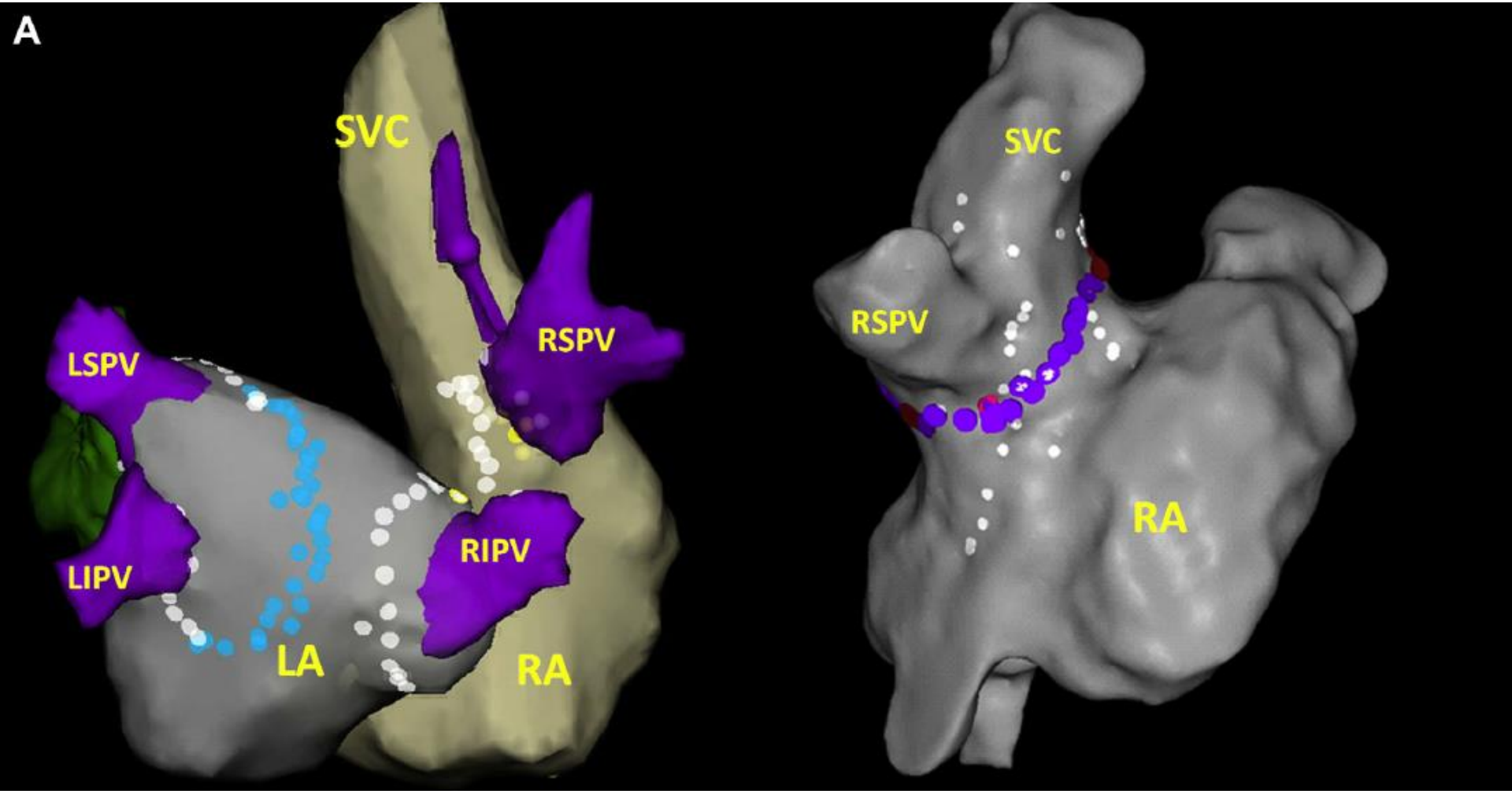
Example: RFCA for AF in PAPVR



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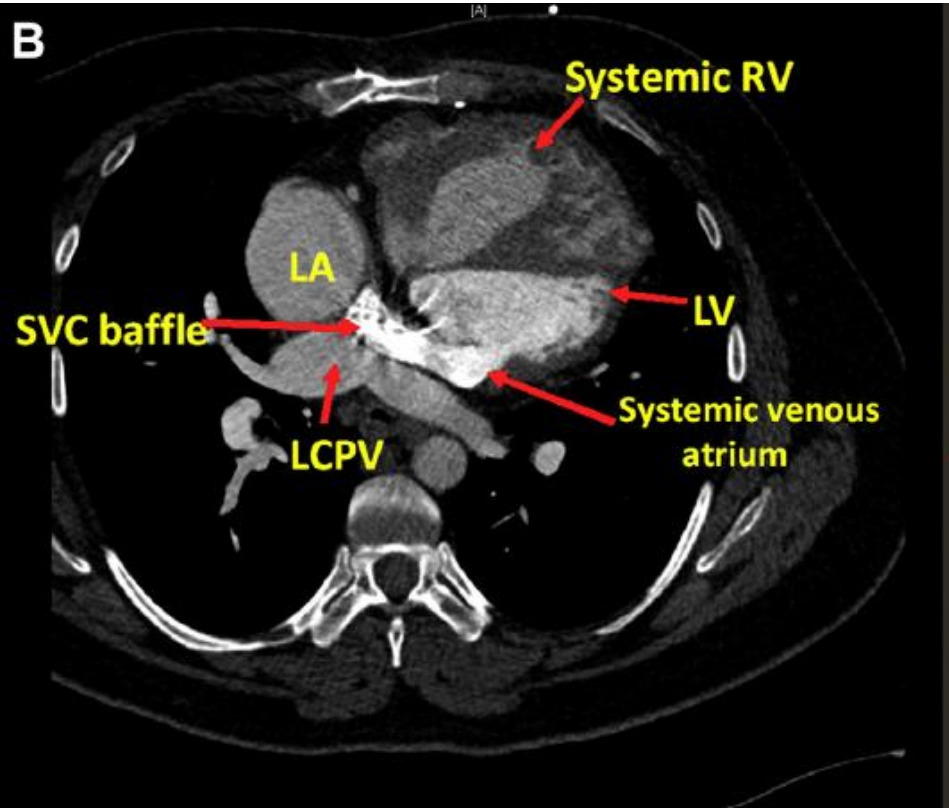
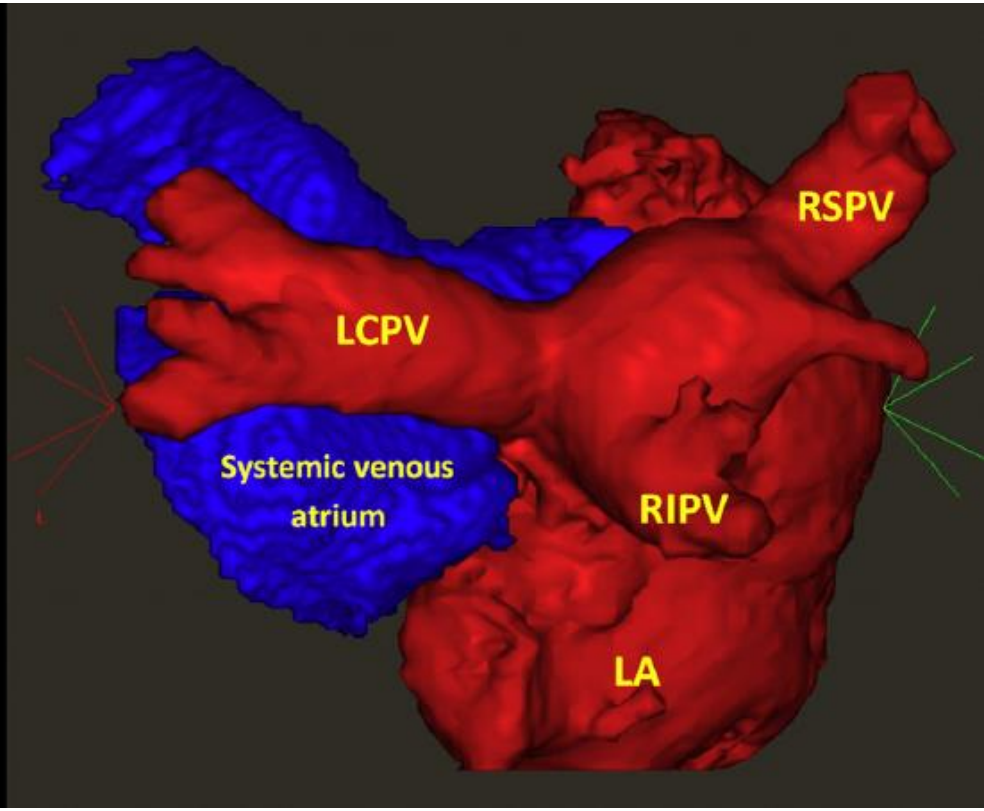
Example: RFCA for AF in Mustard for TGA





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Circulation: Arrhythmia and Electrophysiology

ORIGINAL ARTICLE

Catheter Ablation for Atrial Fibrillation in Adult Congenital Heart Disease: An International Multicenter Registry Study

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BACKGROUND: Data on atrial fibrillation (AF) ablation and outcomes are limited in patients with congenital heart disease (CHD). We aimed to investigate the characteristics of patients with CHD presenting for AF ablation and their outcomes.

METHODS: A multicenter, retrospective analysis was performed of patients with CHD undergoing AF ablation between 2004 and 2020 at 13 participating centers. The severity of CHD was classified using 2014 Pediatric and Congenital Electrophysiology Society/Heart Rhythm Society guidelines. Clinical data were collected. One-year complete procedural success was defined as freedom from atrial tachycardia or AF in the absence of antiarrhythmic drugs or including previously failed antiarrhythmic drugs (partial success).

RESULTS: Of 240 patients, 127 (53.4%) had persistent AF, 62.5% were male, and mean age was 55.2±13.3 years. CHD complexity categories included 147 (61.3%) simple, 68 (28.3%) intermediate, and 25 (10.4%) severe. The most common CHD type was atrial septal defect (n=78). More complex CHD conditions included transposition of the great arteries (n=14), anomalous pulmonary veins (n=13), tetralogy of Fallot (n=8), cor triatriatum (n=7), single ventricle physiology (n=2), among others. The majority (71.3%) of patients had trialed at least one antiarrhythmic drug. Forty-six patients (22.1%) had reduced systemic ventricular ejection fraction <50%, and mean left atrial diameter was 44.1±8.2 mm. Pulmonary vein isolation was performed in 227 patients (94.6%);

AF Ablation in ACHD; International Registry

Simple complexity (n=147)	Moderate complexity (n=68)	Severe complexity (n=25)
ASD (n=78) Bicuspid AV (n=45) VSD (n=11) Persistent left SVC (n=9) Isolated IVC abnormalities (n=4) Situs inversus (n=3) Isolated dextrocardia (n=2) Isolated MV disease (n=1) Isolated AV disease (n=1)	Anomalous PV (n=13) PV stenosis (n=13) Coarctation of the aorta (n=9) Ebstein anomaly (n=8) Tetralogy of Fallot (n=8) AVSD (n=7) Cor triatriatum (n=7) Subaortic stenosis (n=6) Cleft mitral valve (n=1)	Transposition of great arteries (n=7) ccTGA (n=7) Tricuspid atresia (n=6) Heterotaxy Syndrome (n=3) Single ventricle (n=2) Double ventricle (n=2) Crisscross heart (n=1) Truncus arteriosus (n=1) PVOD (n=1) Shone syndrome (n=1)
1 year complete freedom = 45.0% **1 year partial freedom = 22.1%**	**1 year complete freedom = 41.5%** **1 year partial freedom = 20.0%**	**1 year complete freedom = 54.2%** **1 year partial freedom = 12.5%**

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AF Ablation in ACHD; International Registry

Parameter	Overall (N=240)	Simple (n=147)	Intermediate (n=68)	Severe (n=25)	*P* value
Total procedure time, min [n]*	262.23±104.61 [182]	246.86±98.03 [101]	274.37±104.75 [60]	301.48±124.01 [21]	0.050
Total fluoroscopy time, min [n]*	37.86±28.25 [139]	36.88±27.11 [78]	36.83±30.41 [48]	47.54±47.54 [13]	0.434
Ablation strategy					
Any RA ablation, n (%)	80 (33.33)	46 (31.29)	28 (41.18)	6 (24.00)	0.213
Any LA ablation, n (%)	157 (65.42)	102 (69.39)	44 (64.71)	11 (44.0)	0.051
CFAE, n (%)	46 (19.17)	20 (13.61)	16 (23.53)	10 (40.00)	0.005†
Ganglionated plexus, n (%)	1 (0.42)	0 (0.00)	1 (1.47)	0 (0.00)	0.388
Roofline, n (%)	61 (25.42)	40 (27.21)	16 (23.53)	5 (20.00)	0.717
MAL (anterior or septal), n (%)	14 (5.83)	11 (7.48)	3 (4.41)	0 (0.00)	0.379
MAL (lateral), n (%)	21 (8.75)	14 (9.52)	6 (8.82)	1 (4.00)	0.835
CTI line, n (%)	98 (40.83)	58 (39.46)	29 (42.65)	11 (44.00)	0.835
RA atriotomy ablation, n (%)	10 (4.17)	4 (2.72)	4 (5.88)	2 (8.00)	0.177
Other RA flutter ablation, n (%)	25 (10.42)	19 (12.93)	5 (7.35)	1 (4.00)	0.329
Other LA flutter ablation, n (%)	21 (8.75)	17 (11.56)	4 (5.88)	0 (0.00)	0.117
Rotor ablation, n (%)	4 (1.67)	3 (2.04)	1 (1.47)	0 (0.00)	1.000
Focal impulse ablation, n (%)	5 (2.08)	3 (2.04)	2 (2.94)	0 (0.00)	0.800
PVI,‡ n (%)	227 (94.58)	141 (95.92)	64 (94.12)	22 (88.00)	0.227
PVI alone, n (%)	78 (32.50)	50 (34.01)	19 (27.94)	9 (36.00)	0.615
Complete PVI ablations, n (%) [n]*	152 (87.36) [174]	105 (90.52) [116]	39 (81.25) [49]	8 (80.00) [10]	0.139
Isolated PV, n (%) [n]*	3.72±0.81 [174]	3.78±0.77 [116]	3.67±0.78 [48]	3.40±1.35 [10]	0.320

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AF Ablation in ACHD; International Registry

Parameter	Overall (N=240)	Simple (n=147)	Intermediate (n=68)	Severe (n=25)	*P* value
Complications					
Any complication, n (%)	16 (6.67)	5 (3.40)	8 (11.76)	3 (12.00)	0.027*
Death, n (%)	0 (0.00)	0 (0.00)	0 (0.00)	1 (4.00)	<0.001*
Sedation-related, n (%)	2 (0.83)	0 (0.00)	2 (2.94)	0 (0.00)	0.149
Local hematoma, n (%)†	4 (1.67)	1 (0.68)	2 (2.94)	1 (4.00)	0.187
Hemorrhage, n (%)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	1.000
Infection, n (%)	1 (0.42)	1 (0.68)	0 (0.00)	0 (0.00)	1.000
Pericardial effusion, n (%)	2 (0.83)	0 (0.00)	2 (2.94)	0 (0.00)	0.149
Tamponade, n (%)	1 (0.41)	1 (0.68)	0 (0.00)	0 (0.00)	1.000
TIA, n (%)	1 (0.42)	1 (0.68)	0 (0.00)	0 (0.00)	1.000
Bradycardia or hemodynamic instability, n (%)	2 (0.83)	2 (1.36)	0 (0.00)	0 (0.00)	1.000
Phrenic nerve injury,‡ n (%)	2 (0.83)	1 (0.68)	1 (1.47)	0 (0.00)	0.626
Esophageal bleeding, n (%)	1 (0.42)	0 (0.00)	0 (0.00)	1 (4.00)	0.104
Other, n (%)	4 (1.67)	0 (0.00)	3 (4.41)	1 (4.00)	0.024*

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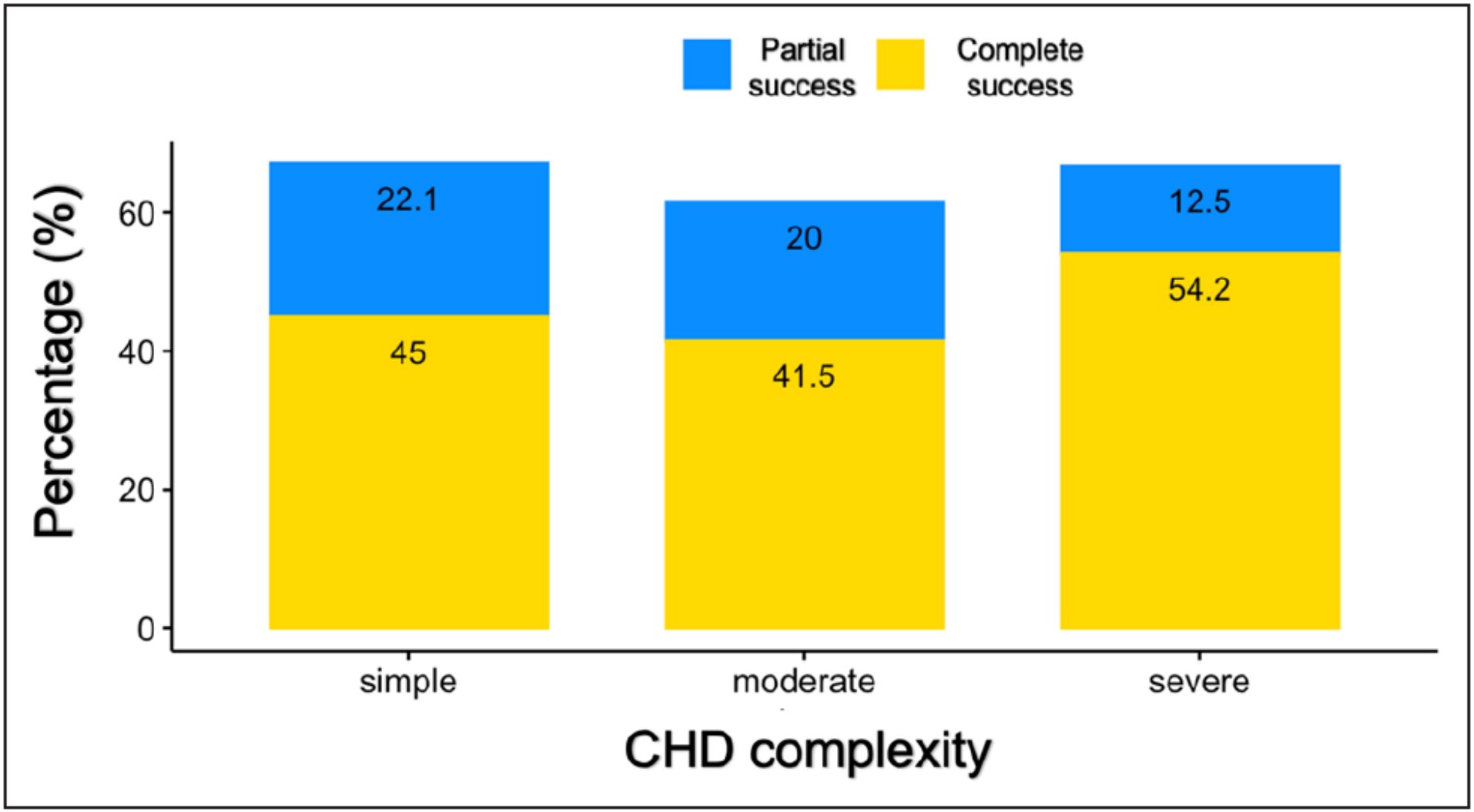
AF Ablation in ACHD; 1-year Success Rate



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ORIGINAL ARTICLES

WILEY

Pulmonary vein and left atrial posterior wall isolation for the treatment of atrial fibrillation: Comparable outcomes for adults with congenital heart disease

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Abstract

Introduction: Optimal treatment strategies for ACHD with AF are unknown. This study sought to assess outcomes of pulmonary vein isolation (PVI) ± left atrial (LA), posterior wall isolation (PWI) for adults with congenital heart disease (ACHD), and atrial fibrillation (AF).

Methods: A retrospective review of all cryoballoon (CB) PVI ± PWI procedures at a single center over a 3-year period were performed. Clinical characteristics and outcomes for patients with and without ACHD were compared. The primary outcome was the occurrence of atrial tachyarrhythmia at 12-months postablation after a 90-day blanking period.

Results: Three-hundred and sixteen patients (mean: 63 ± 12 years, [63% male])

TABLE 2 ACHD procedural characteristics

Characteristic	ACHD (*n* = 31)
Pulmonary vein cryoablation parameters	
Left superior	
Number of applications	3.5 ± 2.5
Total duration, s	471 ± 236
Minimum balloon temp, c	−46 ± 7
Left inferior	
Number of applications	3.0 ± 1.2
Total duration, s	405 ± 165
Minimum balloon temp, c	−42 ± 7
Right inferior	
Number of applications	2.7 ± 1.2
Total duration,	378 ± 174
Minimum balloon temp, c	−41 ± 7
Right superior	
Number of applications	2.3 ± 1.1
Total duration, s	314 ± 121
Minimum balloon temp, c	−42 ± 6
Posterior wall isolation	20 (65)
Radiofrequency energy utilized	23 (74)
Additional target(s)	
Cavotricuspid isthmus	6
Right atrial atypical flutter	2
Perimitral flutter	2
Roof dependent flutter	2
Fluoroscopy duration, min	33 ± 18
Procedure duration, min	278 ± 115
Complications	2 (6)
Oropharyngeal bleeding	1
Prolonged fluoroscopy	1

JP Moore, et al. J Cardiovasc Electrophysiol 2021;32:1868-76

Example: PV & Post Wall Isolation in AVSD

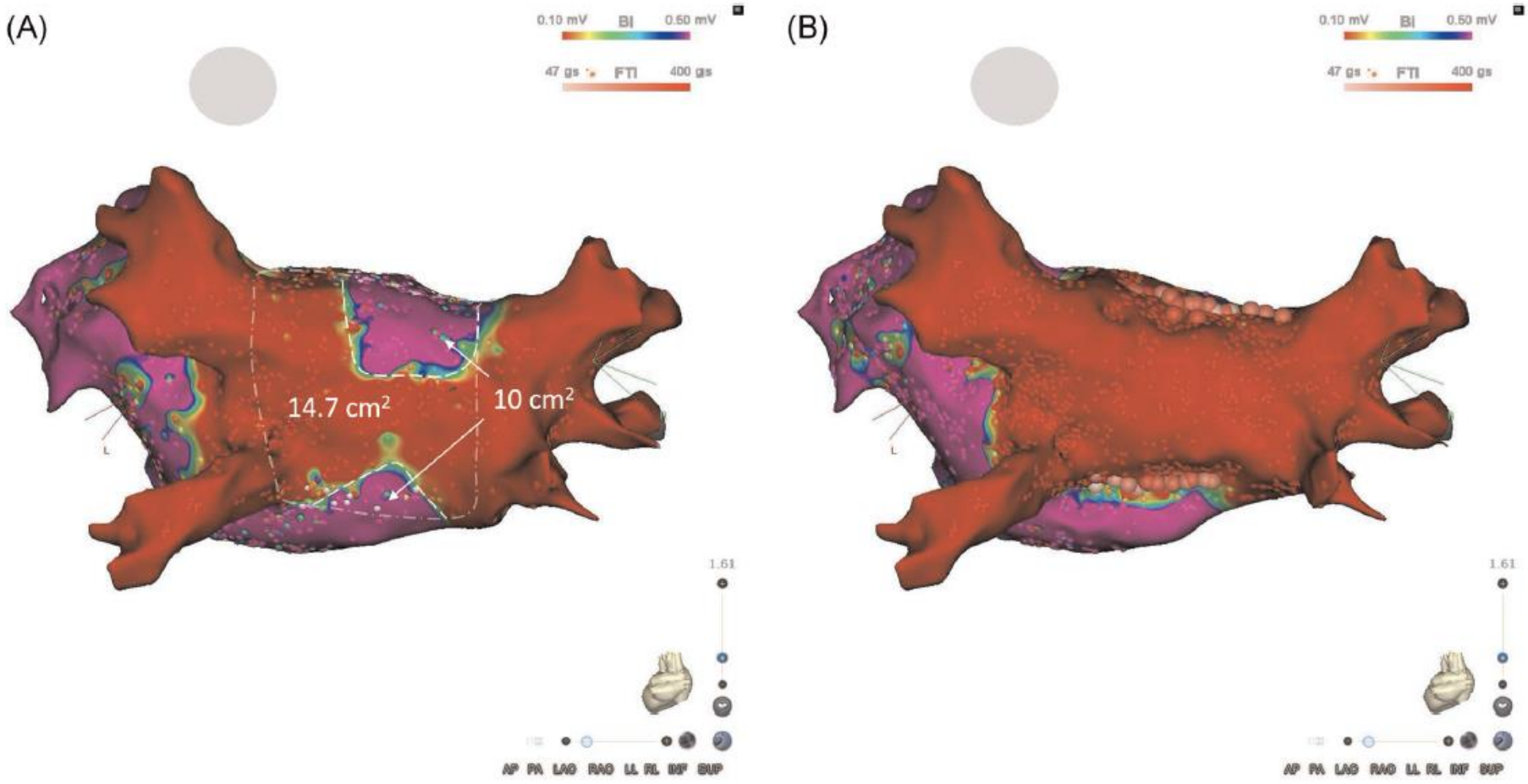

FIGURE 1 Example of voltage mapping during left atrial posterior wall catheter ablation in a 30-year-old female with repaired atrioventricular canal defect and persistent atrial fibrillation. In Panel (A) after CB application has been delivered to the pulmonary veins and posterior wall, repeat electro-anatomical mapping (scar voltage ≤ 0.1 mV) demonstrates CB ablation of most (%PWI = 60, 14.7 cm^2) of the posterior left atrial wall myocardium. In Panel (B) irrigated radiofrequency energy has been used to achieve complete electrical isolation of the left atrial posterior wall. CB, cryoballoon; PWI, posterior wall isolation

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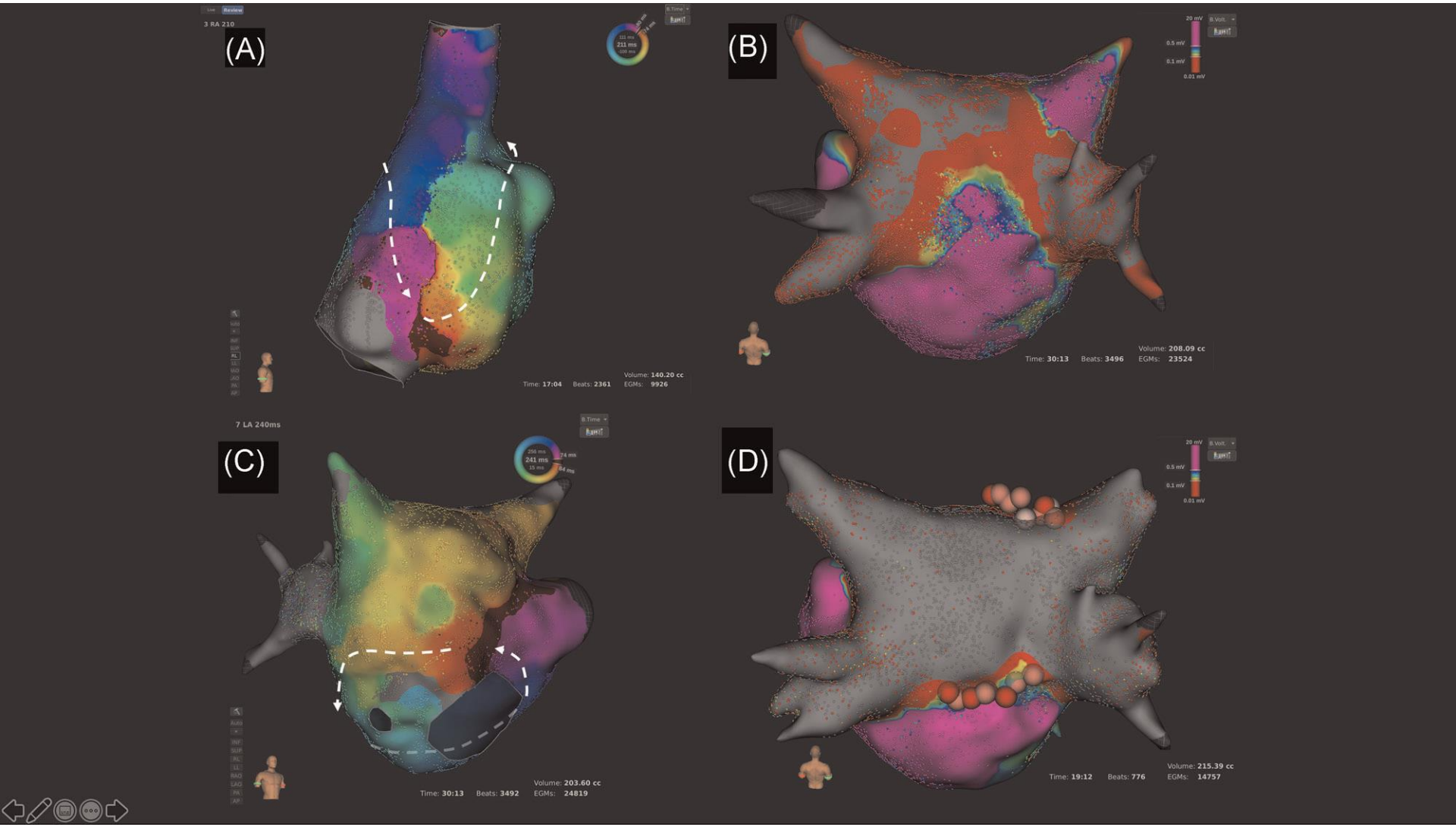
Example: PV & Post Wall Isolation in AVSD



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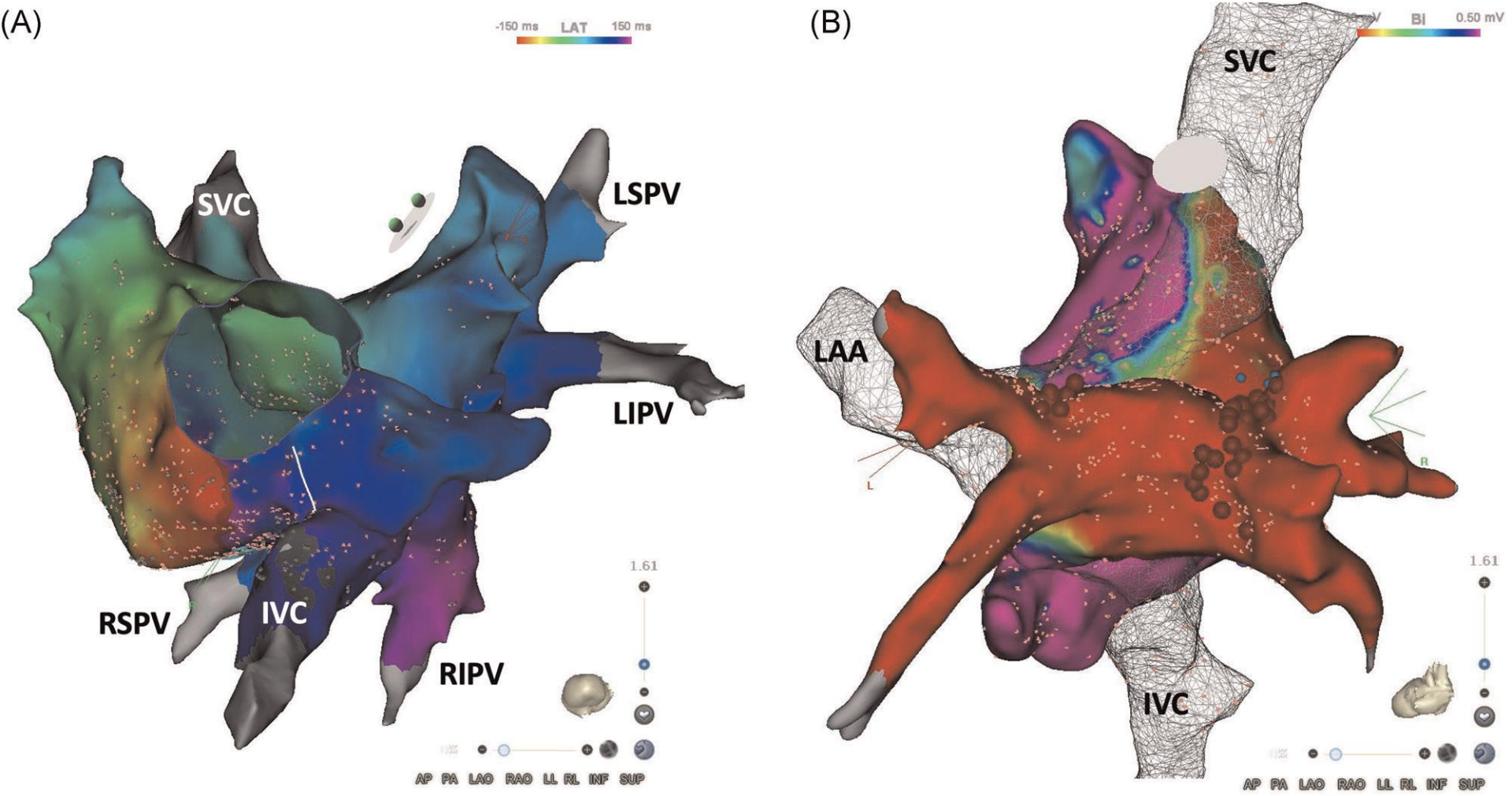
Example: PV & Post Wall Isolation in Mustard Operation for TGA



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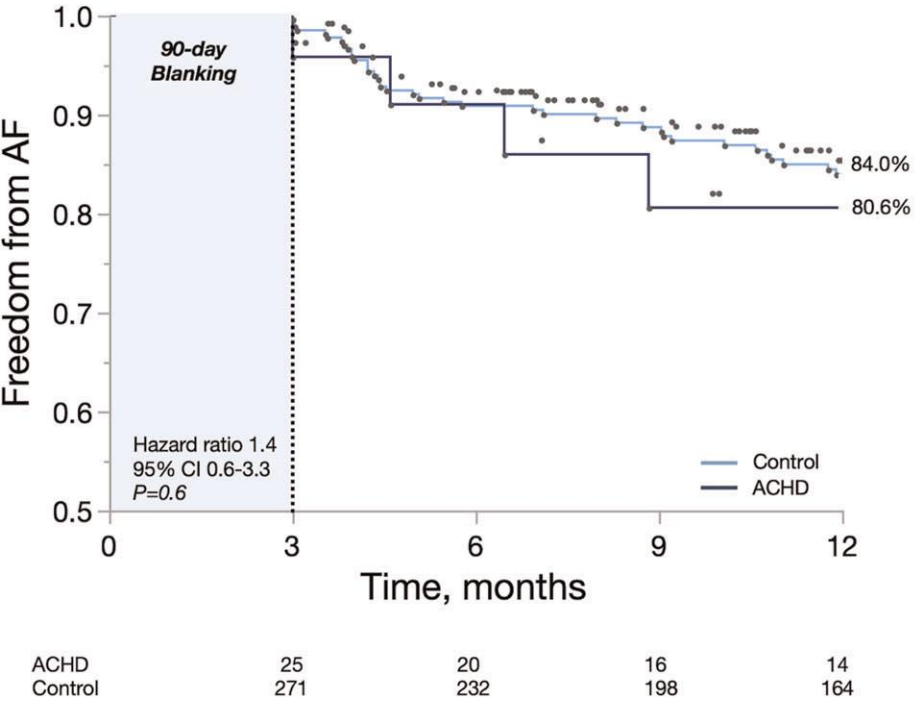
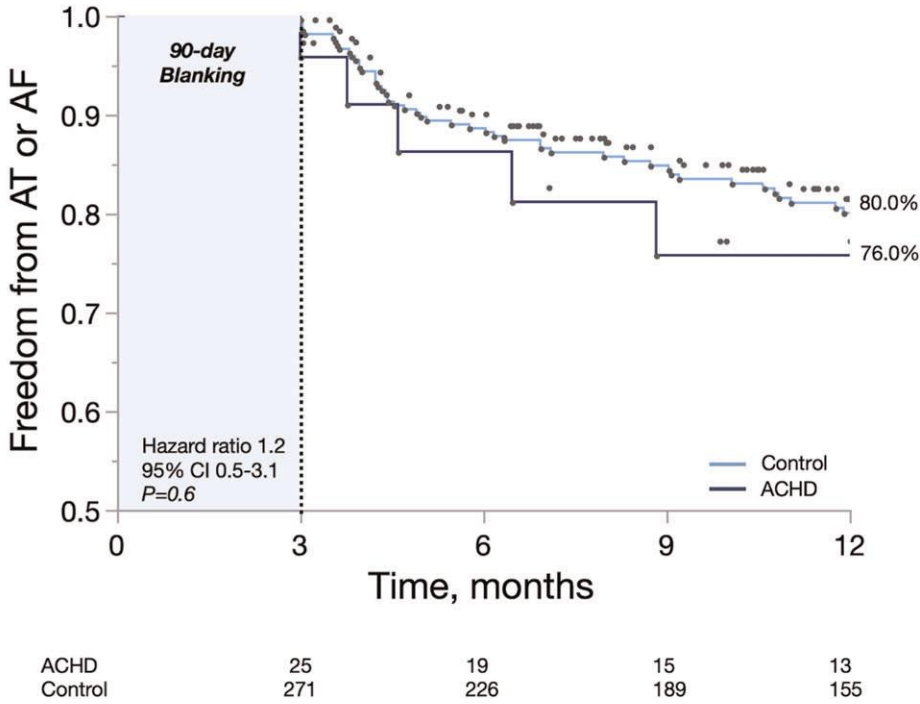
Recurrence after PV & Post Wall Isolation





Outcomes of cryoballoon PVI & post wall isolation is comparable in patients with CHD compared to patients without CHD.

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Catheter ablation of atrial fibrillation using 2nd-generation cryoballoon in congenital heart disease patients — significance of RF ablation of additional atrial macro-reentrant tachycardia

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Abstract

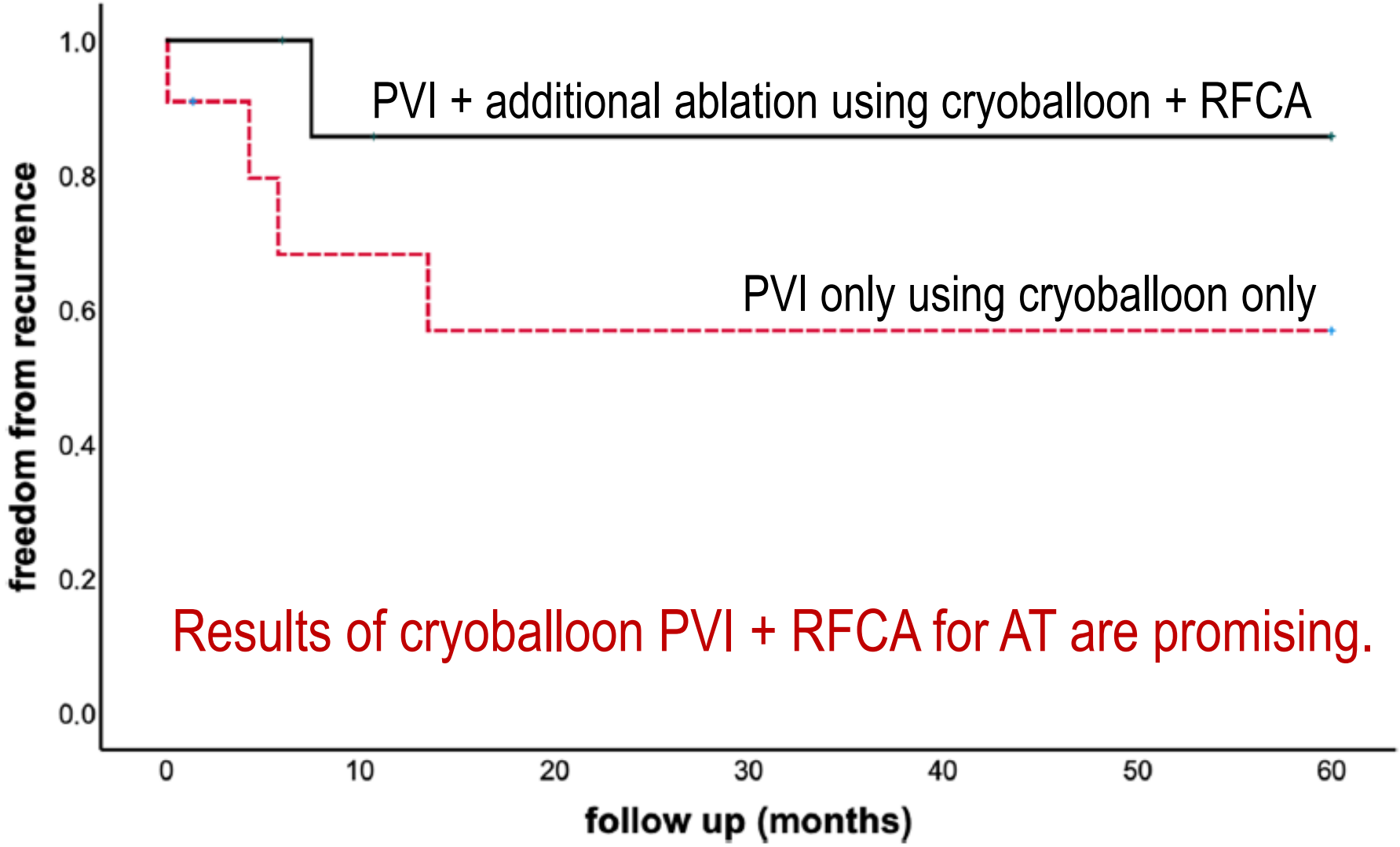
Background Prevalence of atrial fibrillation (AF) is increasing in adult patients with congenital heart disease (CHD). Experience using the cryoballoon to achieve pulmonary vein isolation (PVI) in adult CHD patients is limited. The aim of the present study was to assess the value of PVI by cryoballoon in adult CHD patients and to evaluate the significance of additional radiofrequency (RF) ablation of atrial tachycardia (AT).

Patients and methods Prospective data analysis; all patients with CHD and AF and PVI using the cryoballoon from January 2017 through November 2021 were included.

Results Nineteen patients with various types of CHD were included. Median age was 58 (IQR 47–63) years. A total of 12/19 (63%) patients had had RF ablation of right atrial AT before. Median procedure duration was 225 (IQR 196–261) min. Median fluoroscopy time was 12.3 (IQR 5.2–19.5) min and median freeze time was 32 (IQR 28–36.3) min. Procedural success was achieved in all patients. Additional RF catheter ablation of intraatrial reentrant tachycardia within the left atrium was performed in 3/19 (16%) subjects and within the right atrium in 6/19 (32%) patients. Median follow-up was 26 (IQR 9–49) months. Excluding a 90-day blanking period, recurrence of AF was observed in 6/19 subjects (32%). After one redo procedure deploying RF energy only, 84% of all patients remained free from recurrence. Phrenic nerve palsy was observed in 1 subject.

Conclusion Results after PVI using the cryoballoon plus additional RF ablation of AT were promising (84% success including one redo procedure). Success of AF ablation was unsatisfactory in all patients who had no additional AT ablation. Ablation of any AT in these patients should therefore be considered in addition to PVI.

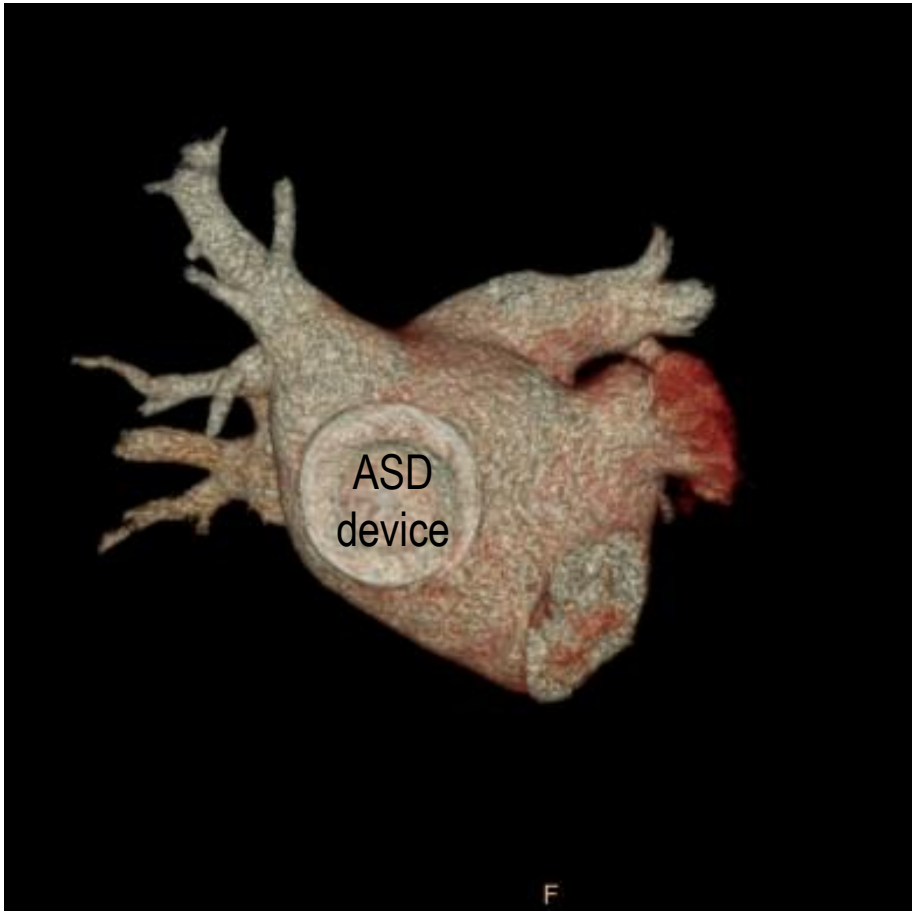
PVI only using Cryoballoon *vs* PVI + Additional Ablation using RFCA

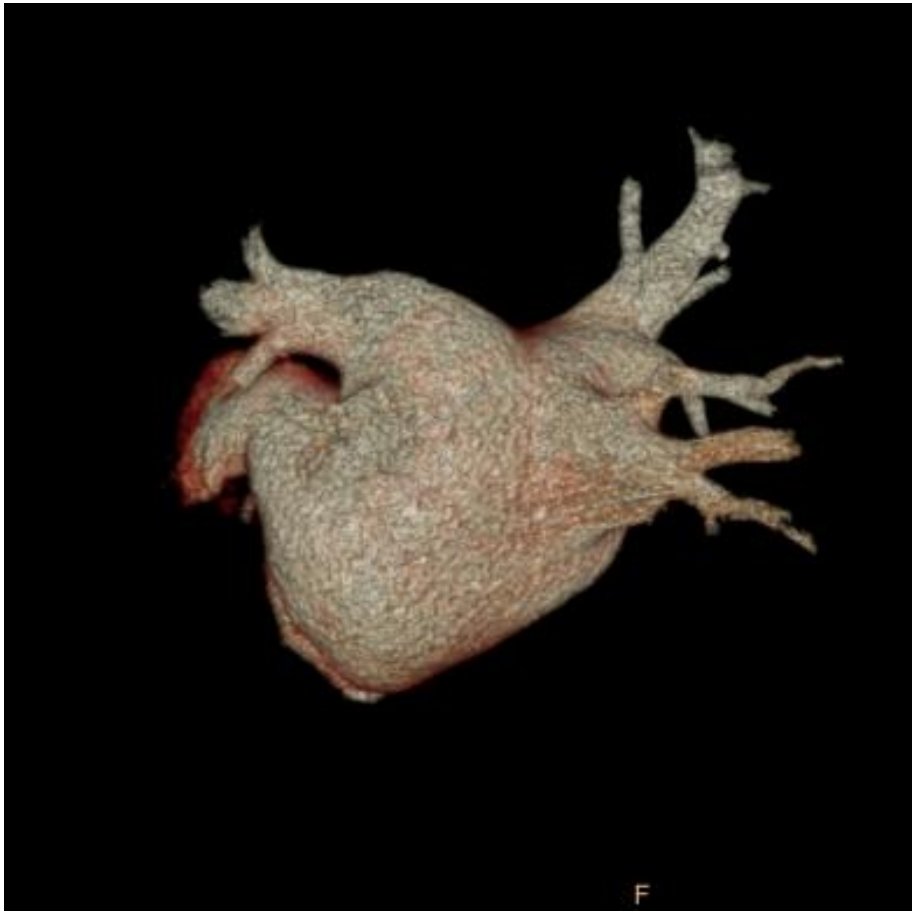


Results of cryoballoon PVI + RFCA for AT are promising.

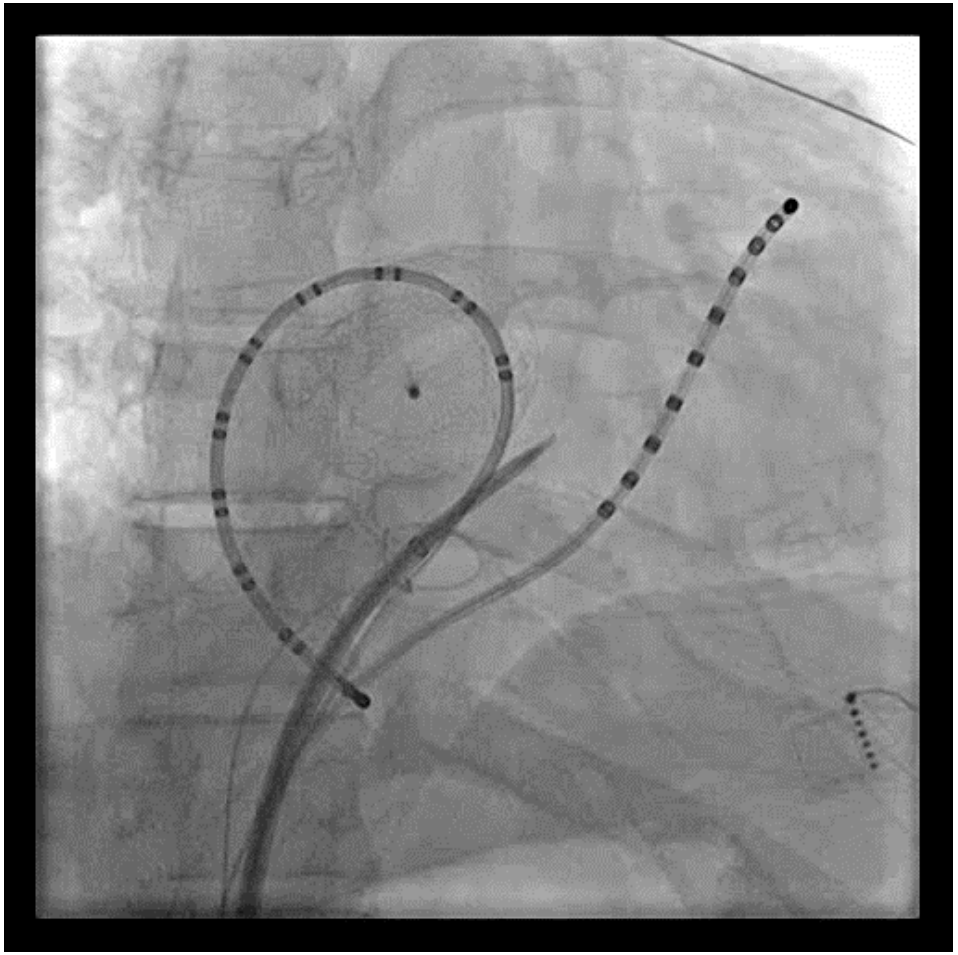
U Krause, et al. J Interv Cardiac Electrophysiol 2022;64:411-7

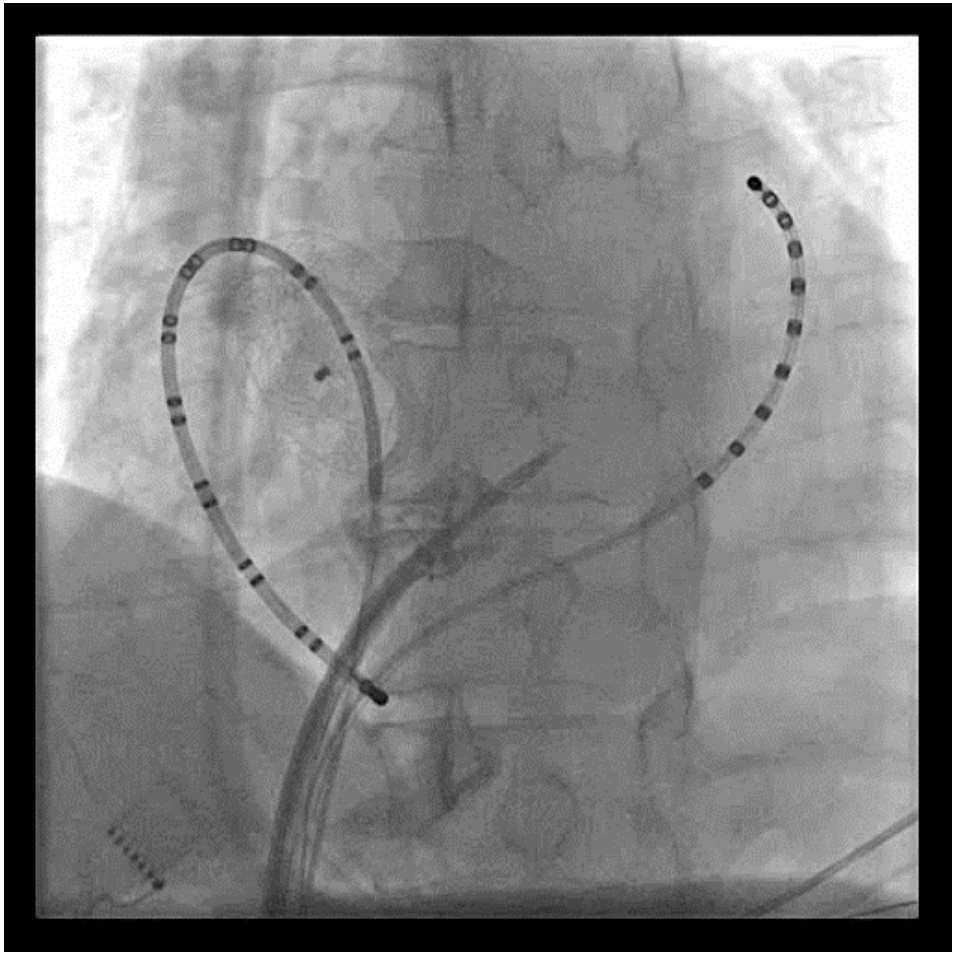
RFCA for AF after ASD Device Closure



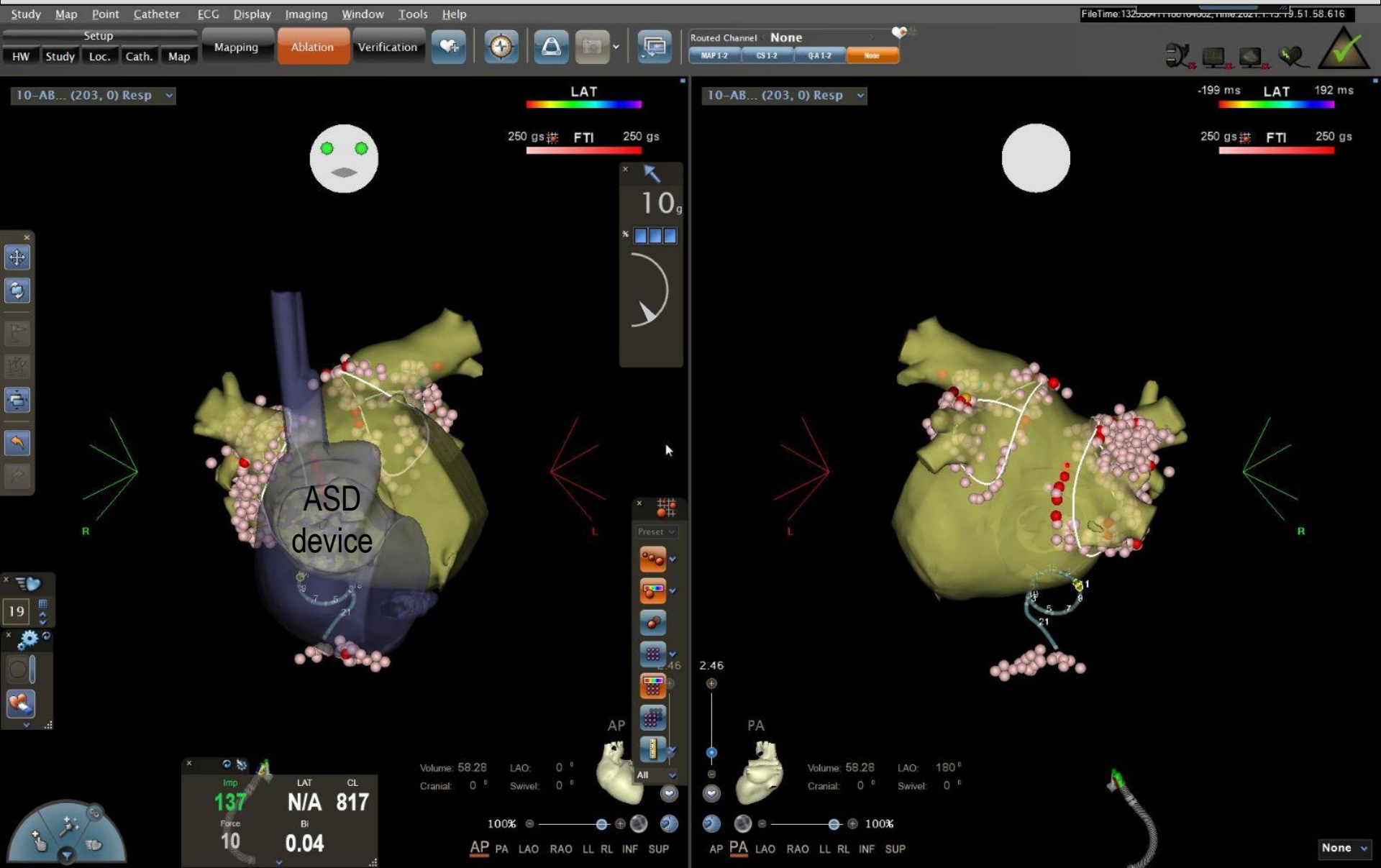


RFCA for AF after ASD Device Closure

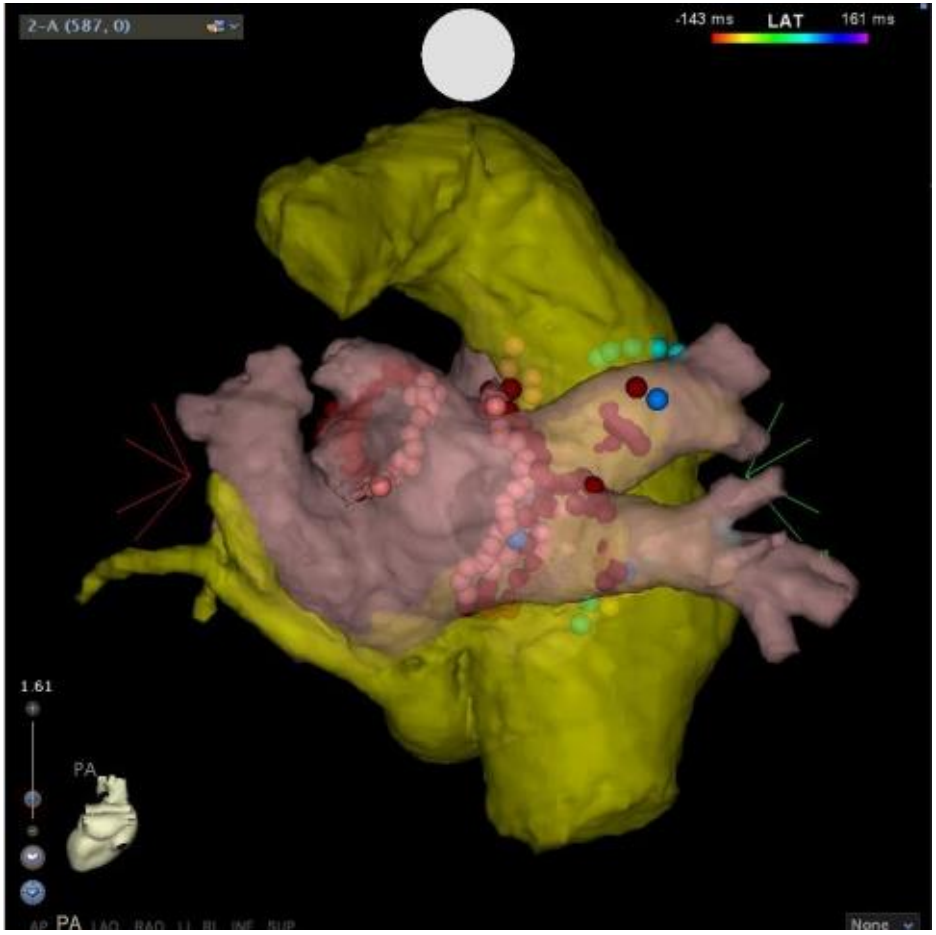




RFCA for AF after ASD Device Closure



RFCA for AF in Lateral Tunnel Fontan



AF recurrence → Conversion to extracardiac conduit Fontan

Pacing Clin Electrophysiol 2018;42:113-6

Summary

- Data on efficacy and safety of AF ablation in complex CHD are not sufficient. Only retrospective data are available.
- Pulmonary vein isolation is the cornerstone of AF ablation in adults with CHD, but is not sufficient.
- Patients with CHD may have more triggers from the right atrium than patients without CHD.
- Cryoballoon only may not be satisfactory in adults with complex CHD.
- LA posterior wall isolation may be effective in adults with CHD.

Thank you

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