

Surgical Approach to Reducing the Atrial Arrhythmia Burden

Kirsten Finucane

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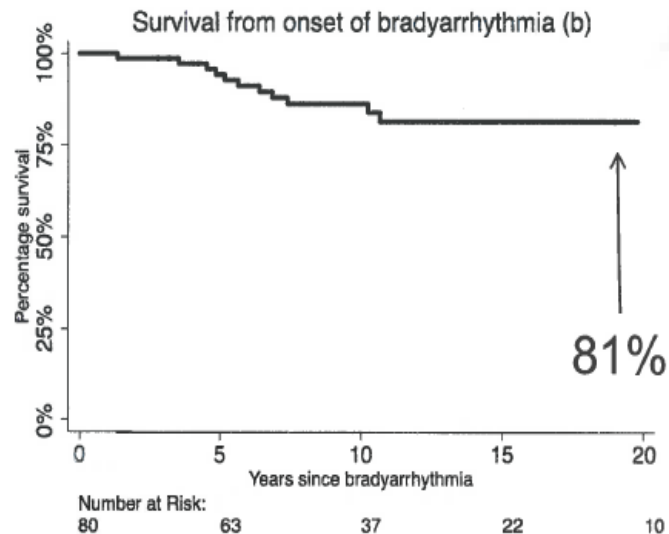
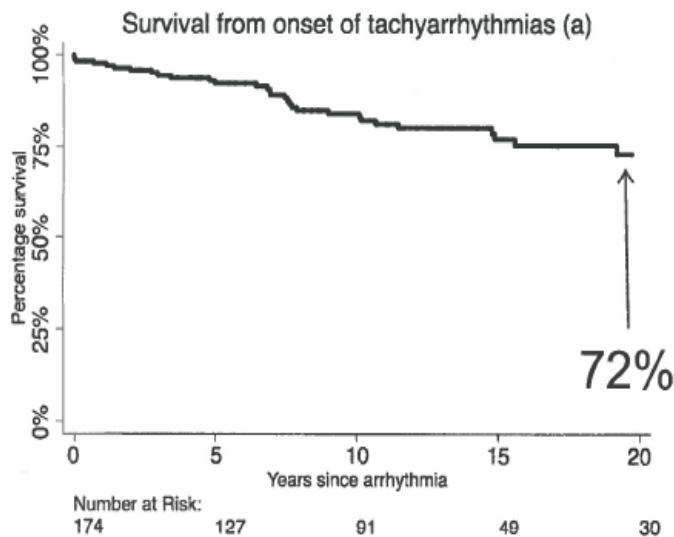
Jamie Rance

Introduction

- Onset of arrhythmias important in CHD
- Arrhythmias reduce output, cause ventricular dysfunction
- Anti-arrhythmics cause bradycardias/ negative inotropic effect
- Thrombotic events & bleeding complications cause morbidity in ACHD pts

Redefining Expectations of Long-term Survival after the Fontan Procedure. Circulation 2014;130: S32-S38

Survival after onset of arrhythmia



Total cavopulmonary conversion and maze procedure for patients with failure of the Fontan operation

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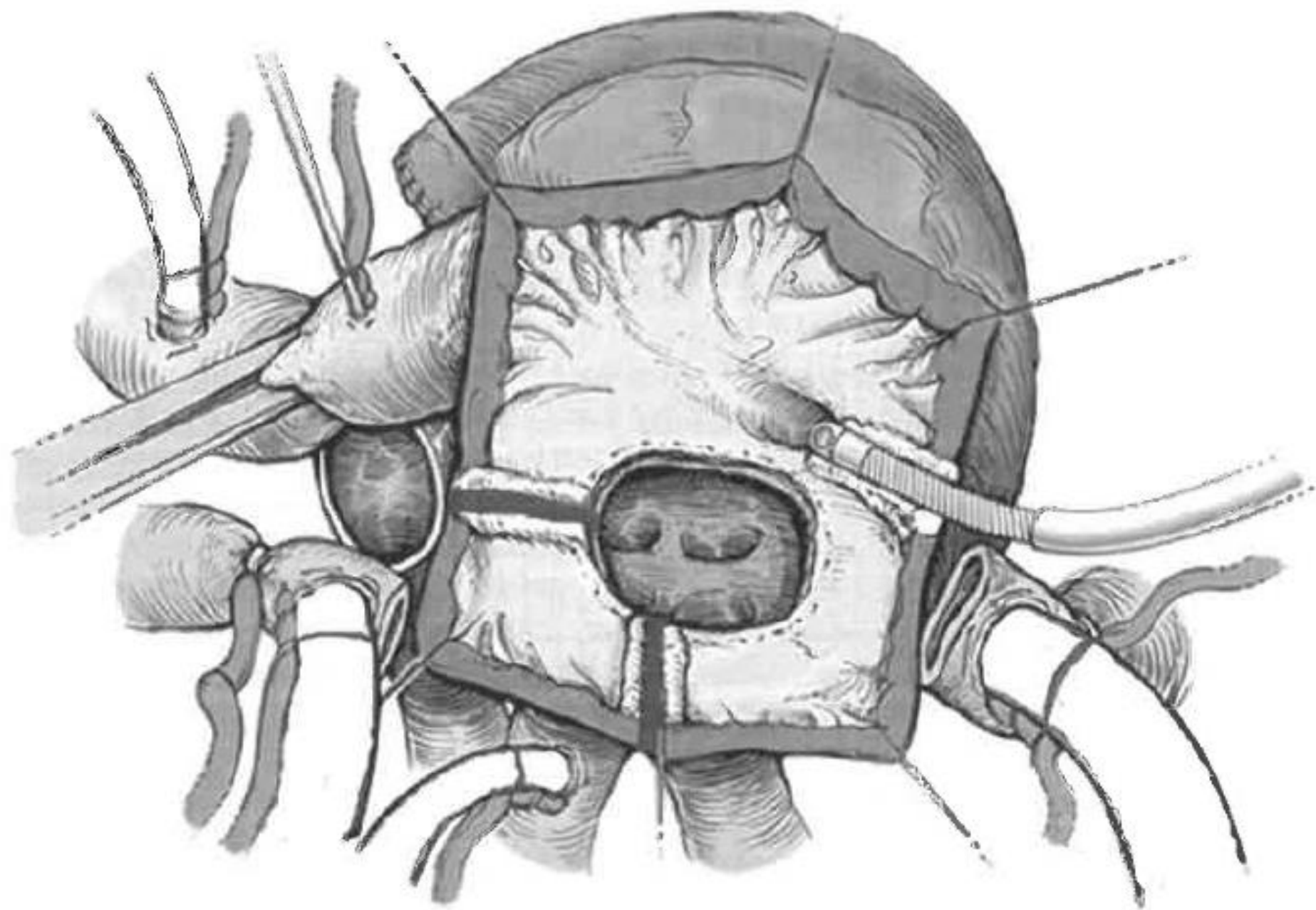
Janette Strasburger, MD



Drs Mavroudis, Deal, and Backer (left to right)

Objectives: Hemodynamic abnormalities and refractory atrial arrhythmias in patients late after the Fontan operation result in significant morbidity and mortality. We review our experience with conversion to total cavopulmonary artery connections and arrhythmia surgery.

Methods: Between 1994 and 2001, 40 patients underwent Fontan conversion and arrhythmia surgery. Significant hemodynamic lesions such as aortic aneurysm ($n = 1$), atrioventricular valve insufficiency ($n = 8$), and pulmonary arterioplasty ($n = 9$) were repaired concomitantly. Thirty-four patients were in New York Heart Association class III or IV. Mean age at the original Fontan operation was 7.5 ± 6.5 years and mean age at Fontan conversion was 18.7 ± 9.0 years. Arrhythmia surgery has evolved from isthmus cryoablation in 10 patients to right-sided maze in 16 patients for atrial reentry tachycardia. The maze-Cox III operation was used for 14 patients with atrial fibrillation. Atrial ($n = 33$) and dual-chamber ($n = 5$) pacemakers were placed.





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111 Fontan Conversions with Arrhythmia Surgery: Surgical Lessons and Outcomes

Constantine Mavroudis, MD, Barbara J. Deal, MD, Carl L. Backer, MD, Robert D. Stewart, MD, MPH, Wayne H. Franklin, MD, Sabrina Tsao, MD, Kendra M. Ward, MD, and R. Andrew DeFreitas, MD

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Background. The evolving operative strategy and course of 111 consecutive Fontan conversions with arrhythmia surgery and pacemaker therapy were reviewed to identify risk factors for poor outcome.

Methods. Since 1994, 111 patients (mean age 22.5 ± 7.9 years) underwent Fontan conversion with arrhythmia surgery. The series was divided into three time periods: (1) 1994 to 1996 (initial isthmus ablation, $n = 9$, group I); (2) 1996 to 2003 (early modified right atrial maze and Cox-maze III, $n = 51$, group II); and (3) 2003 to 2006 (recent modifications of the modified right atrial maze and left atrial Cox-maze III for both atrial fibrillation and left atrial reentry tachycardia, $n = 51$, group III).

Results. There were one early (0.9%) and six late deaths (5.4%); six patients required cardiac transplantation (5.4%). Two late deaths occurred after transplantation. Renal failure requiring dialysis occurred in four patients (3.6%). Mean hospital stay was 13.7 ± 12.1 days. Mean cross-clamp

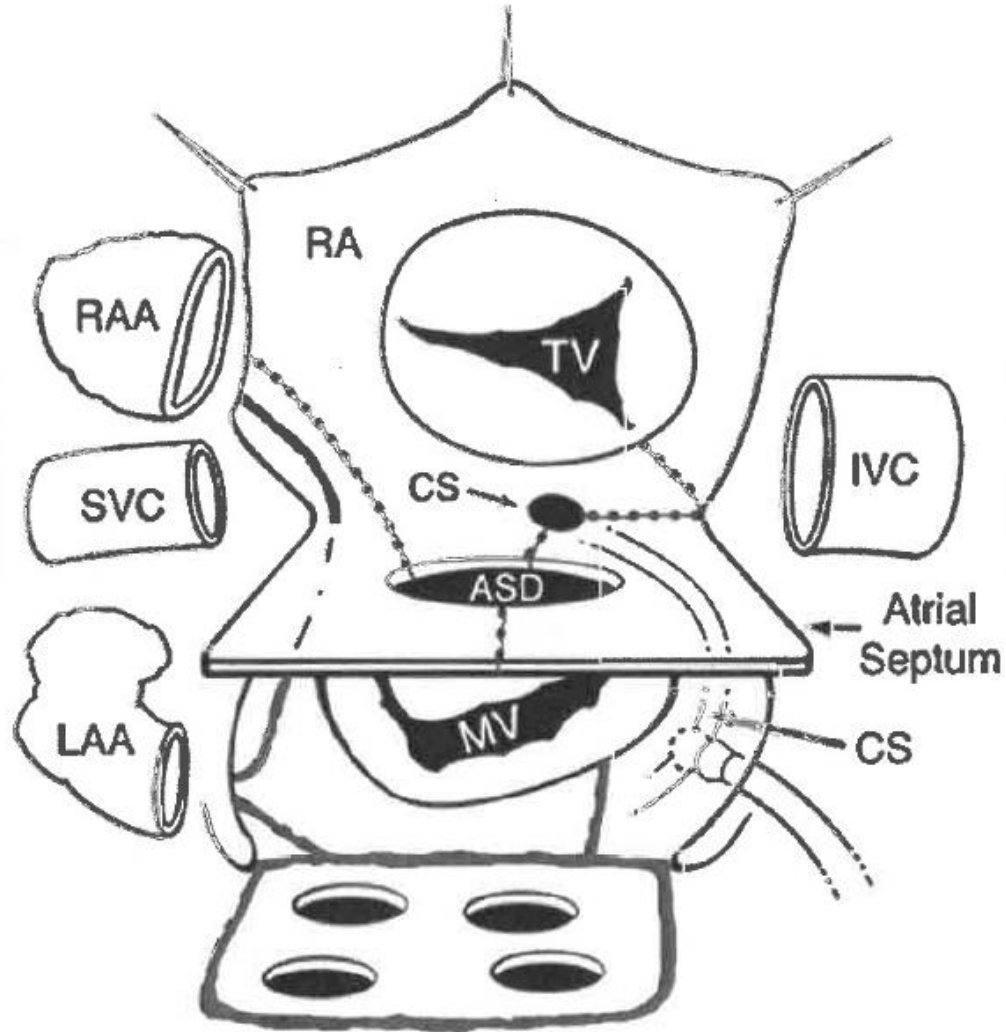
time was 70.8 ± 41.6 minutes. Four risk factors for death or transplantation were identified: presence of a right or ambiguous ventricle, preoperative protein-losing enteropathy, preoperative moderate-to-severe atrioventricular valve regurgitation, and long (>239 minutes) cardiopulmonary bypass time. In intergroup comparisons (groups I and II versus group III), three trends were noted: increased incidence of concomitant surgical repairs ($p = 0.03$), older patients ($p = 0.01$), and increased incidence of left atrial reentry tachycardia and atrial fibrillation ($p = 0.04$). Late recurrence of atrial tachycardia ensued in 15 of 111 (13.5%); 8 of 51 in group II (15.7%) and 4 of 51 in group III (7.8) ($p = 0.3$).

Conclusions. Fontan conversion with arrhythmia surgery is safe and efficacious. Based on improved results and evolving surgical techniques, selection criteria can be more clearly defined.

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Modified RA maze & left atrial Cox-maze



The Failing Fontan With Atrial Flutter: A Successful Surgical Option

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Two successful cases of eliminated atrial flutter and improved clinical status for Fontan patients are presented. An operation combining introduction of an extracardiac conduit for the Fontan connection, to direct all systemic venous blood away from the atrium, and atrial pathway division and cryoablation, is a useful surgical option for failing Fontan patients.

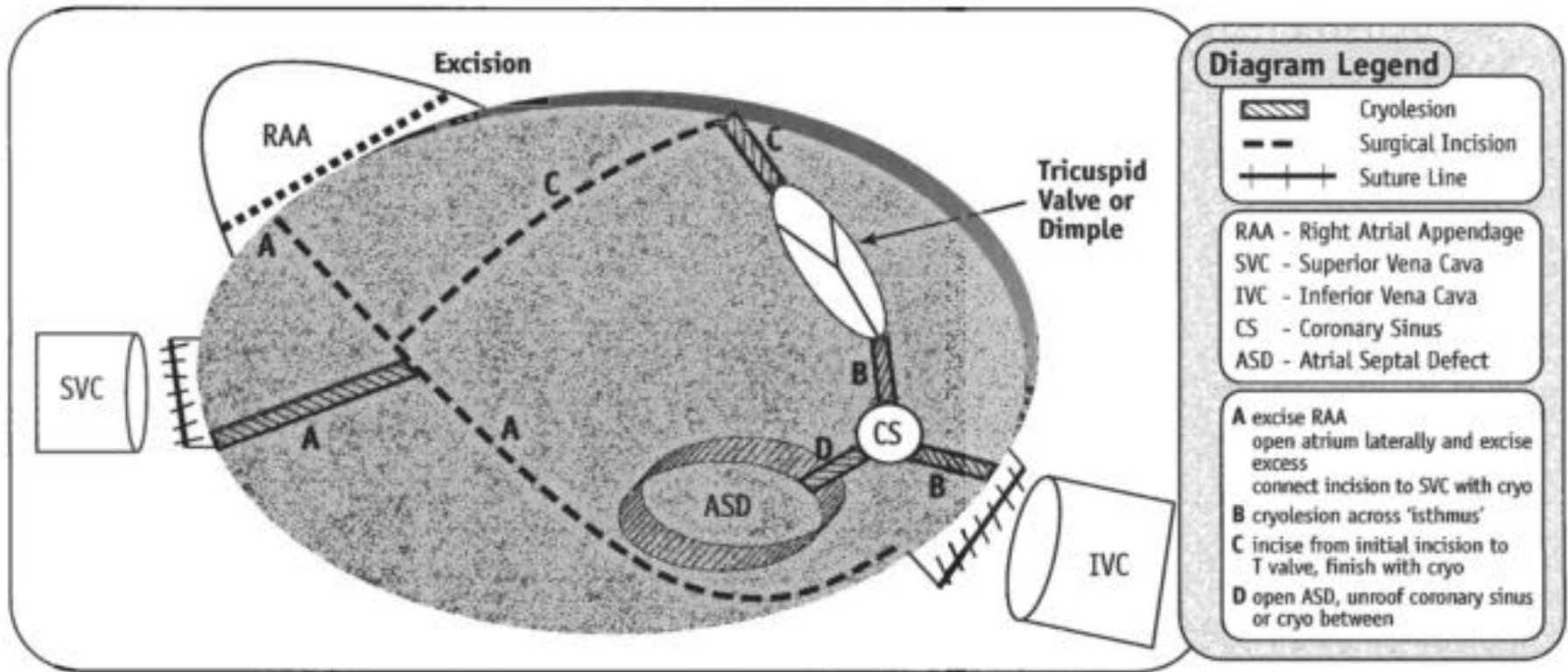
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Limited Right Atrial Maze



Extracardiac Conduit with a Limited Right Atrial Maze Procedure for the Failing Fontan with Atrial Tachycardias

Kirsten Finucane, FRACS, Shaun Setty, MD, Jon Skinner, MD, FRCPC, Alan R. Kerr, FRACS

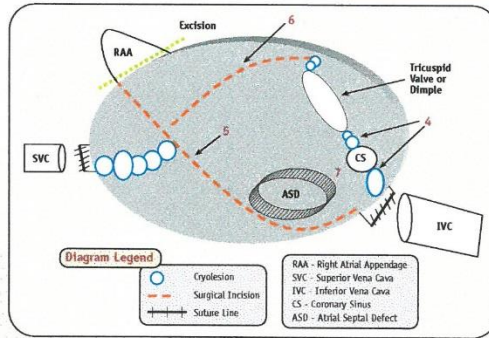
Green Lane Hospital Departments of Paediatric and Congenital Cardiac Surgery and Cardiology

Patient Characteristics

- 6 Patients since 1997
- Average Age: 22.8 (14-34 years)
- Time Since First Fontan: 14.6±4.4 years
- 5 Patients had pre-operative EP Study
- All 6 patients had medically uncontrollable atrial tachycardias and a reduction of exercise tolerance
- 2 patients had significant RA thrombus (see pre-operative echo pictures)

Operative Procedure

- Takedown of previous Fontan and replacement with 22 or 24 mm extracardiac PTFE conduit from IVC to pulmonary artery
 - Right atrial reduction
 - Epicardial Pacemaker Placement (usually for atrial bradycardia control)
 - Limited Right Atrial (RA) Maze Procedure
- See diagram for details



Explanation of RA Maze Technique

Evolution of incision and cryoablation technique over the 6 cases

The technique can differ because of variable morphology and previous surgical scars.

Principles of RA incision and cryolesions

- 1 Reduce atrial size as much as possible
- 2 Excise old scars
- 3 Run all incisions into either SVC or IVC tissue or another incision (avoid leaving any narrow muscular pathways)

RA Maze Lesions

Created with a combination of incisions and cryoablation

For numbers 4-7, refer to diagram

- 4 Crucial cryo-lesions across the "isthmus" between the IVC and tricuspid annulus via posterior aspect of coronary sinus (one of the most common atrial flutter pathways)
- 5 RA incision antero-laterally
 - Excise all scar tissue and RA appendage
 - Reduce atrial size
 - Running one end of incision to IVC and the other end is cryoablated to the SVC laterally to avoid SA node
- 6 Separate incision at right angles anterior to the A-V groove is completed with cryolesions.
- 7 Excise ASD patch and surrounding scar tissue and connect ASD to either right atriotomy or posterior aspect of CS using incisions or cryoablation.

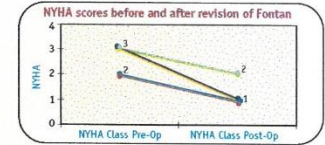
Results

- No Mortality
- CPB Time: 205±37 minutes (176-257)
- Aortic Cross Clamp time: 128±33 minutes (79-165)
- LOS: 16.7 days (7-38)
- ICU stay: 3 days (1-7)

Complications

- 1 patient returned to the operating theatre for exploration due to bleeding.
- 1 patient had an epicardial lead replaced 3 weeks after operation for malfunction.
- 1 patient developed complete heart block from an accompanying subaortic stenosis resection.
- Follow-up is a mean of 20.5 months (3-38 months).
- In hospital 5 patients had transient post-operative atrial arrhythmias treated with antiarrhythmics.
- Out of hospital 2 have had further atrial dysrhythmias.

- 2 patients are still on antiarrhythmics other than Digoxin, one at only 3 months post-operatively.
- All patients have had a significant improvement in exercise tolerance (refer to NYHA graph)



Conclusions

- Limited right atrial maze procedure, size reduction and pacemaker implantations are worthwhile additions to simple conversion to an extracardiac conduit in this patient sub-group.
- Control of atrial tachycardias is improved with reduction of antiarrhythmic medications and better exercise tolerance.
- Long-term efficacy will need further assessment.

| Patient # | Diagnosis | Type of Atrial Arrhythmia | Age at First Fontan (y) | Age at Operation (y) | Interval (y) | Indications | Operative Procedure - venous to venous bypass - Fontan conversion - extracardiac conduit | Pacer Model | Pre-op Atrial Antiarrhythmic Medication (antiarrhythmics) | Post-operative Antiarrhythmic Medication (antiarrhythmics) | Post-operative Antiarrhythmic Medication (antiarrhythmics) | Comments |
|-----------|---|---------------------------|-------------------------|----------------------|--------------|---|--|-------------|---|--|--|--|
| 1 | Talipexilol, Amiod, ASD, VSD | Atrial flutter | 7.2 | 26.2 | 21.1 | 1) Fatigue 2) Atrial Tachycardia 3) Nocturnal Awakening (NYHA 2) | Bilateral Bi-Directional Glenn | AAE | None | Digoxin | Digoxin | Follow-up Atrial Tachycardia controlled with Digoxin. Pacer generator placed 26 days after conversion with significant lead fracture. Doing well. (NYHA 1) |
| 2 | Tricuspid Atresia, d-RA | Atrial flutter | 4 | 13.7 | 9.7 | 1) Atrial Tachycardia 2) Fatigue (NYHA 2) | | AAE | Sotalol | Digoxin | Digoxin | Doing well, no arrhythmias. (NYHA 1) |
| 3 | Talipexilol, Amiod, VSD | Block Modification | 3.6 | 17 | 13.4 | 1) Atrial fibrillation 2) Decreased exercise tolerance (NYHA 2) | | AAI | Digoxin | Digoxin | None | Doing well, no arrhythmias. (NYHA 1) |
| 4 | DSB, L-RA, Hypertrophic right ventricle | Atrial flutter | 11 | 27 | 12 | 1) Atrial fibrillation 2) Near block due to lead 3) Decreased exercise tolerance 4) Subaortic stenosis (NYHA 2) | Resection of subaortic stenosis | DSB | Digoxin (rate controlled atrial fibrillation) | Digoxin | Digoxin | Suppl'y treated heart block. Post-op atrial flutter treated with sotalol. Doing well. (NYHA 1) |
| 5 | TSA, VSD, Hypertrophic right ventricle | Atrial flutter | 6.5 | 11.1 | 11.6 | 1) SVT 2) Atrial flutter 3) Dist to RA (NYHA 2) | | AAE | Digoxin (Atrial flutter) | None | None | Doing well, no arrhythmias. (NYHA 1) |
| 6 | Tricuspid Atresia, VSD | Block Modification | 14 | 34 | 20 | 1) Atrial fibrillation and flutter 2) Pre-operative (NYHA 1) | Bilateral Bi-Directional Glenn | DSB | Digoxin | Sotalol | Digoxin | Atrial flutter day 5 post-op, none since Sotalol. Improved exercise tolerance. (NYHA 2) |

Greenlane-Auckland series

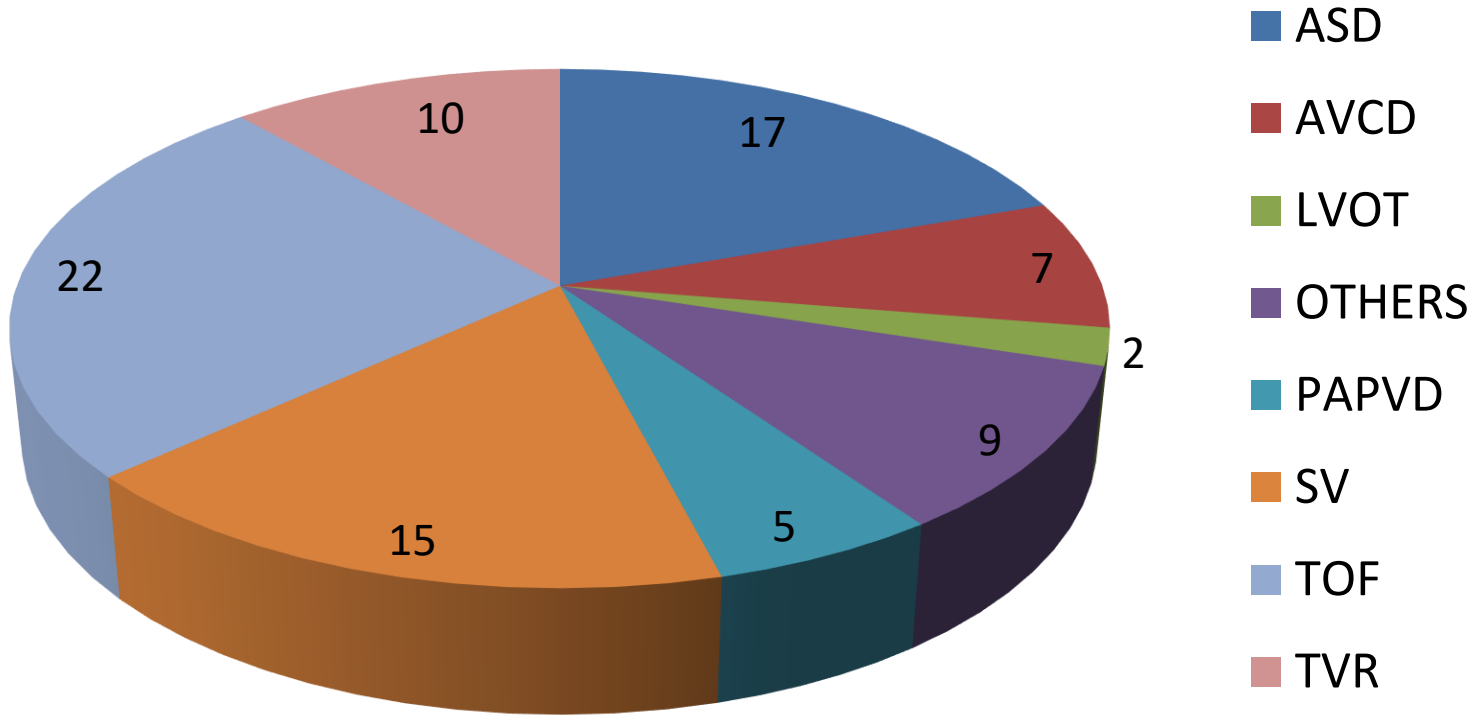
- Audit of all surgical (cryo)ablations in congenital cases (indications expanded from Fontan conversions to other CHD)
- Over age 15 years
- 1996 to 2012
- Congenital cardiac patients only
- All had concomittant procedures

- Congenital surgeons operating in adult unit
- Adult congenital cardiologists
- Adult congenital anaesthetists & intensivists
- Congenital EP service

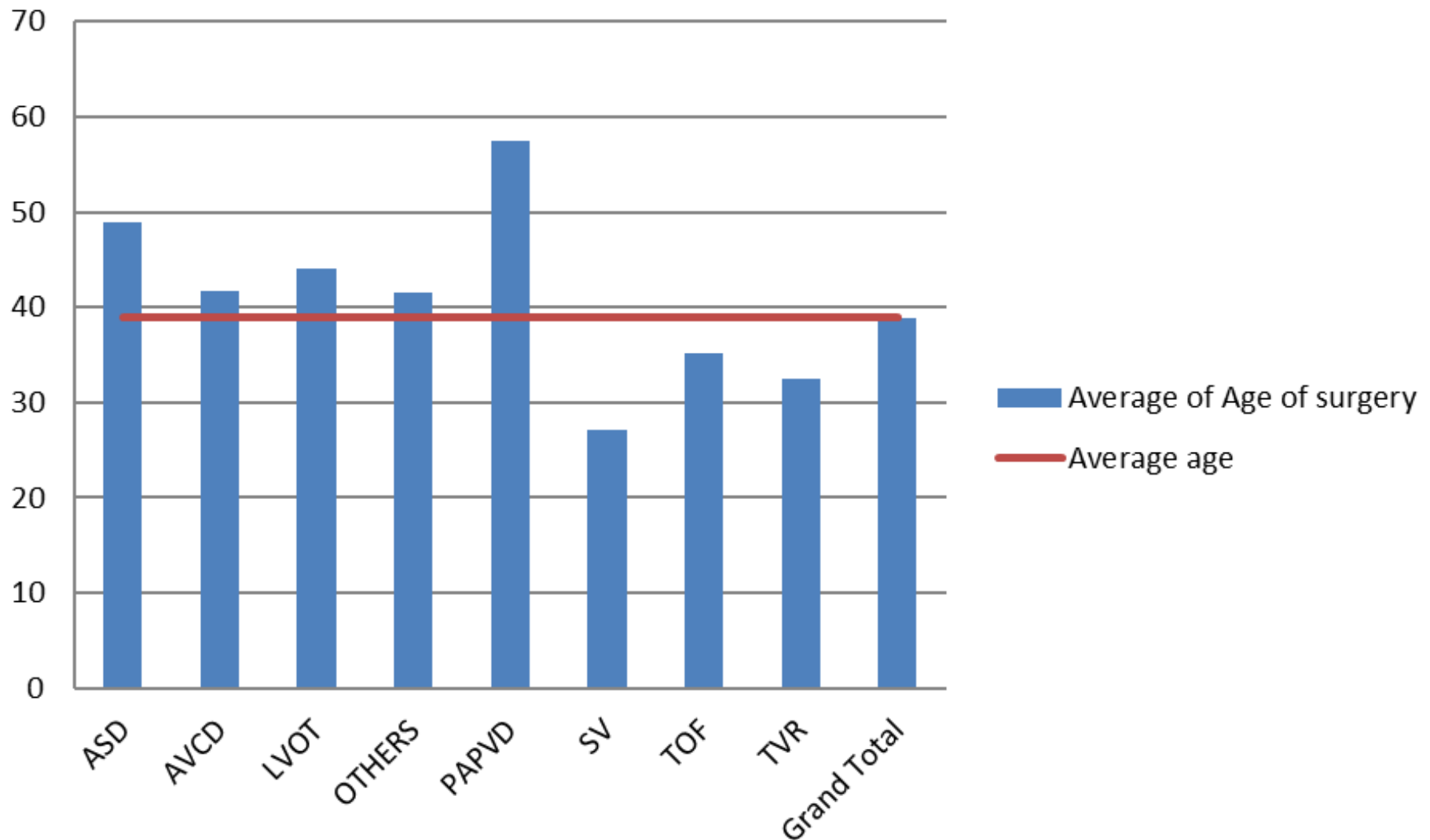
Demographics

- 87 consecutive patients
- Male n=44, Female n=43
- Average age 39, range 15-71 years

Diagnostic Category



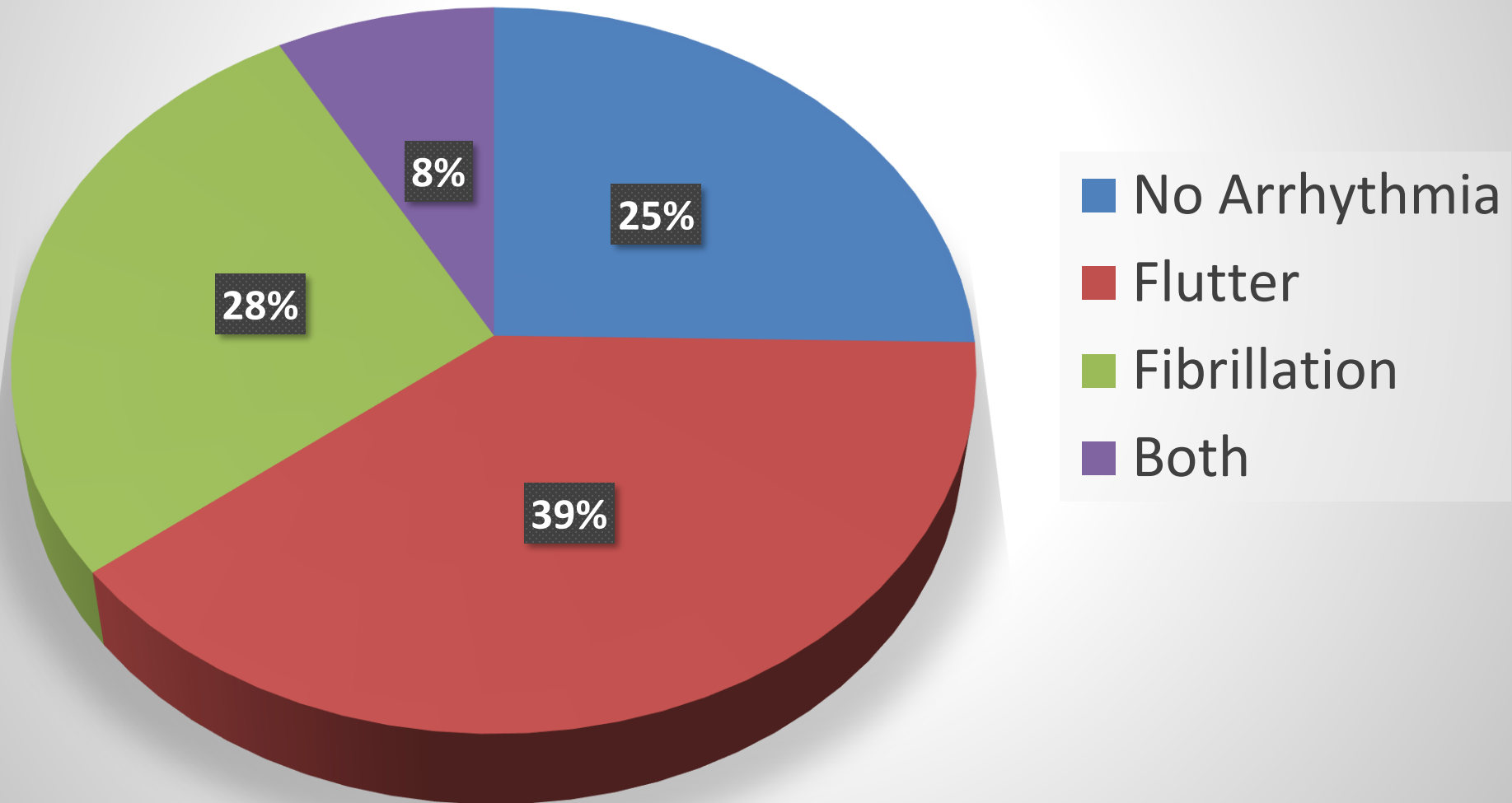
Age vs Diagnostic Category



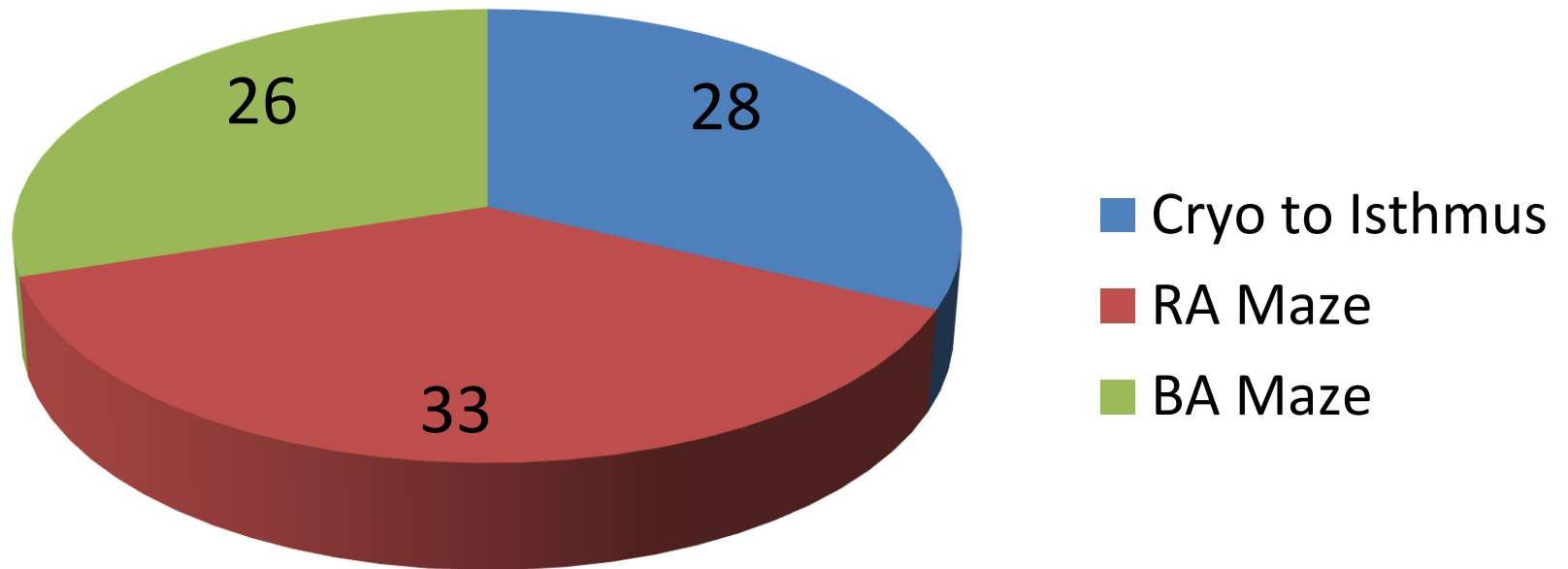
Concommittant procedures

- PVR 22 incl PVR+TVR 8, PVR+AVR 2, PVR+MVR 1
- TVR 10 incl Bidirectional Glenn 5, TVR+MVR 3
- Fontan conversions 14
- Prim ASD 5
- Sec ASD 14
- PAPVD 5
- MVR/LAVVR 6
- LVOT/Aortic 2
- Mustard takedown+ switch 1
- Cortriatriatum 1

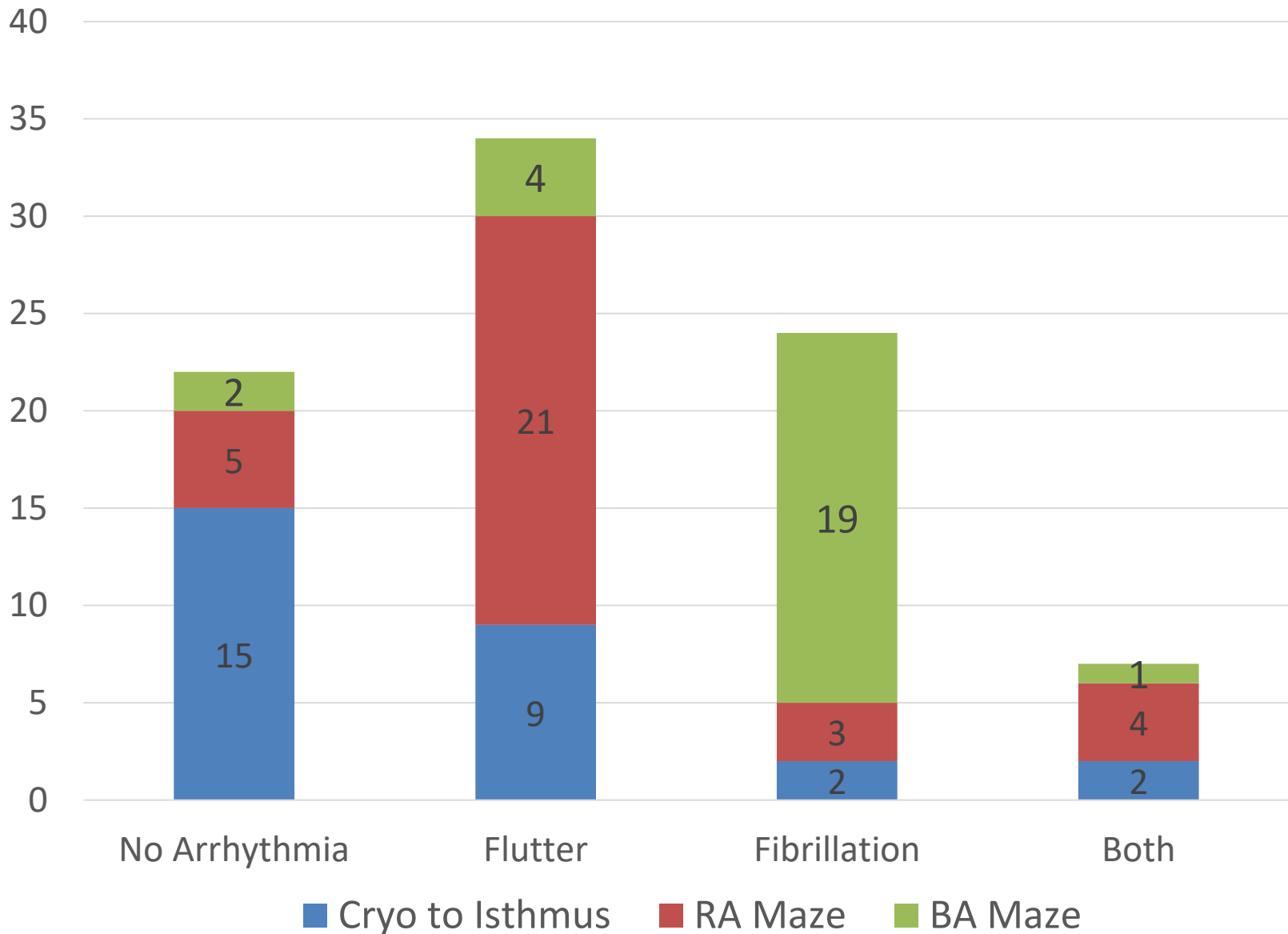
Documented Preoperative Arrhythmias



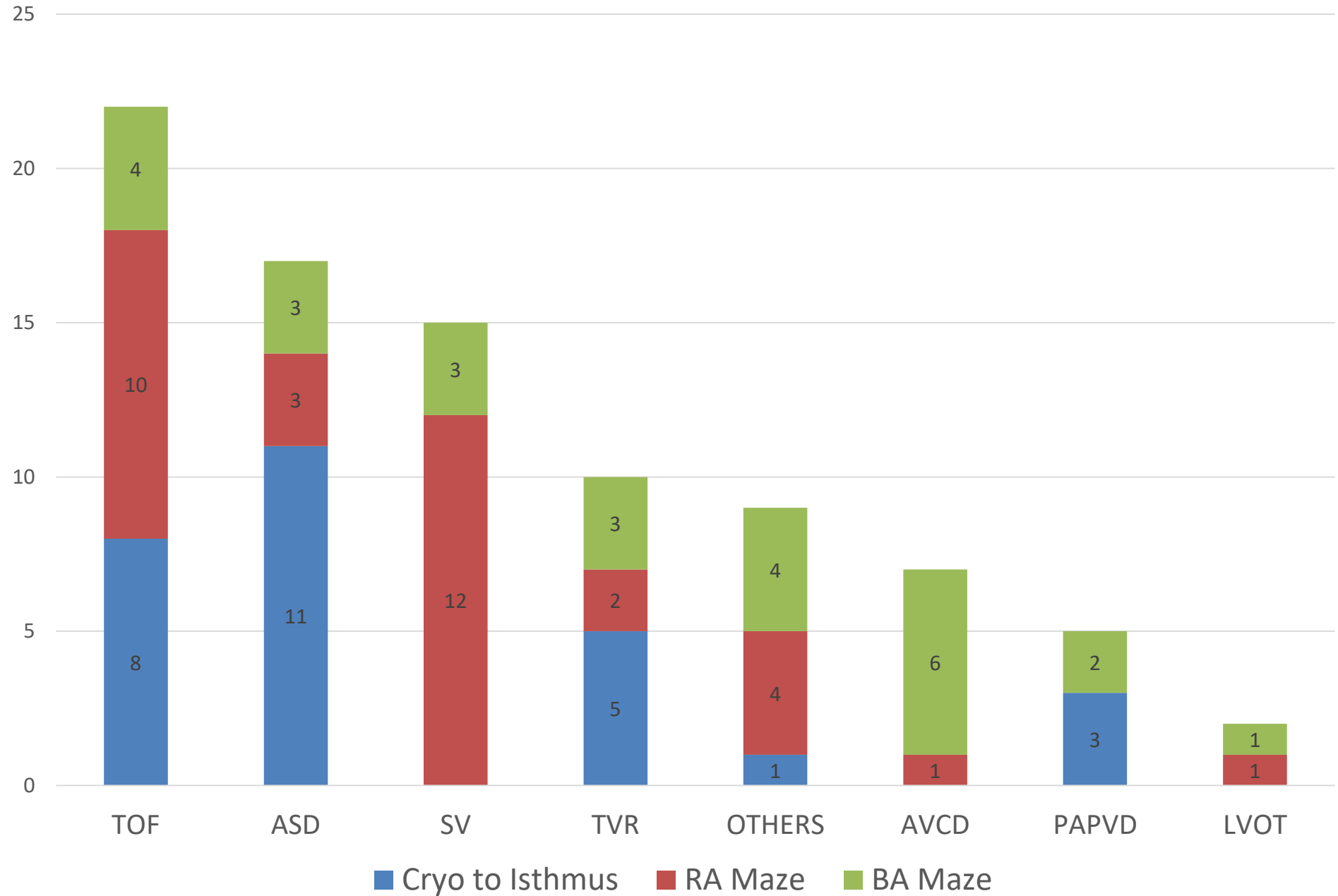
Type of Cryoablation: n=87



Type of Cryo vs Preoperative arrhythmia



Type of Cryo vs Diagnosis



Pacemakers

- Pacemakers inserted in 24/87 (28%)
- 5 patients had preoperative pacemakers
- Another 8 had leads only inserted and capped
- 2 acquired complete heart block but with redo TVR or Left AVVR , may not be maze.

Outcomes

- Early mortality n=2 (2.3%)
- 1 single ventricle, PA/IVS with gross coronary aneurysm, LV infarct and VT
- 1 Ebsteins/ASD age 63 RV failure and VT
- 2 Prolonged lymphatic leak, pleural effusion, both single ventricles

Late outcomes

- 10 late deaths, 4 at 1 year, 6 at 8-16 years.
(11.5%)
- 1 homicide at 1 year
- 5 Congestive heart failure
- 2 sudden cardiac deaths
- 3 unknown causes, ages 71, 79, 79 yrs

Followup

- 10 lost within 12 months, incl 2 overseas
- 75 alive and followed at least 1 year
- Average follow-up 100 months, 8.3 years
- Longest is 20 years

Recurrent Atrial Tachyarrhythmias

- 5/32 recurrences at 5 years, 16%
- 10/24 recurrences at 10 yrs, 42% (early cryo)
- Risk factors: preoperative atrial fibrillation, PAPVD
- 3 patients repeat ablations, one pt had 3
- 3 patients needed late AICD's
- 2 patients had pacemakers late, one bivent



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Freedom from arrhythmia recurrence

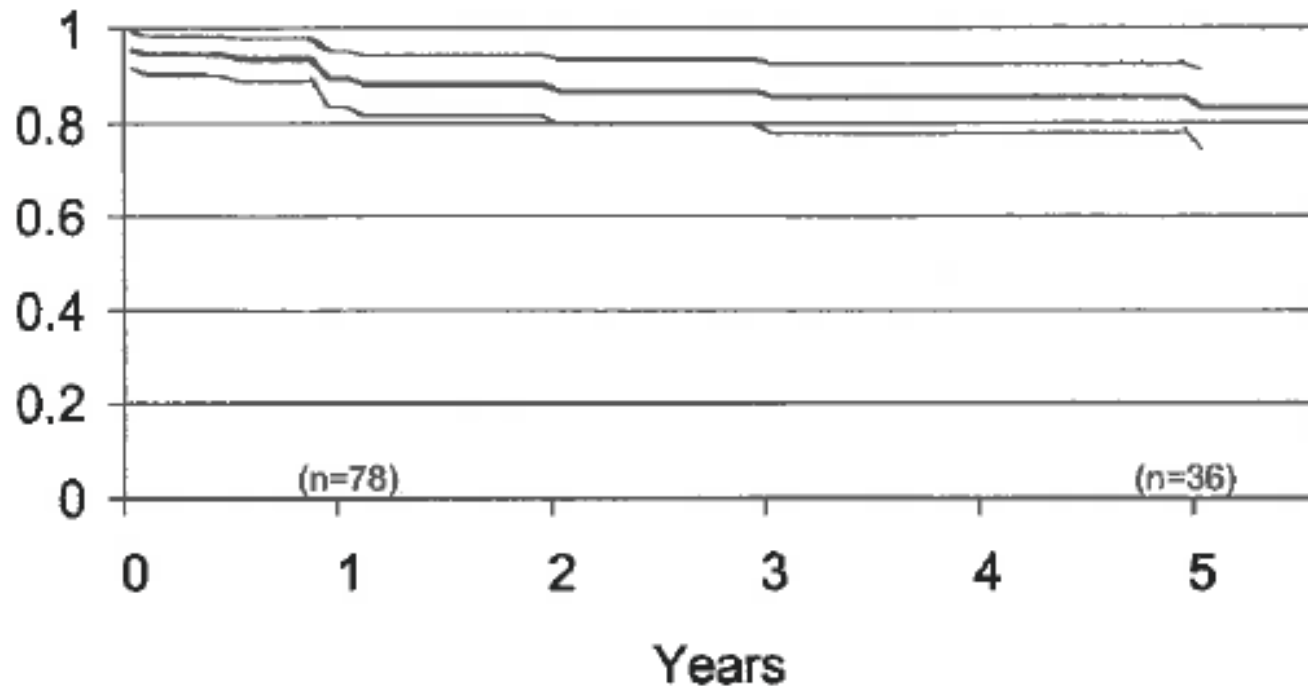


Fig 3. Kaplan-Meier curve showing actuarial freedom from arrhythmia recurrence in 111 patients who underwent Fontan conversion with arrhythmia surgery. Confidence limit cannot be calculated beyond last incidence of arrhythmia recurrence.

Conclusions

- Cryoablation is a useful low risk adjunct to adult congenital cardiac surgery
- Prophylactic cryolesions to isthmus may reduce atrial flutter incidence. Need a trial?
- Careful documentation of preoperative rhythmns helps direct surgeon to the right type of Maze.
- Maze surgery may be done with sinus node preservation and without mandatory pacing with 16% recurrence rate at 5 years.

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