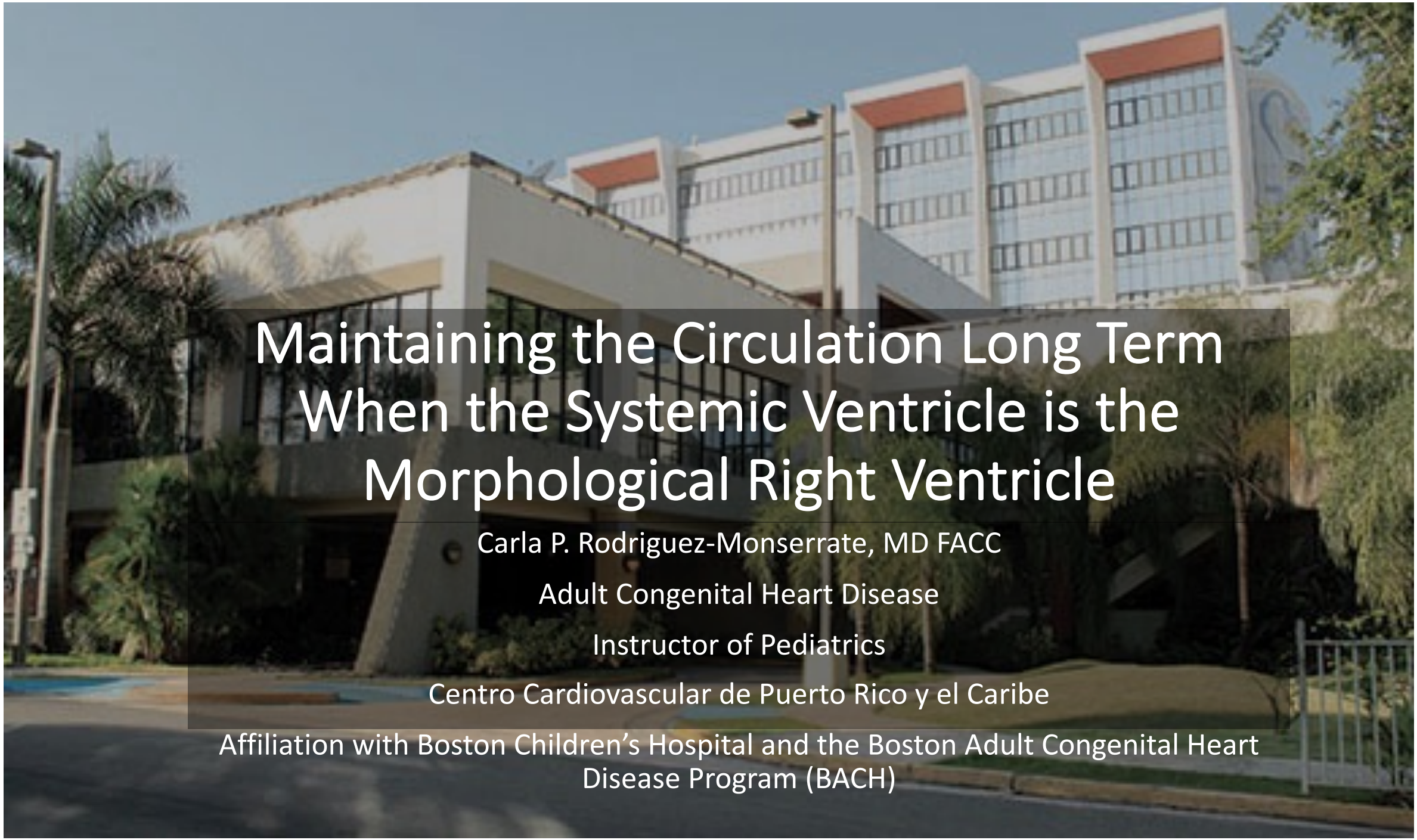


Maintaining the Circulation Long Term When the Systemic Ventricle is the Morphological Right Ventricle

Carla P. Rodriguez-Monserrate, MD FACC

Adult Congenital Heart Disease

Instructor of Pediatrics

Centro Cardiovascular de Puerto Rico y el Caribe

Affiliation with Boston Children's Hospital and the Boston Adult Congenital Heart Disease Program (BACH)

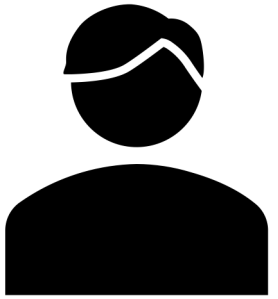
Disclosures

- None

Objectives

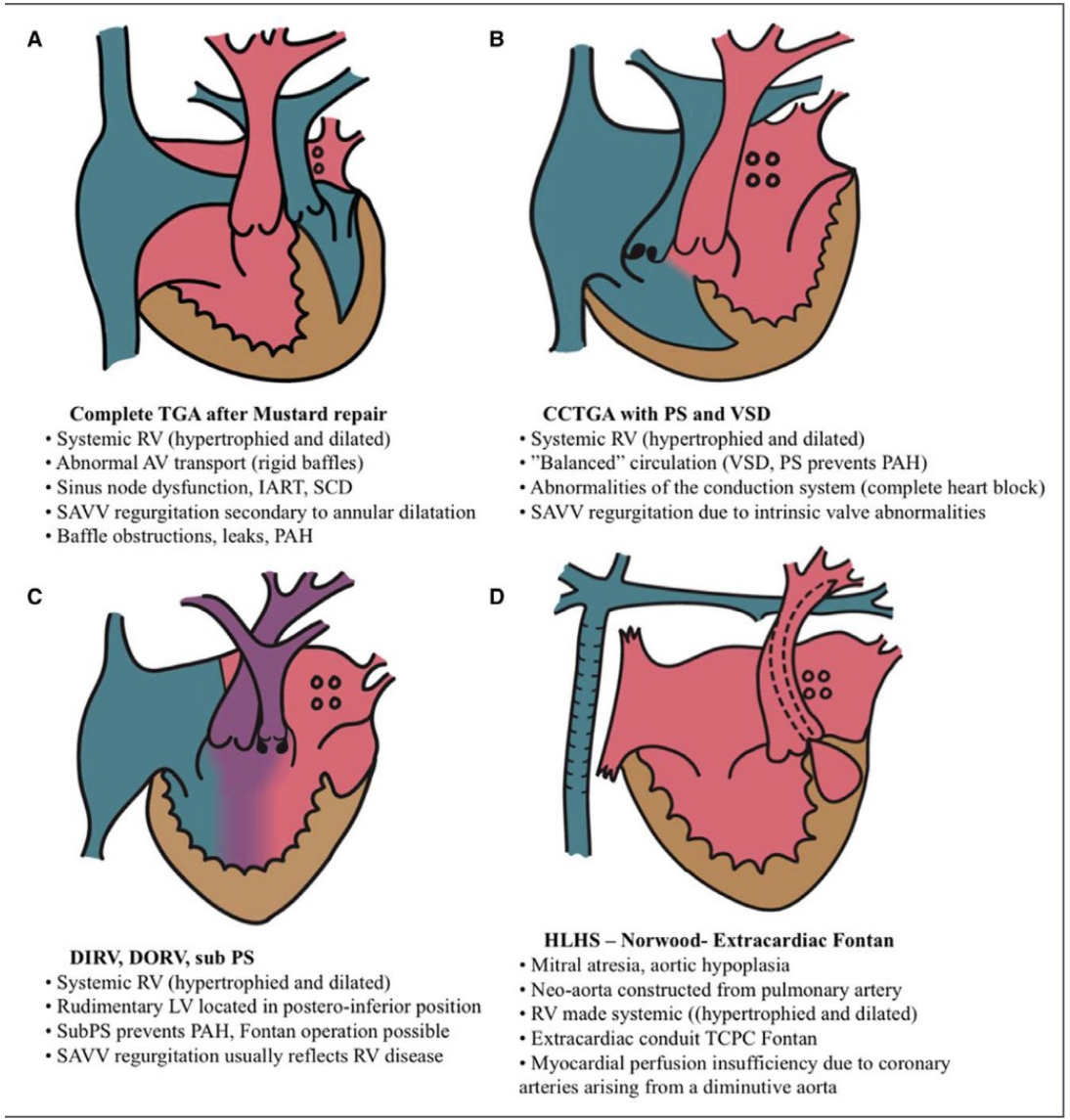
- Discuss the anatomical and physiological differences between the right and left ventricles
- Review the longterm outcomes of the systemic right ventricle
- Evaluate the therapies available for systemic right ventricles
- Highlight future directions in the therapy of systemic right ventricle

Case (CM)



- HPI: CM is a 36-year-old man with D-TGA s/p atrial switch surgery who presents now with his first HF admission and atrial flutter de novo. Lost in care for the past 10 years.
- Symptoms: worsening fatigue and DOE during working hours as a security guard for the past few months
- The echocardiogram showed severe sRV systolic dysfunction and severe TR. Borderline normal LV size and function. Baffle without evidence stenosis
- Outpatient Meds: lisinopril 5mg for high blood pressure
- He was started on anticoagulation, betablockers and IV diuretics.
- What are the next best steps in management?

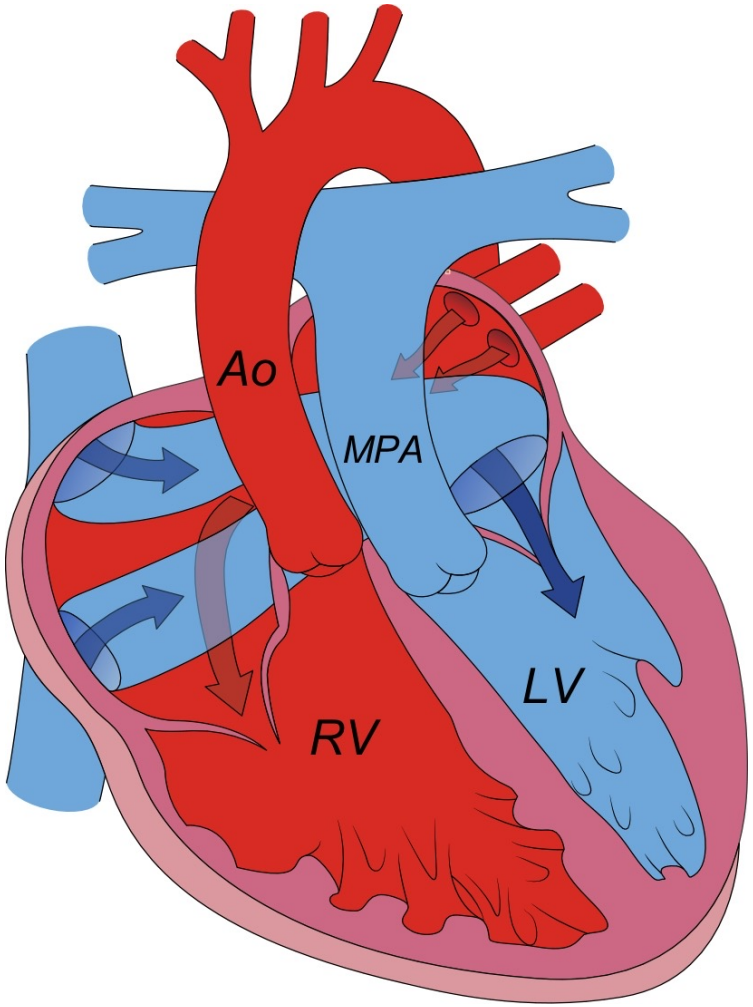
Types of Systemic Right Ventricle



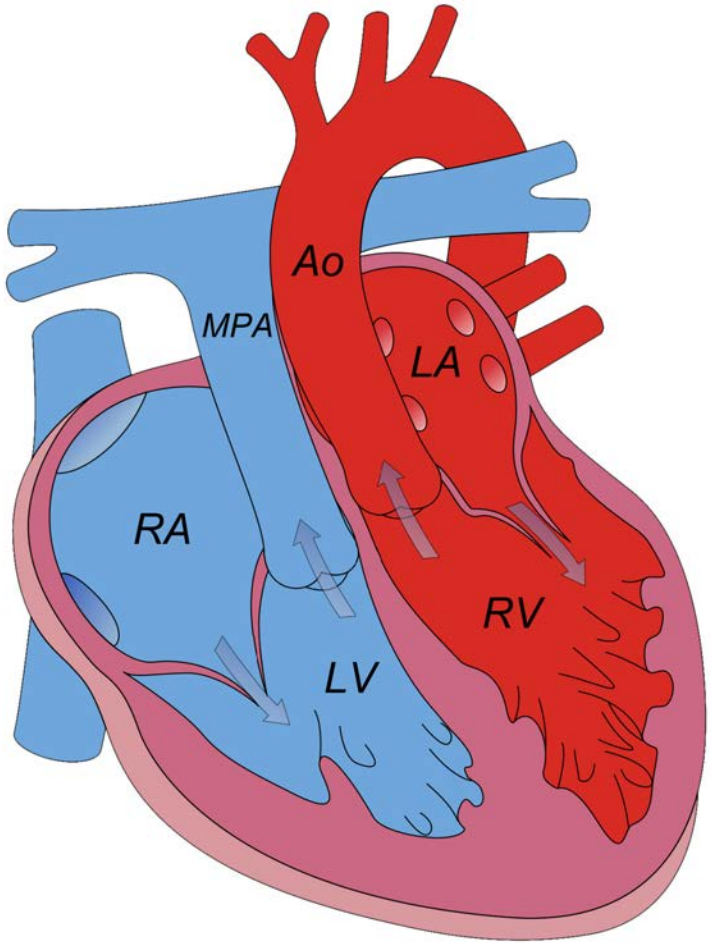
It is estimated that conditions with SRV account for ≈10% to 12% of all CHD.

Brida et.al. Circulation 2018.

D-loop TGA, atrial switch
Mustard, Senning (surgical)



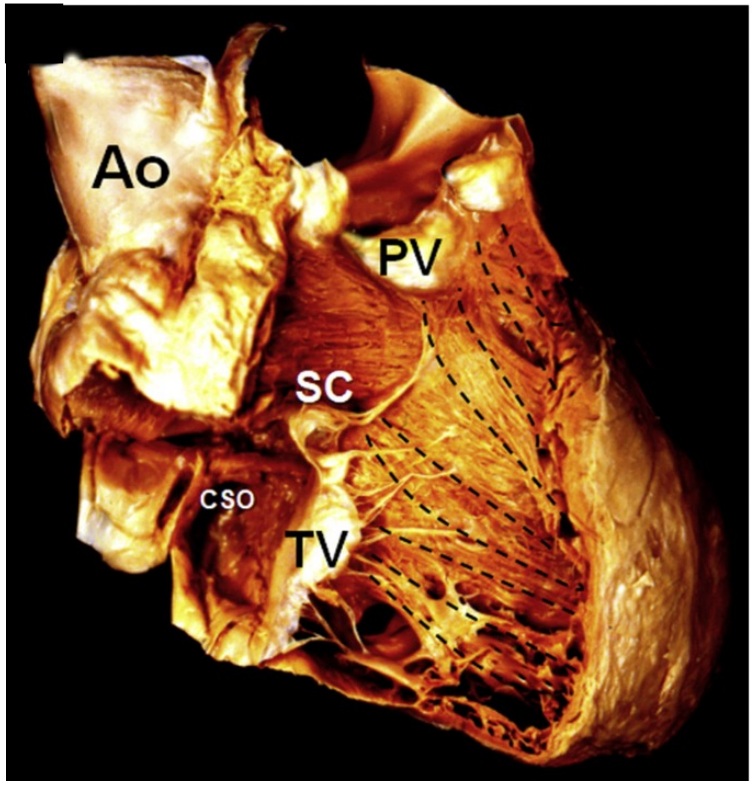
Physiologically (non surgical) corrected TGA
“Congenitally corrected” TGA



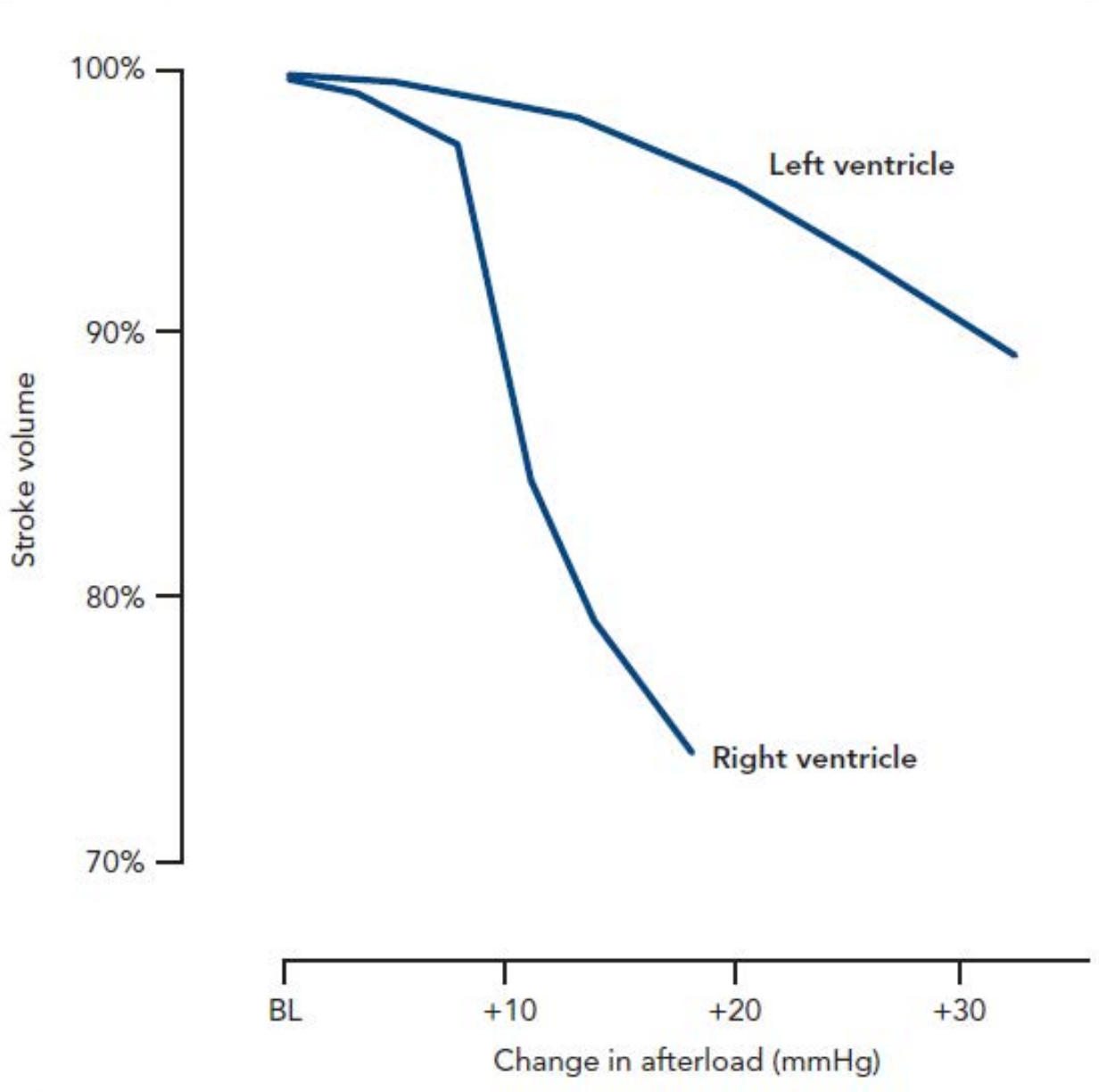
Source: Partington SL, Valente AM. Methodist Debakey Cardiovasc J. 2013 Jul-Sep;9(3):156-62.

Anatomical and Physiological Differences Between RV and LV

- Less muscle fibers
- More complaint and slightly larger cavity
- Longitudinal shortening
- 40 % dependent on the septal contraction
  - Ventricular interdepence
- RV perfusion is mostly from the RCA.
- More sensitive to brisk changes in afterload

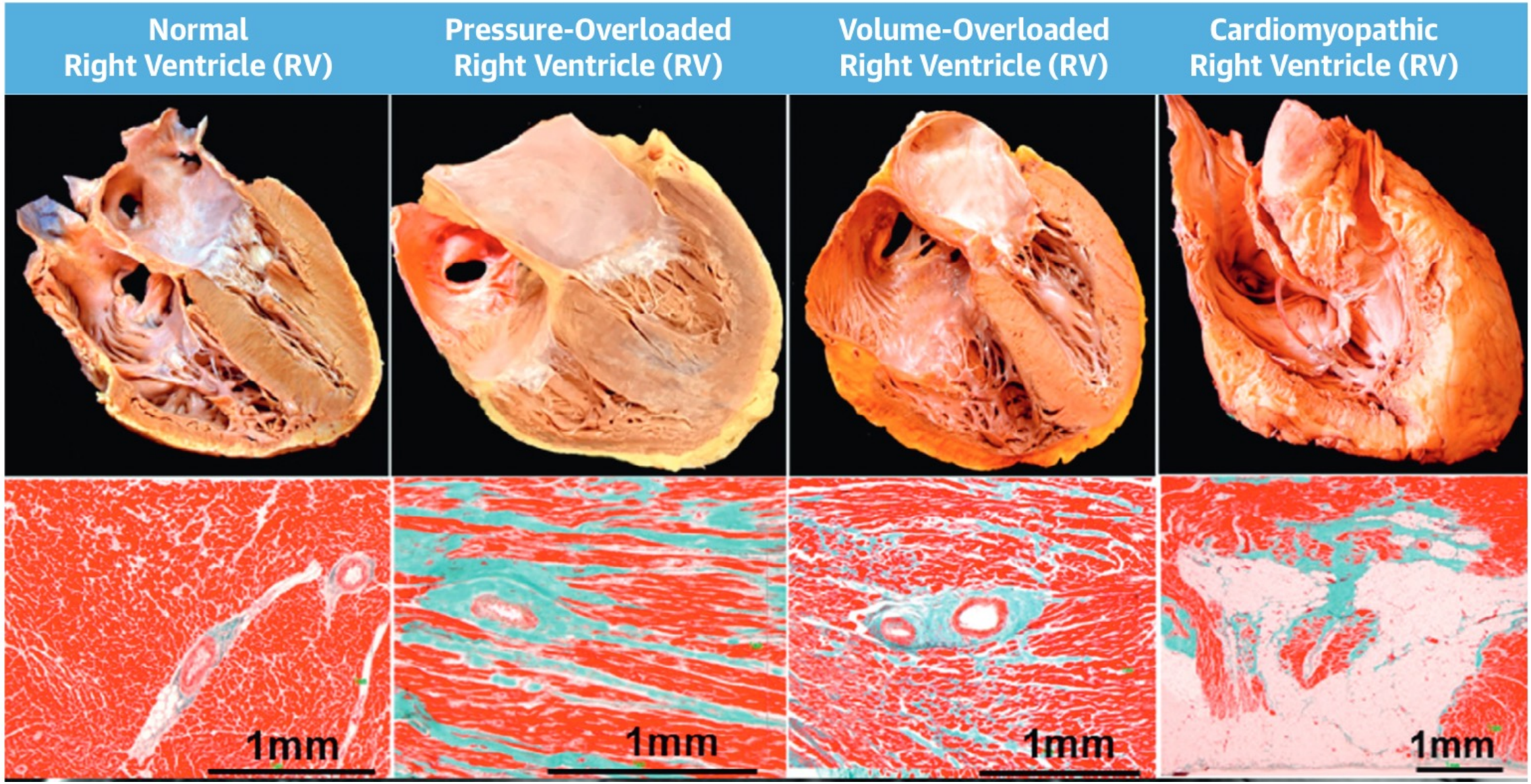


Arrigo M, Huber LC et. Al Card Fail Rev. 2019 Nov 4;5(3):140-146.



Brisk increases in afterload are poorly tolerated by the RV causing RV dilation and decrease SV

Arrigo M, Huber LC et. Al Card Fail Rev. 2019 Nov 4;5(3):140-146.



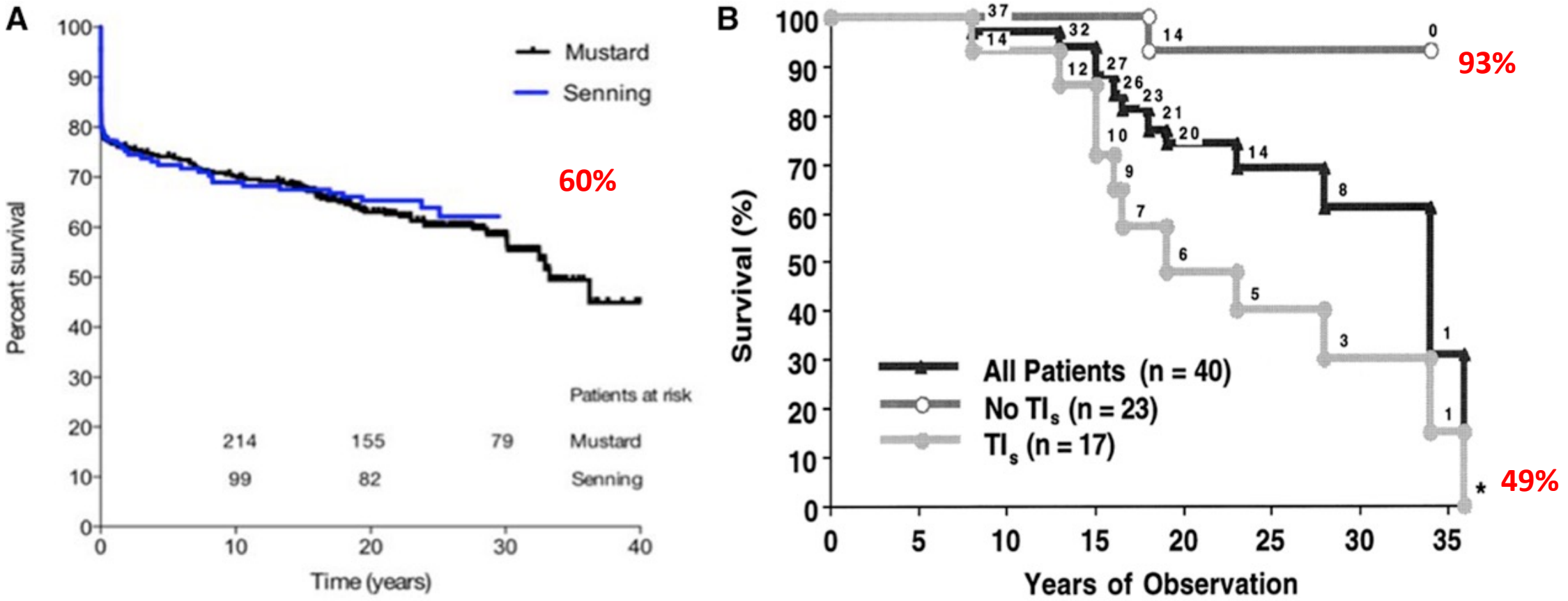
Sanz et al . JACC. 2019

What are the Anatomical and Physiological Challenges of the Systemic RV?

- Distinct fibromuscular architecture, shape and function
- Coronary artery supply mismatch
- Intrinsic abnormalities of the tricuspid valve
- Intrinsic or acquired conduction abnormalities
- Varied SRV adaptation to pressure or volume overload.

Brida et.al. Circulation 2018.

Survival for SRV



Vejlstrup N, et.al. *Circulation.* 2015 Aug 25;132(8):633-8.

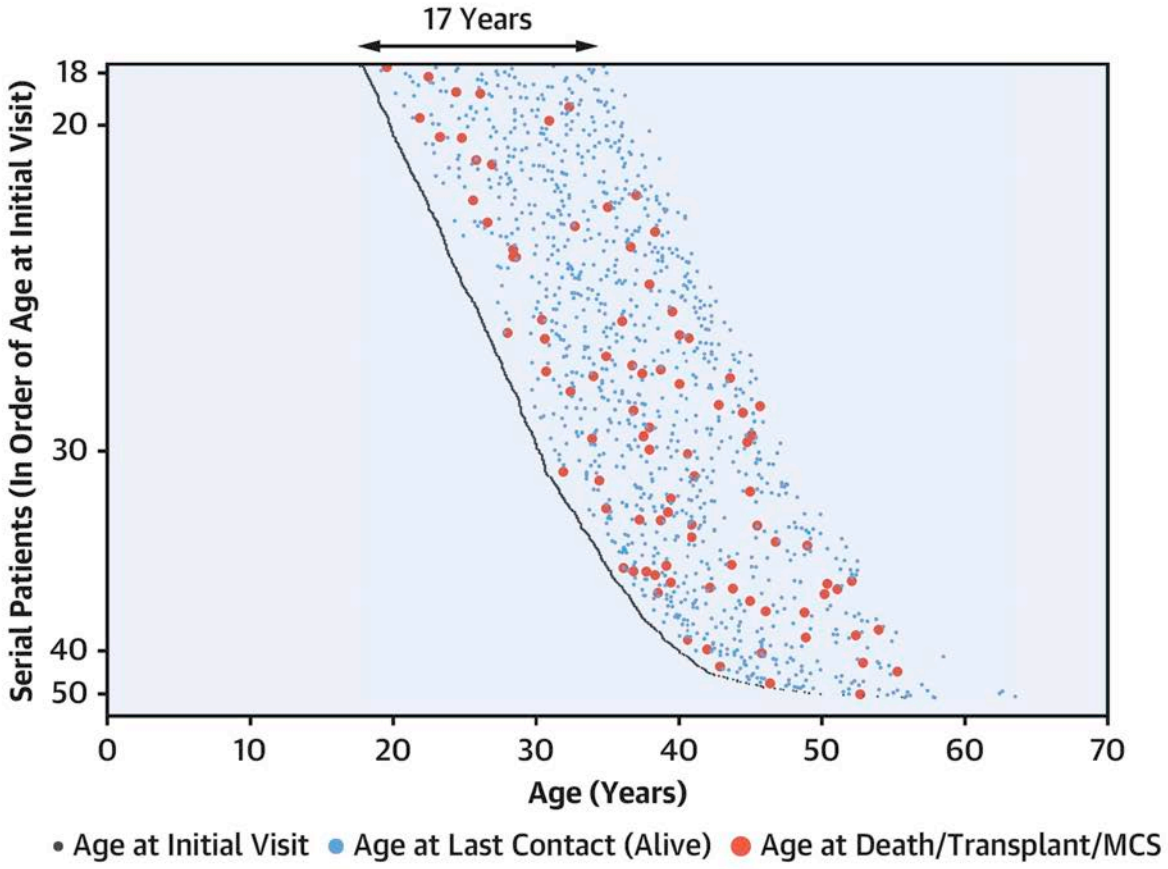
Predictors of Late Mortality in D-Transposition of the Great Arteries After Atrial Switch Repair: Systematic Review and Meta-Analysis

Prashanth Venkatesh [1], Arthur T Evans [2], Anna M Maw [2], Raymond A Pashun [1], Agam Patel [1], Luke Kim [1], Dmitriy Feldman [1], Robert Minutello [1], S Chiu Wong [1], Judy C Stribling [3], Damian LaPar [1], Ralf Holzer [1], Jonathan Ginns [1], Emile Bacha [1], Harsimran S Singh [1]

- Meta analysis of 29 studies
- At least 10y follow up
- Survival dropped to 65% after 40 years of Atrial Switch

- Risk factors for late Mortality and SCD
  - Supraventricular tachycardia
  - Mustard procedure
  - Complex D-TGA

Long Term Outcomes After Atrial Switch



5-year predictors of adverse outcome
(Heart Transplant, MCS or Death)

- Ventricular arrhythmia
- Heart failure admission
- Complex anatomy
- QRS duration >120 ms
- Severe RV dysfunction

Broberg C, va. J Am Coll Cardiol. 2022 Sep, 80 (10) 951–963.

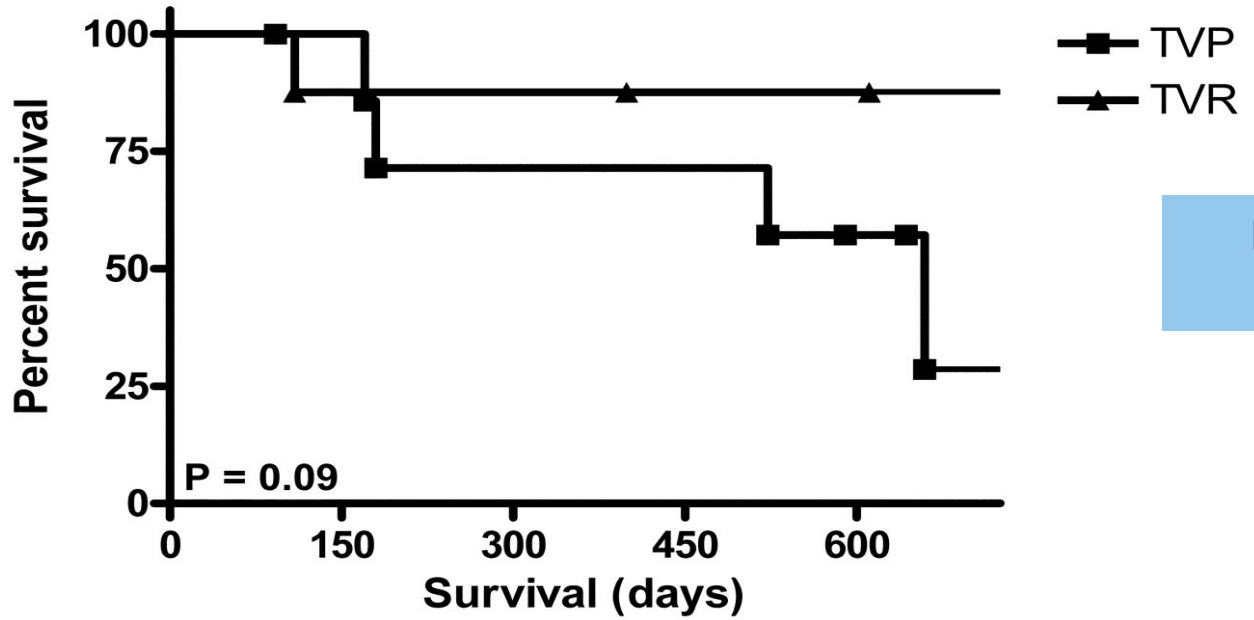
What are the main problems to maintain long term circulation in the systemic RV?

1. Tricuspid regurgitation
2. Arrhythmias -> SCD
3. Heart Failure

Tricuspid Valve Surgery in Adults With a Dysfunctional Systemic Right Ventricle

Repair or Replace?

Roderick W.C. Scherptong, Hubert W. Vliegen, Michiel M. Winter, Eduard R. Holman, Barbara J.M. Mulder, Ernst E. van der Wall and Mark G. Hazekamp



Improvement of Functional Class

Roderick W.C. Scherptong. Circulation. Volume: 119, Issue: 11.2009

Tricuspid Regurgitation- When to Replace It ?

1995

Late results of systemic atrioventricular valve replacement in corrected transposition

J A van Son [1], G K Danielson, J C Huhta, C A Warnes, W D Edwards, H V Schaff, F J Puga, D M Ilstrup

→ **Early intervention**

2011

Congenitally corrected transposition of the great arteries ventricular function at the time of systemic atrioventricular valve replacement predicts long-term ventricular function

François-Pierre Mongeon [1], Heidi M Connolly, Joseph A Dearani, Zhuo Li, Carole A Warnes

→ **SVEF falls below 40% and the subpulmonary VSP >50 mm Hg.**

2018

Long-Term Outcomes of Tricuspid Valve Surgery in Patients With Congenitally Corrected Transposition of the Great Arteries

Long Deng, MD, [1] Jianping Xu, MD, [1] Yajie Tang, MD, [1] Hansong Sun, MD, [1] Sheng Liu, MD, [1] and Yunhu Song, MD [1]

→ **Preoperative RVEDD**

Sudden Cardiac Death

- As high as 15%
- Proposed risk factors
  - supraventricular tachyarrhythmias (SVT)
  - right ventricular dysfunction (RVD)
  - atrioventricular block
  - tricuspid regurgitation (TR)
  - QTc dispersion on electrocardiography

Khairy P, Circ Arrhythm Electrophysiol. 2008; 1:250–257.

What are the recommendations for ICD placement?

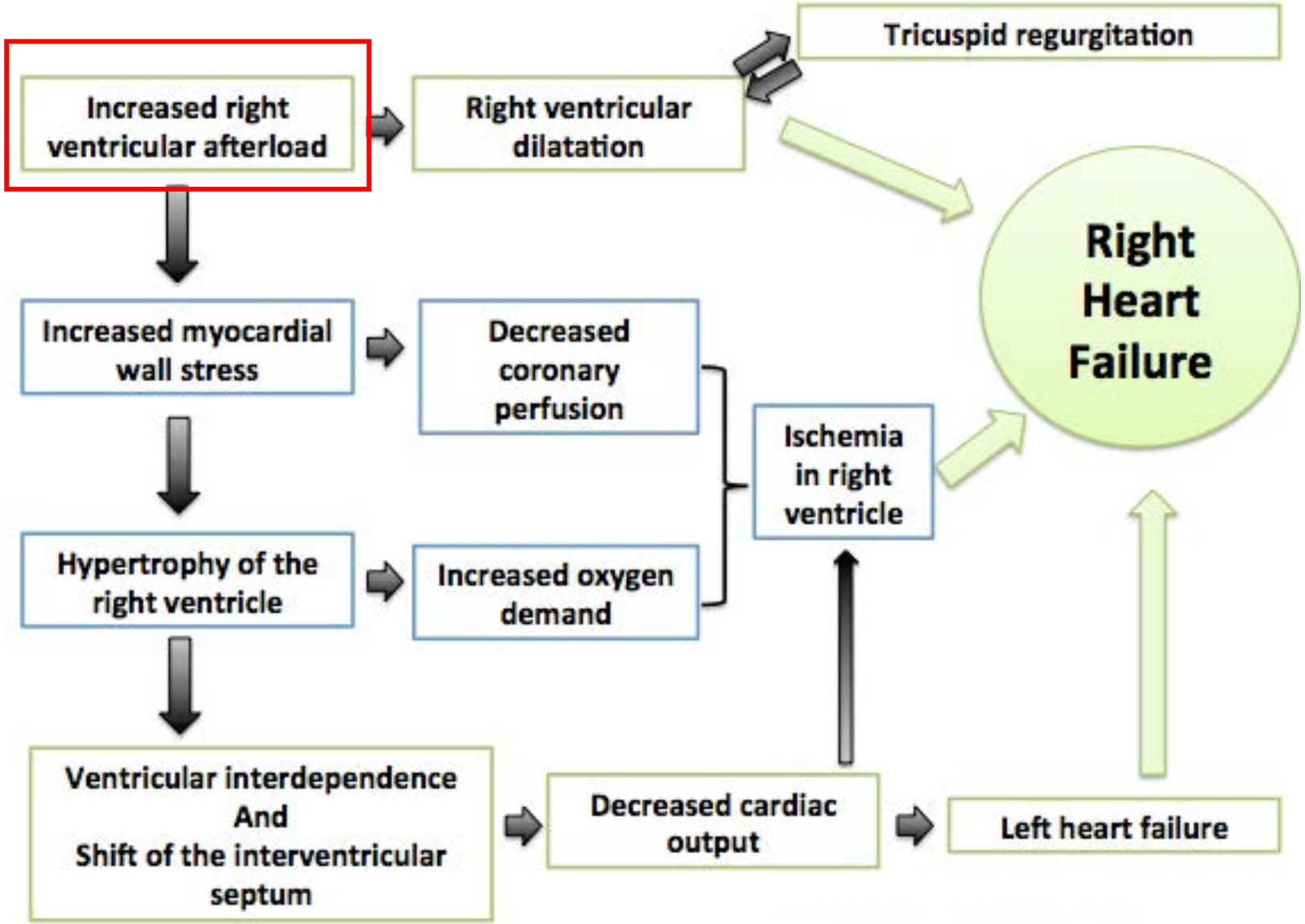
Practice Guideline > Can J Cardiol. 2014 Oct;30(10):e1-e63. doi: 10.1016/j.cjca.2014.09.002.

PACES/HRS expert consensus statement on the recognition and management of arrhythmias in adult congenital heart disease: developed in partnership between the Pediatric and Congenital Electrophysiology Society (PACES) and the Heart Rhythm Society (HRS). Endorsed by the governing bodies of PACES, HRS, the American College of Cardiology (ACC), the American Heart Association (AHA), the European Heart Rhythm Association (EHRA), the Canadian Heart Rhythm Society (CHRS), and the International Society for Adult Congenital Heart Disease (ISACHD)

HRS/PACES 2014: Class IIB recommendation: level of evidence C

- SRV with EF<35% with or without other risk factors (QRS duration >140 ms, NYHA class II or more, symptoms)

Pathophysiology of Systemic RV Failure



Adapted from Chest. 2005;128:1836-1852

Management Systemic RV and Heart Failure

Medical Therapy	Catheter based/ EP	Surgery
BB Ace-inh /ARBs Aldosterone Antagonists ARNI GLT2 inh	Cardiac resynchromization therapy	TVR RVAD Heart Transplant

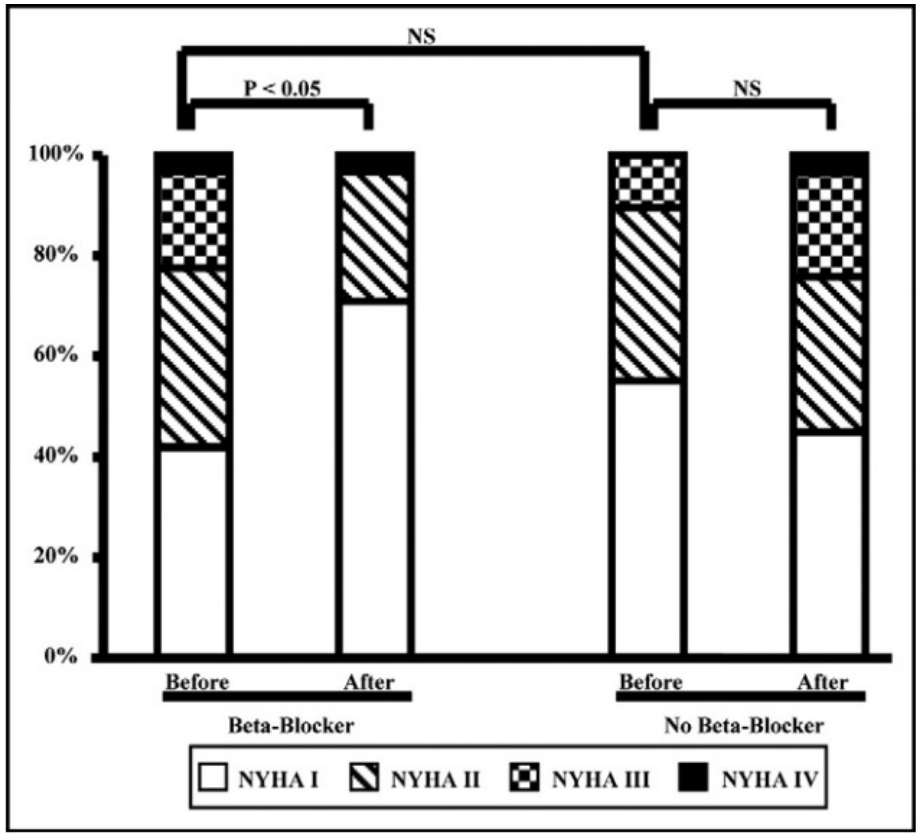
Medical therapy

- Limited data
- Small group of patients
- Anatomic heterogeneity

Gallego, P. et al. Heart, 106(2), 154. 2019

Beta- Blockers

- Positive RV remodeling vs neutral
- Improved exercise duration
- Improved NYHA functional class and QOL



Doughan et. al 2007: Effect of Beta blockers in Patients with TGA and dysfunction of the Systemic Right Ventricle

Giardini et al, 2007
Shaddyetal et al, 2007
Khairy et al,2017

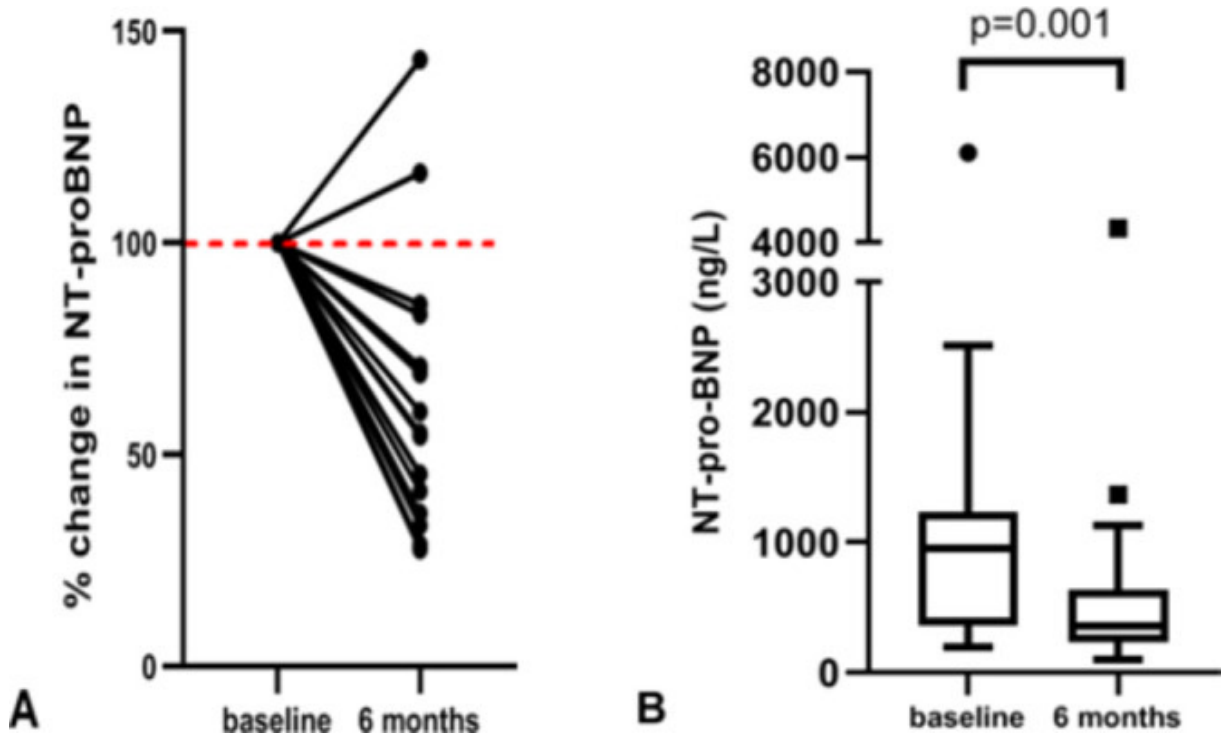
Other Therapies

Treatment	Results	References
Ace inhibitors and ARBs	• No effect on RVEF RVEDV and RVESV • No improvement in exercise performance • Decreases NT-pro (BNP) levels	Hechter et al,2001 Therrien et al, 2008 Tutarel et al,2012
Eplerenone	• Improvement of an altered baseline CTB and SRV mass suggesting reduction of myocardial fibrosis	Dos et al,2013

Gallego, P. et al. *Heart, 106*(2), 154. 2019

ARNI (Sacubritil- Valsartan)

- Single center study of 20 patients
- Inclusion criteria: systemic RV EF <35% with symptoms on beta blocker/ACEi or ARB therapy
- 6-month follow up:
  - pro NT BNP decreased
  - Echo RV FAC and GLS improved slightly (19→22%, 11% to 13%)
  - 6-minute walk increased from 564 to 600



Zandstra TE et al. *Heart*. 2021

ESC Heart Failure
Open Access
HFA Heart Failure Association

Case Report | Open Access

The first experience with sodium-glucose cotransporter 2 inhibitor for the treatment of systemic right ventricular failure

Anastasia D. Egorova, Marieke Nederend, Laurens F. Tops, Hubert W. Vliegen, Monique R.M. Jongbloed, Philippine Kiès

First published: 30 March 2022 | https://doi.org/10.1002/ehf2.13871

- Case report: cc-TGA patient initiated on SGLT-2 inhibitor → no heart failure re-admissions; slight improvement in RV FAC and peak VO2

Egorova AD et al. ESC Heart Fail. 2022 Mar 30

In process : Possible effects of medication use on outcomes in patients with systemic right ventricles

- **Retrospective Multicenter Study**
- Patients with systemic RV

(taking Ace-inh or ARBs, BB, both or none)

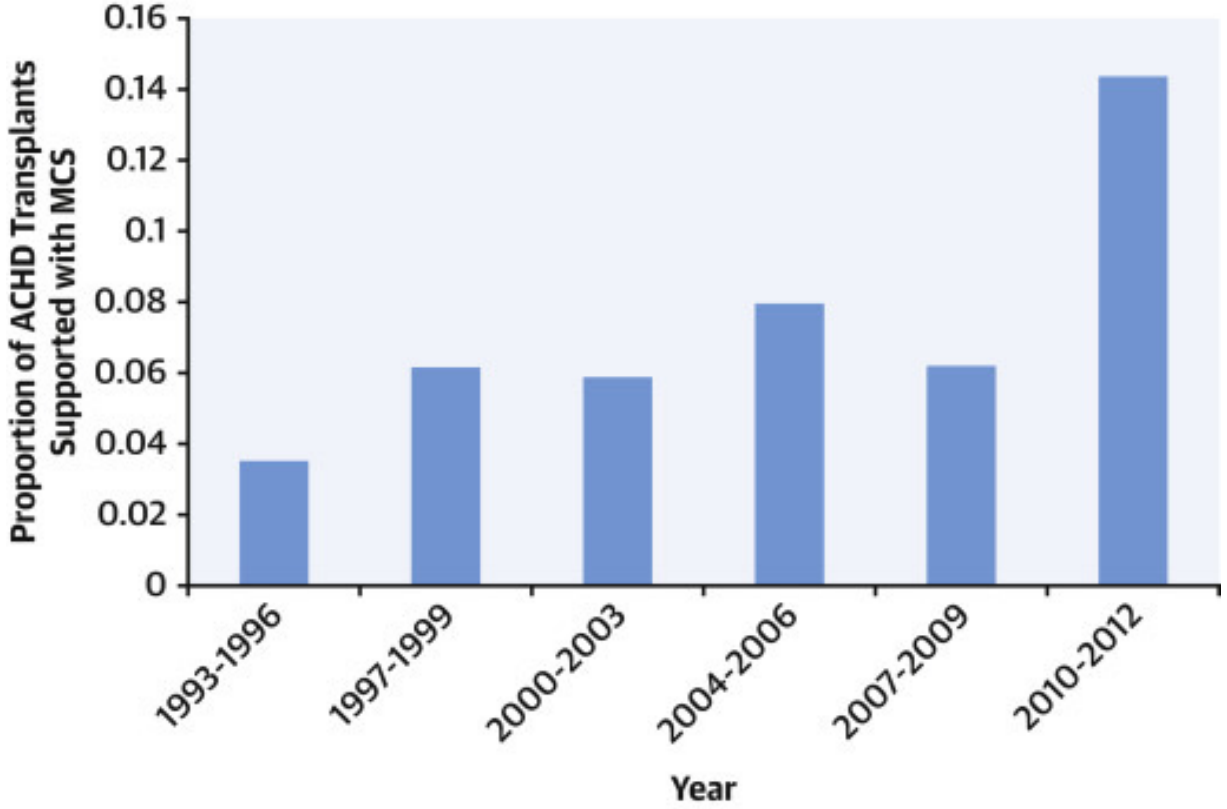
- Median follow up - 8 years
- Primary outcomes – Death/Transplant/MCS
- Secondary outcomes- HF hospitalizations

CRT Therapy

Indications	Results
• Functional class ≥II, impaired SRV function, and right bundle-branch block • LV pacing with SRV desynchrony and dysfunction	• Improvement in SRV systolic and diastolic function and in functional class • No benefit on tricuspid valve regurgitation • Bridge to Mechanical assist device or HT.

Eur Heart J. 2016; *37*:1419–1427

Ventricular Assist Devices



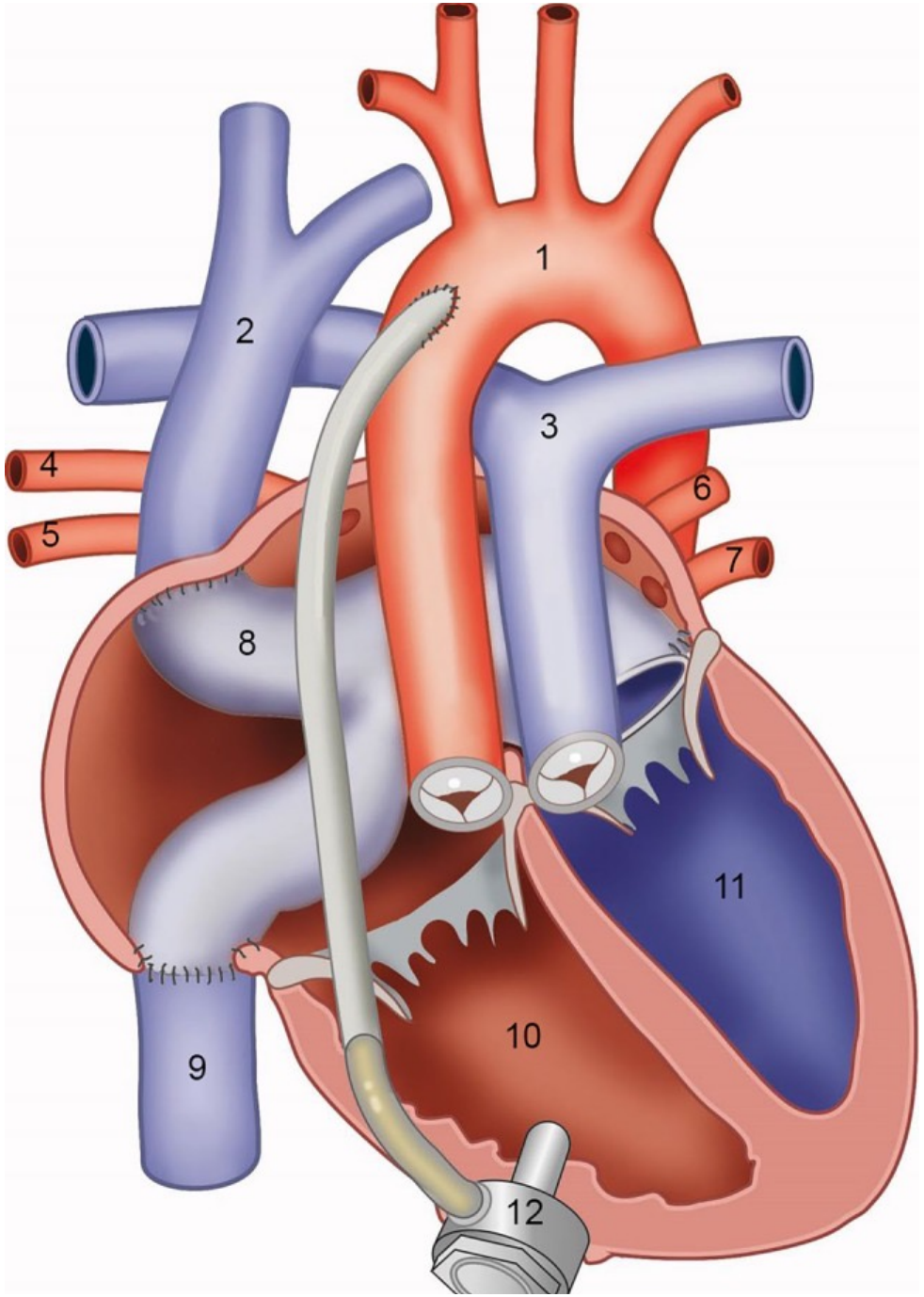
LVAD 81%, RVAD 6%, BIVAD 7%, TAH 6%

ACHD patients supported with MCS:

<4% from 1993 to 1996
6% between 2000 and 2009
>14% from 2010 to 2012

Longer Hospital stay
No difference in 30-day mortality or long term survival post transplant

Michael M. Givertz et al.JACC ,2019 Volume 74, Issue 18



Advance Heart Therapies

Technical Challenges in Systemic RV

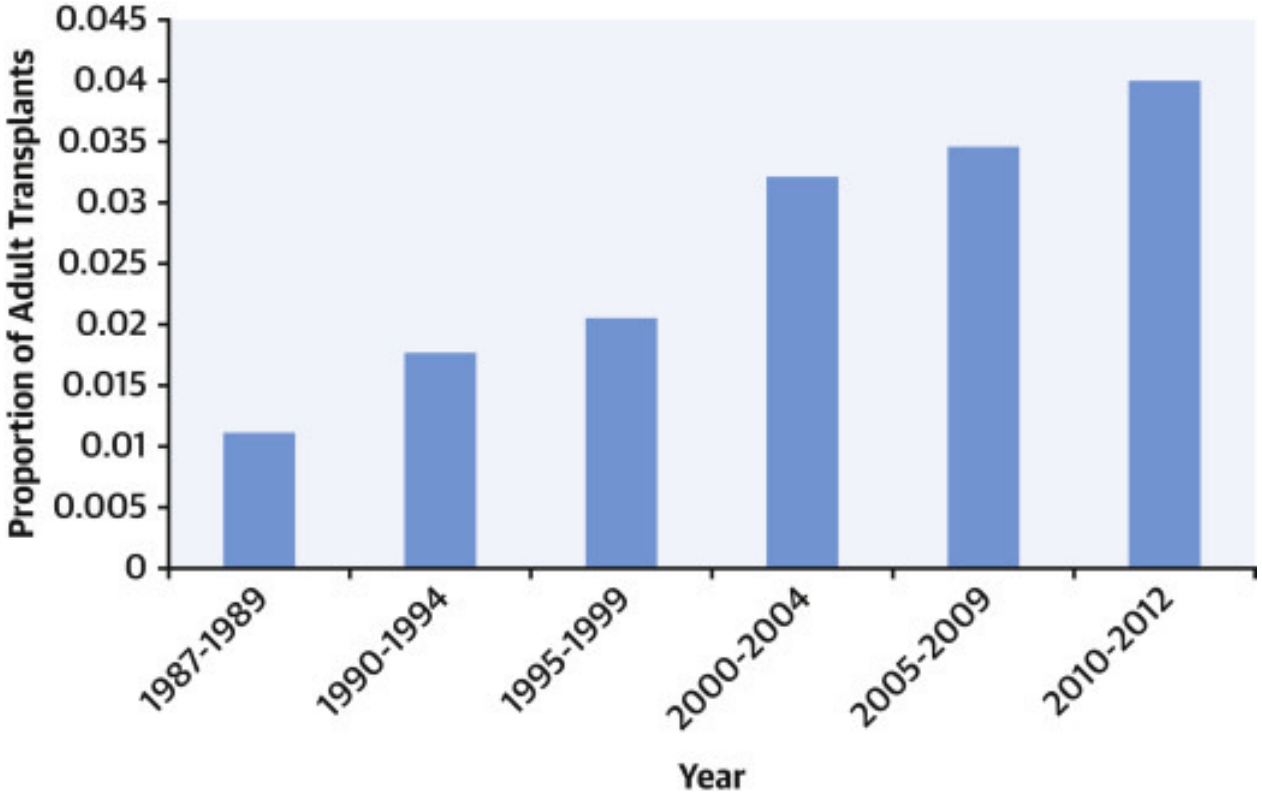
- Difficulty positioning cannula due to anatomic constraints
- Significant trabeculae and moderator band in SRV
- Prior sternotomies

* Positive hemodynamic results after adequate positioning

Zandstra et.al. 2018

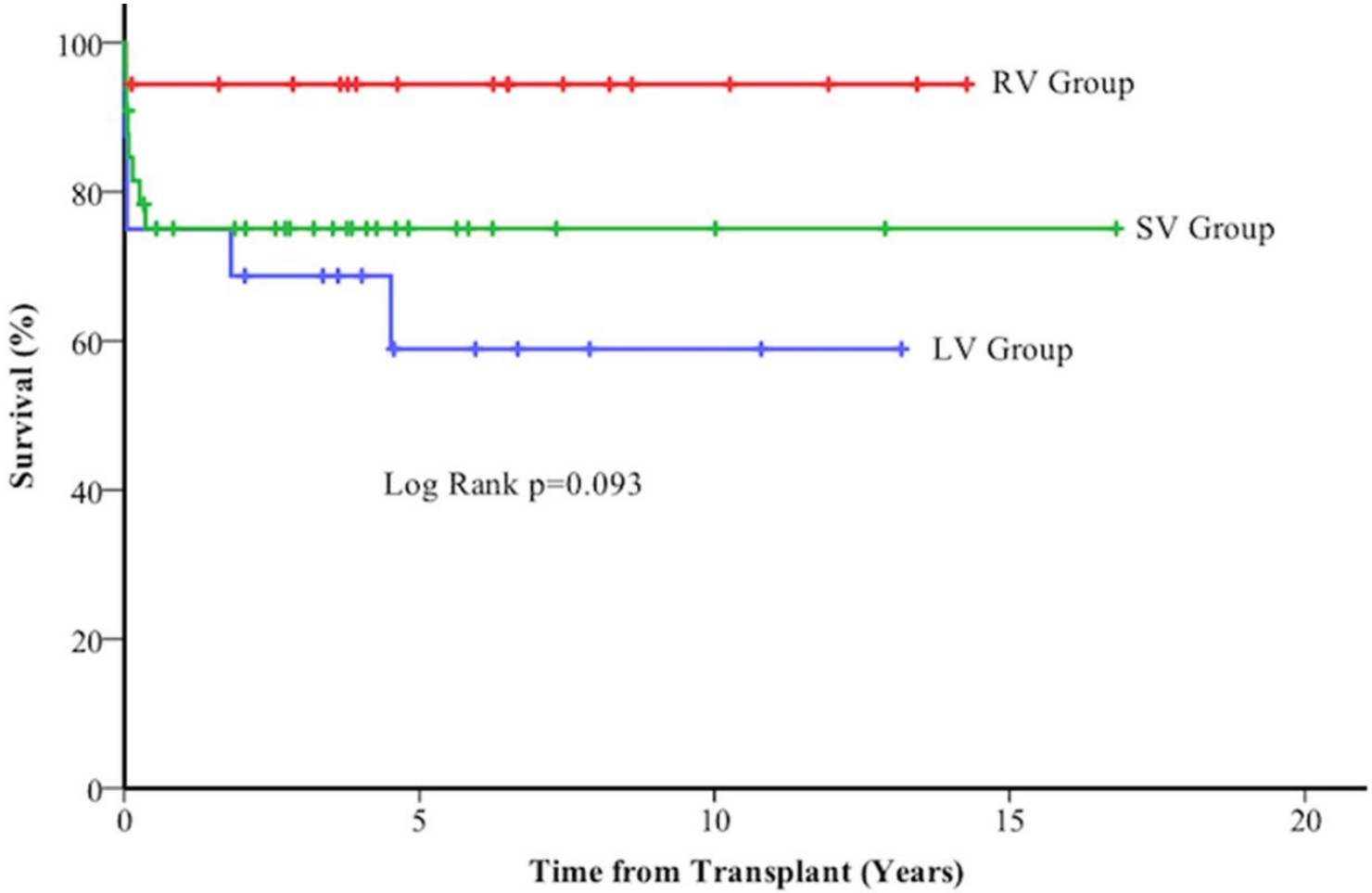
Heart Transplantation in CHD

- >50% are single ventricle followed by DTGA or L-TGA
- ACHD is an independent risk factor for 30-day and 1-year mortality following a heart transplant.
- Survival Paradox with better long-term survival at 10y



D. Boucek et al. International Journal of Cardiology 172 (2014) e89–e9

Transplant Outcomes



Number at Risk	0 years	5 years	10 years	15 years
RV Group	18	10	4	0
SV Group	33	7	3	1
LV Group	16	5	2	0

The RV group survival was >90% at 10 year follow up

Crossland DS, et.al. *Heart*. 2019 Nov;105(22):1741-1747.

JOURNAL ARTICLE

Pregnancy outcomes in women with a systemic right ventricle and transposition of the great arteries. Results from the ESC-EORP Registry of Pregnancy and Cardiac disease (ROPAC)

O Tutarel, L Baris, M Johnson, R Hall, J.W Roos-Hesselink ROPAC Investigators Group

European Heart Journal, Volume 41, Issue Supplement_2, November 2020,

ESC
European Society of Cardiology

- 163 women with sRV (D-TGA atrial switch or CC-TGA)
- 26 MACE (HF most common, then arrhythmias)
- Predictors of MACE : pre-pregnancy signs of HF and SRV EF <40%
- No deaths
- No changes in echocardiogram parameters pre and post partum
- No deterioration in sRV EF

Take Home Message

- Patients with SRV, are at increased risk for ventricular dysfunction due to pressure overload
- sRV has anatomical and physiological differences that present a challenge for HF management
- Newer agents, such as ARNI or SGLT-2 inhibitors may show some positive results for SRV HF management
- CHD patients have a “survival paradox” post-heart transplant
- Pregnancy does not seem to affect sRV function

Questions ?

Info :
carla.Rodriguez@cardio.chboston.org
drcrodriguez@achdbcaribbean.org

Gracias ....