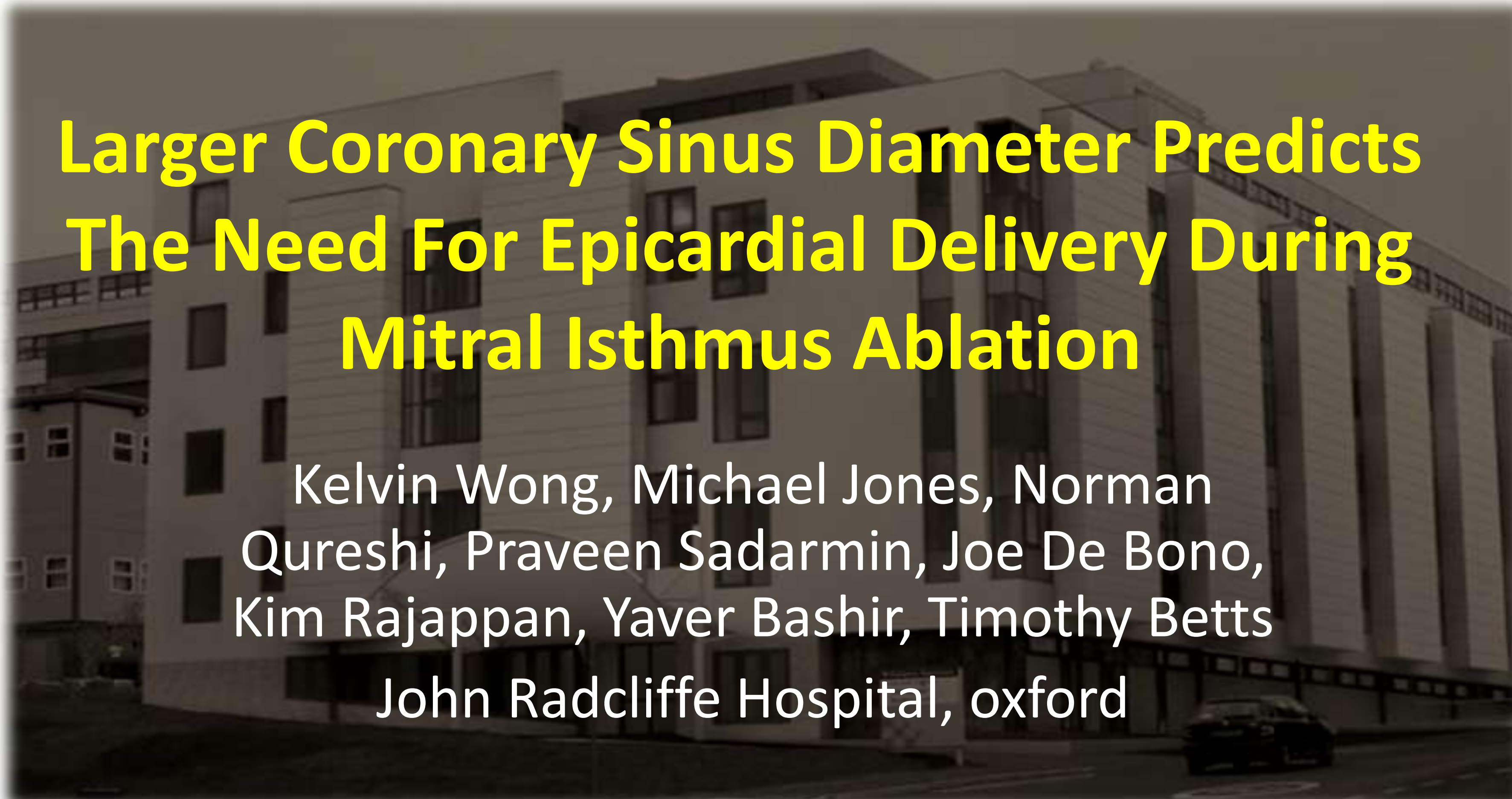
Heart Rhythm Congress 2010

Oxford Heart Centre

Oxford Radcliffe Hospitals NHS Trust



Larger Coronary Sinus Diameter Predicts The Need For Epicardial Delivery During Mitral Isthmus Ablation

Kelvin Wong, Michael Jones, Norman Qureshi, Praveen Sadarmin, Joe De Bono, Kim Rajappan, Yaver Bashir, Timothy Betts

John Radcliffe Hospital, oxford

Supported by unrestricted educational grants from St Jude Medical and Medtronic

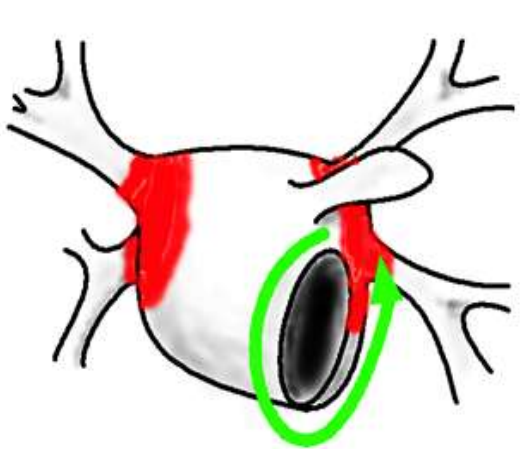
Background

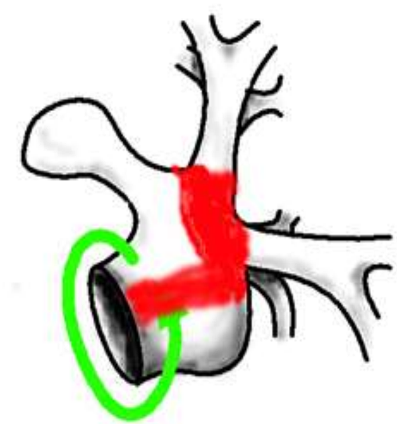
- Incremental benefit of mitral isthmus ablation in paroxysmal (15-20%) and persistent AF (20-40%)

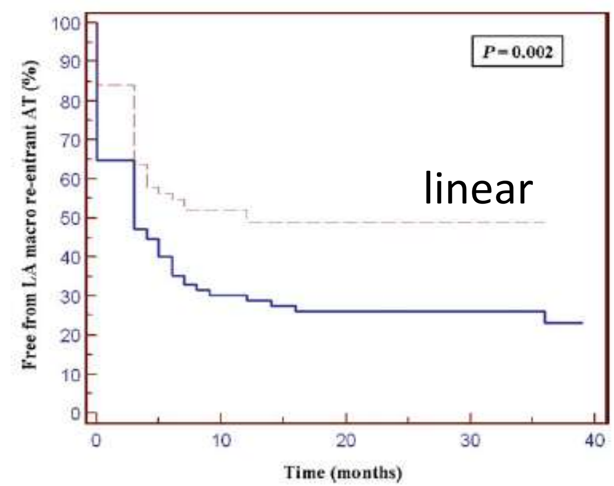
  (Jais Circ 2004, Fassini JCE 2005, Willems EHJ 2006, Gaita Circ EP 2008)

- Treatment and prevention of perimitral flutter

  (Chae JACC 2007, Pappone Circ 2004, Haissaguerre JCE 2005, Knecht EHJ 2008)

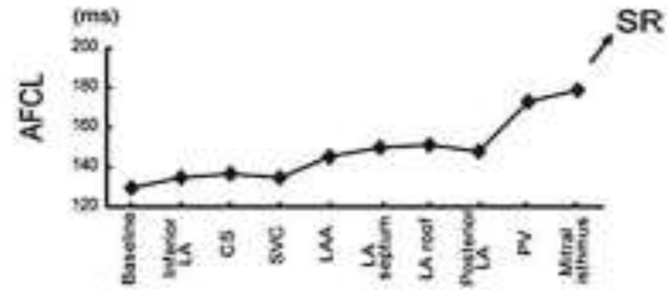






Part of the “stepwise” approach

- Linear ablation responsible for termination in about 20% of cases (Haissaguerre JCE 2005; O’Neil EHJ 2009)
- 40% of patients had significant AFCL prolongation during linear ablation (Haisaguerre JCE 2005)
- 86% of patients ultimately needed a mitral isthmus line (Knecht EHJ 2008)



Site of AF termination	Number of patients
Left atrium ($n = 118$)	
Inferior LA	11
CS os	2
CS (epicardial)	17
Left atrial appendage	25
Mitral isthmus	17
Pulmonary veins	14
Interatrial septum	12
Roof	8
Posterior LA	6
Anterior LA	4
Lateral LA	2
Right atrium ($n = 12$)	
Right atrial appendage	4
Intercaval	3
Cavotricuspid isthmus	2
Superior vena cava	2
Foramen ovale	1

Mitral isthmus ablation is challenging!

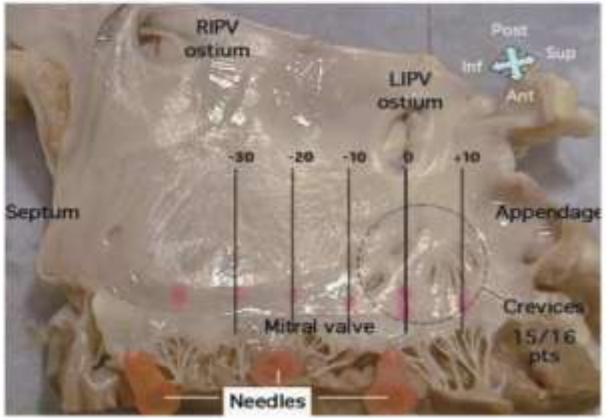
- Mitral isthmus ablation often requires
  - substantial ablation: >15 min
  - High ablation powers
  - epicardial ablation in the CS to achieve block: >70%
  - Only moderate success: 31% - 92%

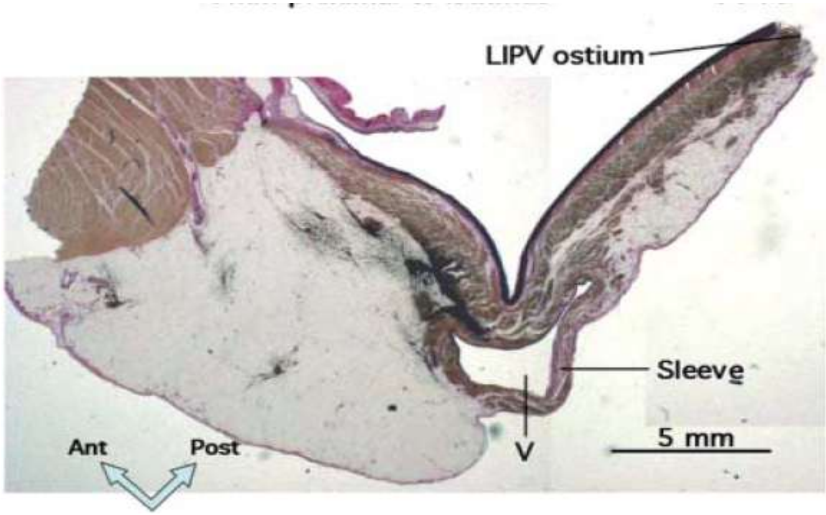
  (Jais et al. Circ 2004; Fassini et al. JCE 2005; Knecht et al. EHJ 2008; Willems et al. EHJ 2006; Gaita et al. Circ EP 2008)

- Higher complication rates of tamponade and circumflex artery injury associated with the use of higher ablation powers *(Jais Circulation 2004; Takahashi JCE 2005; Takatsuki EP 2009; Wong EP 2010)*

Obstacles to mitral isthmus ablation

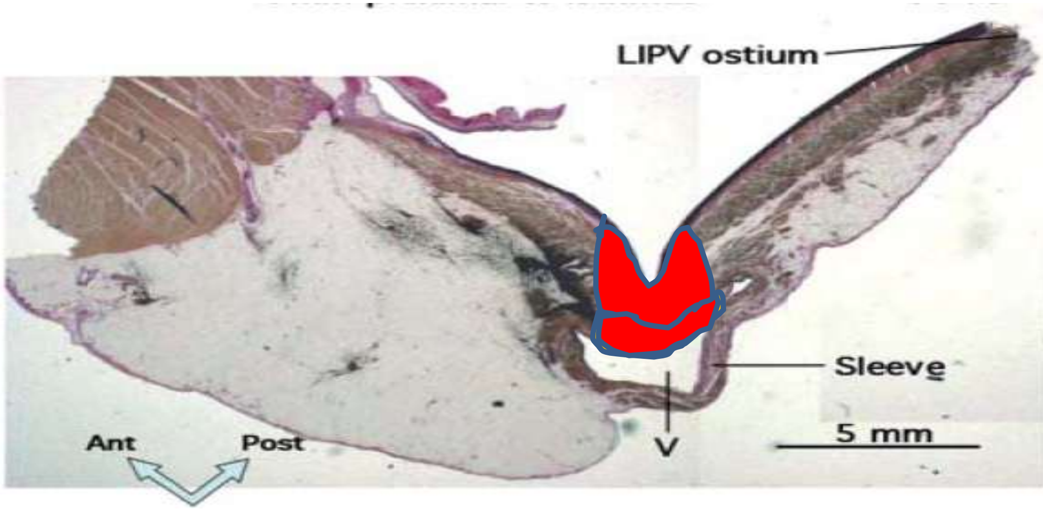
- Depth
- Length
- Recesses and crevices
- Myocardial sleeve around CS
- Extension of atrial myocardium to MV

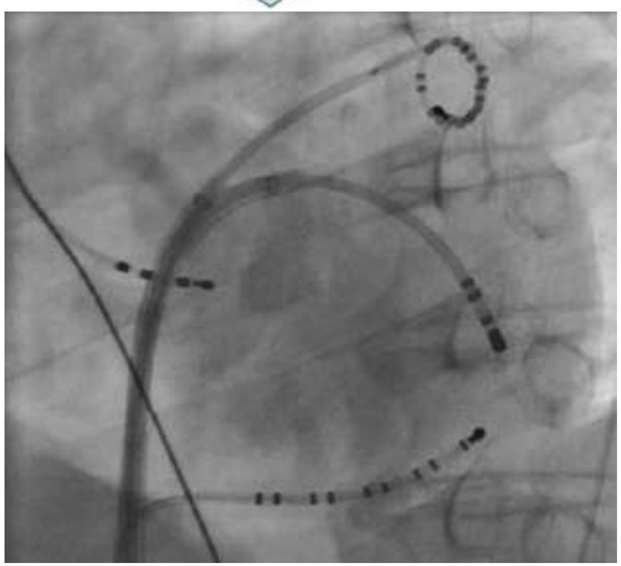


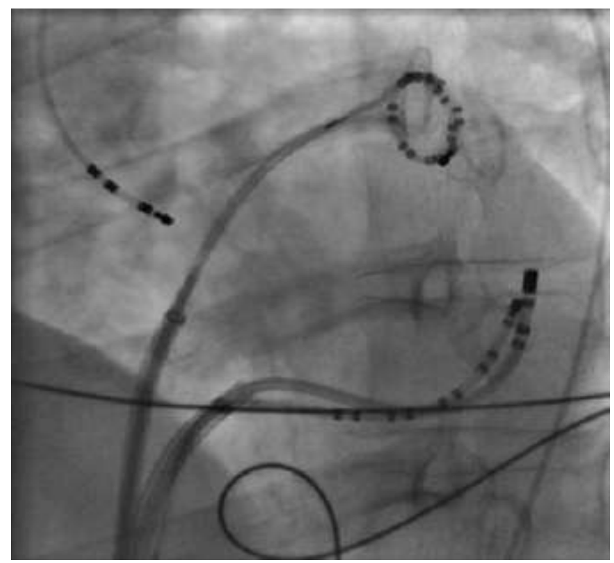


Wittkampf EHJ 2005;
Becker JCE 2004

CS acting as "heat sink"

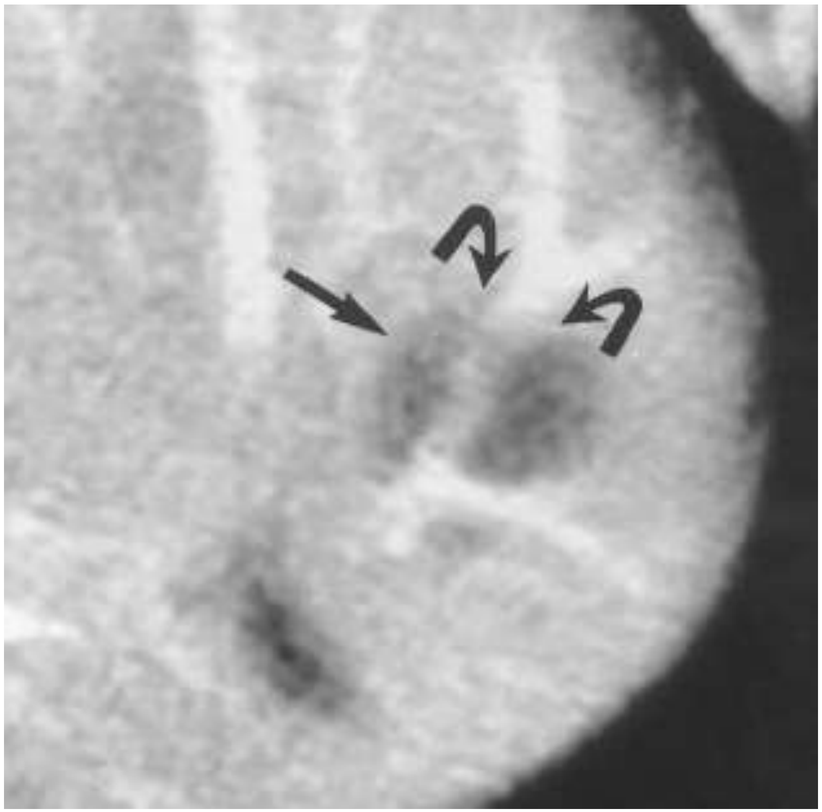


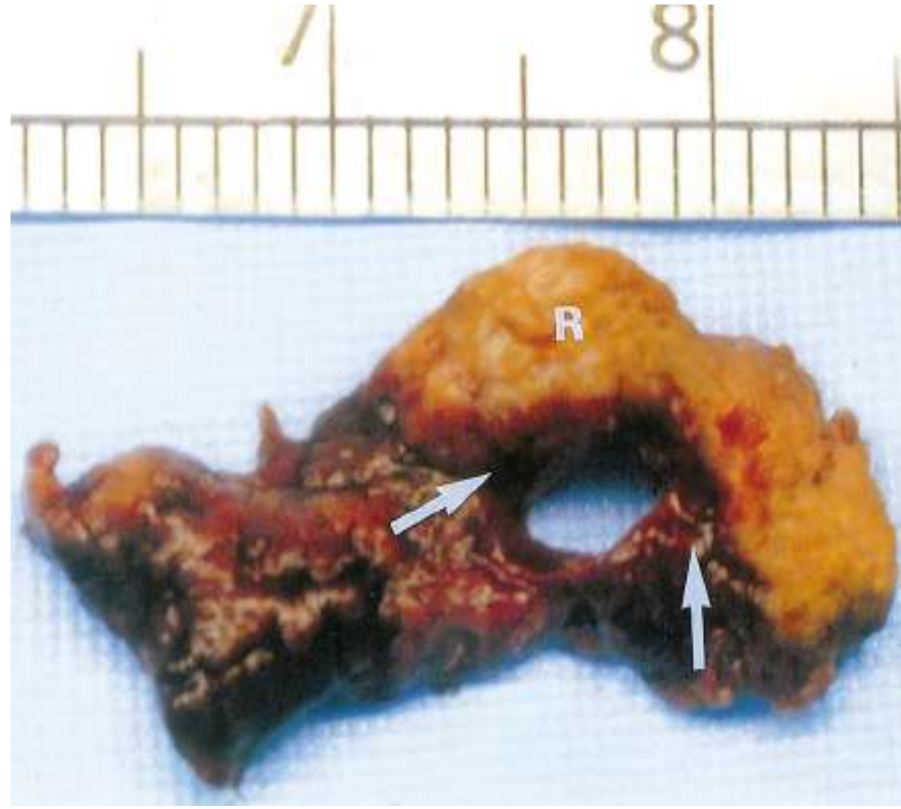




Wittkampf EHJ 2005

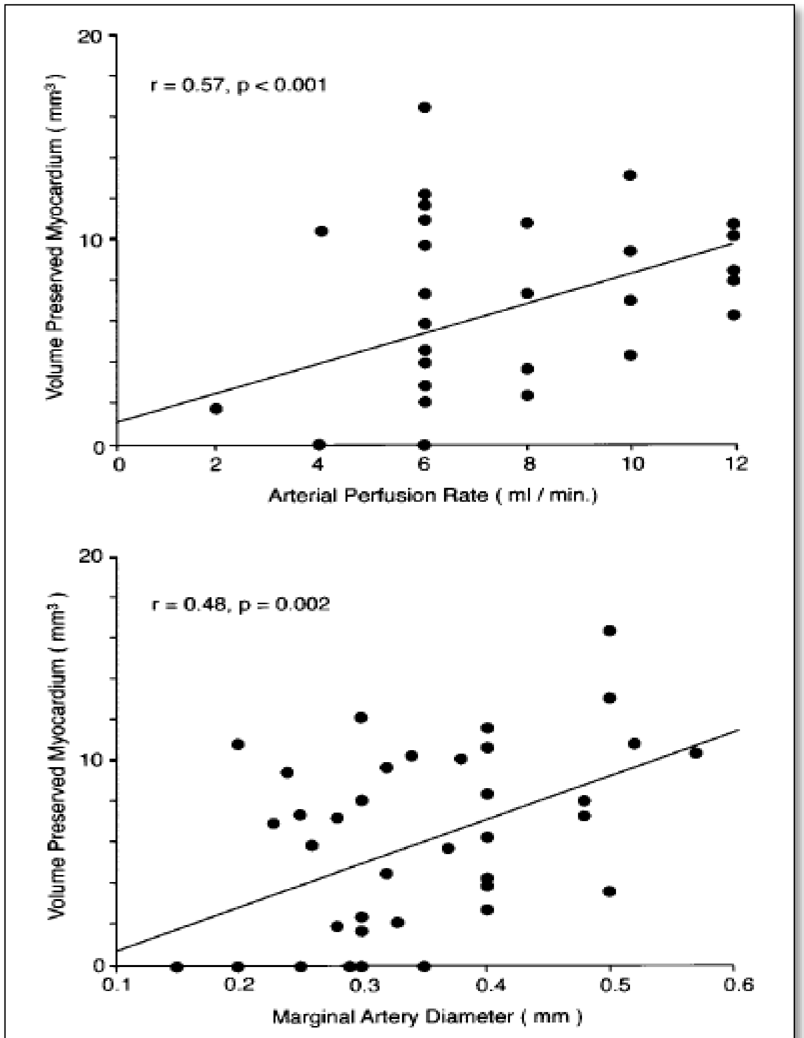
“Heat sink” effect in hepatic RFA

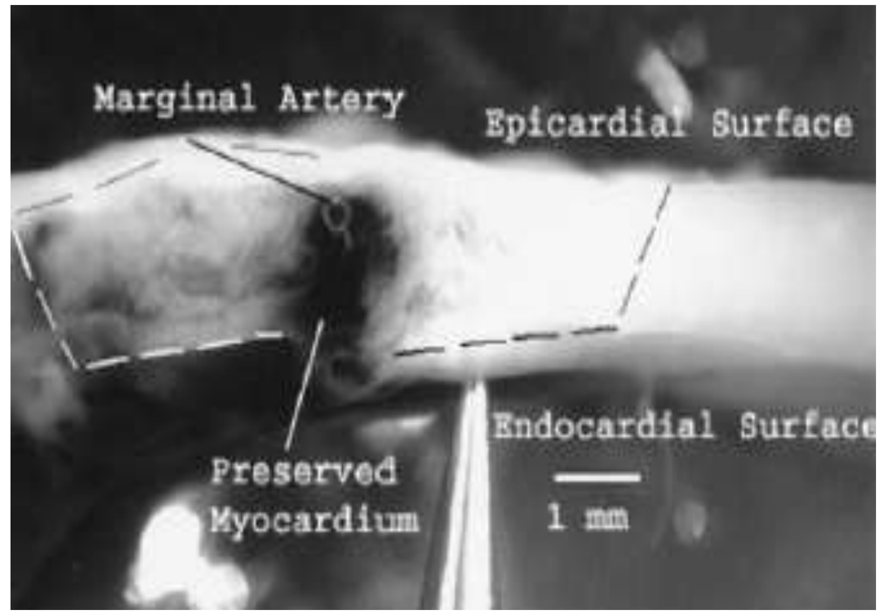




Lu AJR 2002

In vitro study





Fuller Circulation 2003

Objective

- To investigate the effect of CS and Cx anatomy (especially the diameter) on mitral isthmus ablation.

Methods

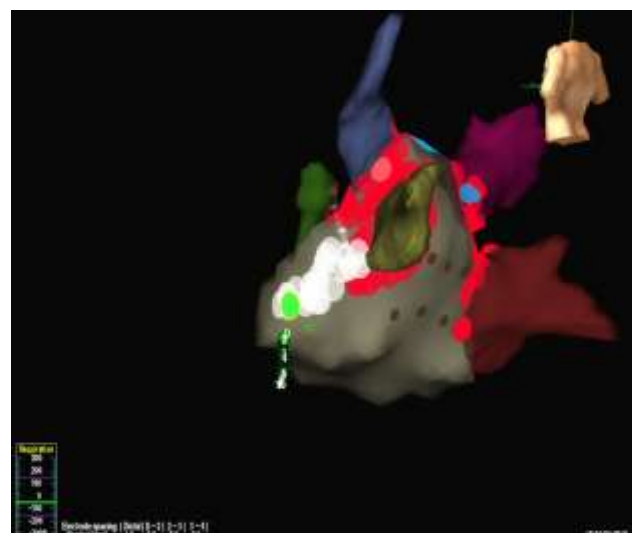
- prospective, single centre, non-randomized cohort study
- Patients with persistent and paroxysmal (long paroxysms) who had AF ablation including mitral isthmus line were recruited

Study protocol

- Circumferential pulmonary vein isolation and roof line was performed initially. Patients still in AF had DCCV to SR

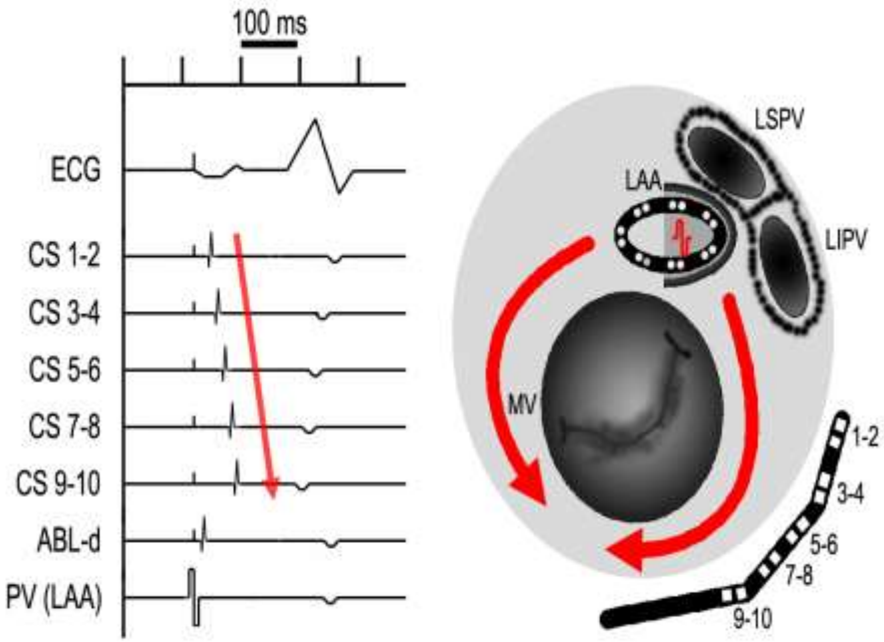
- Mitral isthmus ablation performed during left atrial appendage (LAA) pacing with the following settings:
  - Endocardial: max power:40W at the annular end, 30-40W at the venous end; max temp:48°C; flow rate:17ml/min
  - CS: max power:25W; max temp:48°C; flow rate: 17ml/min

- After at least 10 minutes of endocardial ablation and no atrial EGMs along line, ablation was performed in distal CS for up to 5 minutes. Further ablation was at the discretion of the operators

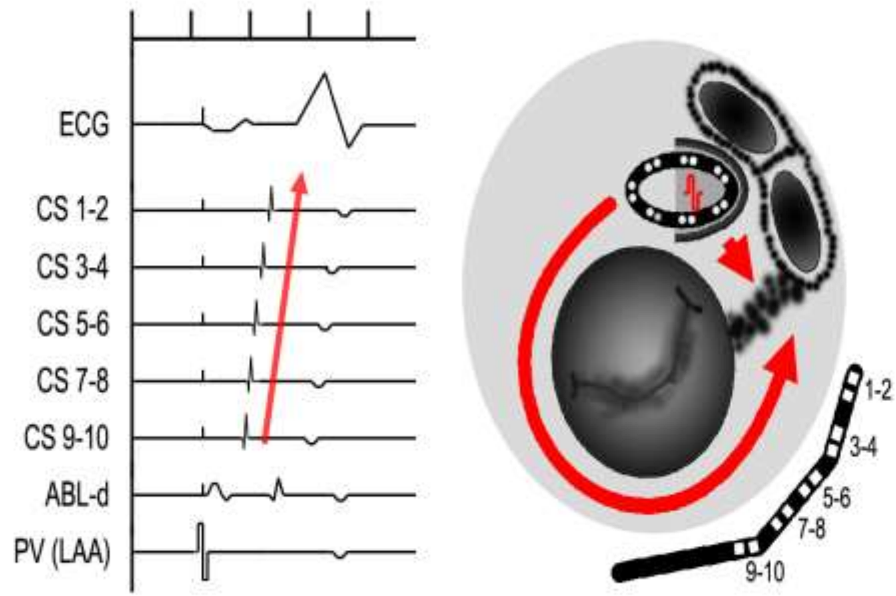


Assessing mitral isthmus block

No mitral isthmus block



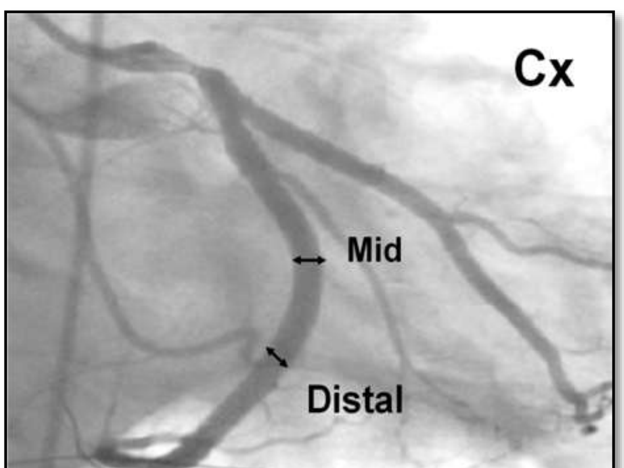
Mitral isthmus block

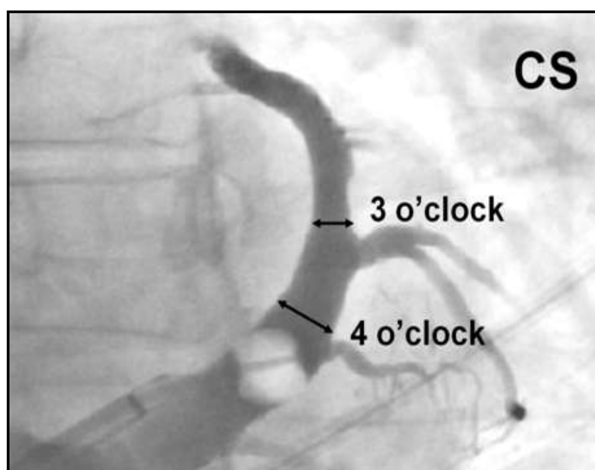


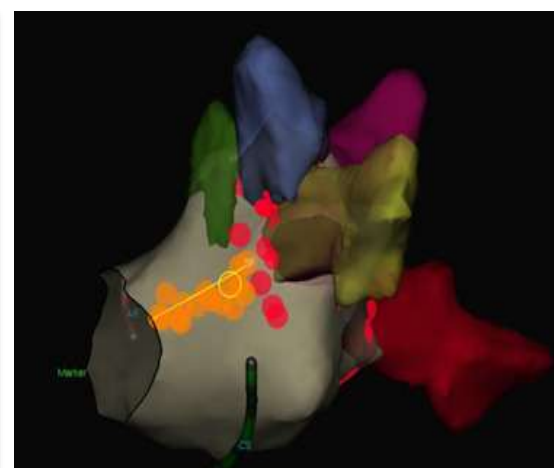
Change to a proximal to distal CS activation signifies block
(Paisey et al. JCE 2009)

Study Protocol

- Left coronary angiography was performed pre- and post-ablation in the following 3 caudal views (20˚ to 30˚):
  - left anterior oblique (LAO 30˚ to 45˚)
  - anteroposterior (AP, 0)
  - right anterior oblique (RAO 30˚ to 45˚)
- Analysed off line by 2 cardiologists blinded to the procedure with the aid of Quantitative Coronary Angiography (QCA, Siemens, Germany)
- Position of mitral isthmus line determined as 3 or 4 o'clock in the LAO caudal view
- Measurement of mitral isthmus length







Results

- Mean procedure and fluoroscopy times were 179±32 min and 62±22 min respectively
- 31 of 35 (89%) patients achieved mitral isthmus block; 74% needed CS ablation to achieve block
- Mean total mitral isthmus ablation time was 14±5.9 min (Endocardium: 9.9±3.3 min; CS: 4±3.4 min)
- Mean mitral isthmus procedure time was 30±19 min

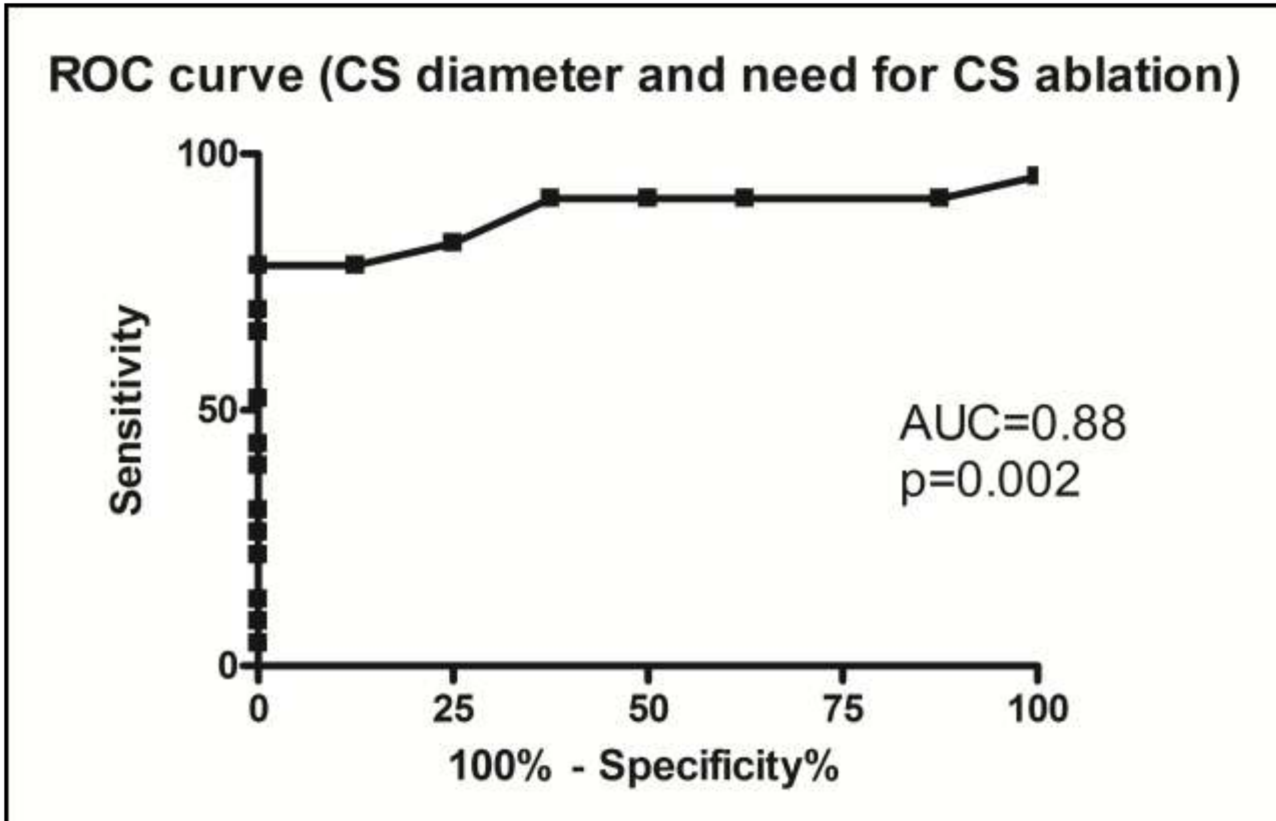
Baseline characteristics

	No CS ablation (n=8)	CS ablation (n=23)	P value
Clinical factors			
Age	58±12	60±10	ns
Male	7 (88%)	16 (70%)	ns
Persistent AF	7 (88%)	14 (61%)	ns
Cardiovascular diasease	4 (50%)	8 (35%)	ns
Impaired LV function	2 (25%)	1 (4%)	ns
LA diameter (mm)	44±7	43±5	ns
MI length (mm)	26±9	37±9	<0.008
Ablation characteristics			
Total MI ablation time (min)	5.9±2.5	15.3±3.4	<0.0001
MI procedure time (min)	13±20	30±14	<0.04
Ablation @ 3 o'clock	4 (50%)	12 (52%)	ns

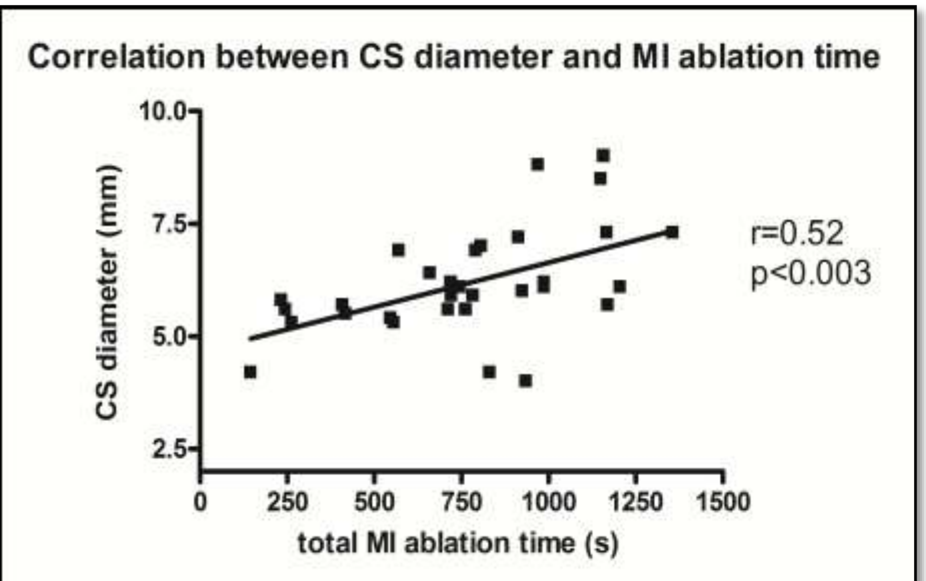
Larger CS diameter associated with CS ablation

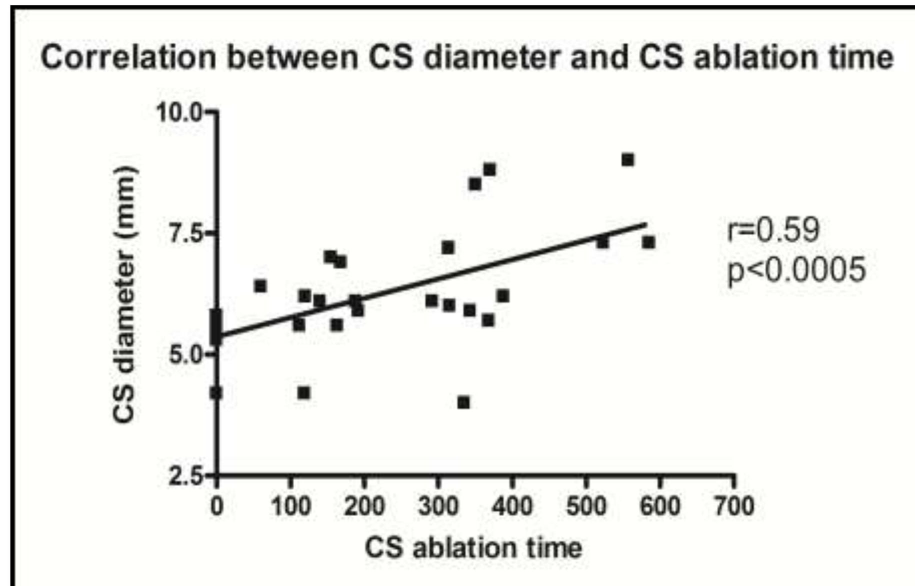
	No CS ablation (n=8)	CS ablation (n=23)	P value
Coronary sinus (CS)			
CS diameter @ 3 o'clock (mm)	5.4±0.5	6.5±1.2	<0.02
CS diameter @ 4 o'clock (mm)	6.1±1.1	7.2±1.5	0.06
"Mean" CS diameter (mm)	6.8±1.3	5.7±0.6	<0.03
"Adjusted" CS diameter (mm)	6.8±1.6	5.6±0.6	<0.04
CS branch between 3 & 4 o'clock	4 (50%)	17 (74%)	ns
Circumflex artery (Cx)			
Mid Cx diameter (mm)	2.6±1.0	2.2±0.8	ns
Distal Cx diameter (mm)	2.1±1.3	1.7±0.7	ns
Dominant Cx	3 (38%)	3 (13%)	ns
No. of OM branches (median)	1	2	ns
Presence of CAD in Cx	0 (0%)	5 (22%)	ns

CS diameter>5.9cm predicts need for CS ablation (specificity 100%; sensitivity 78%)

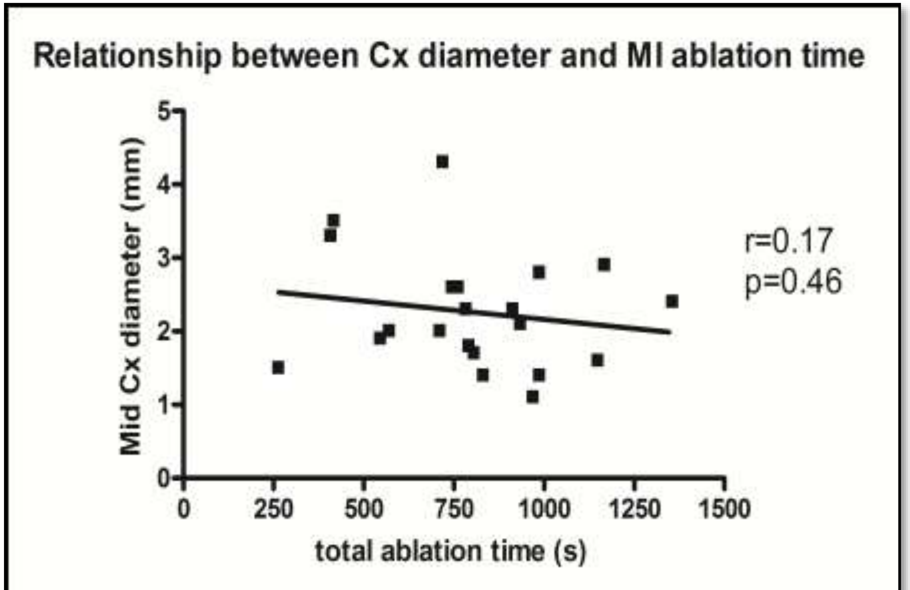


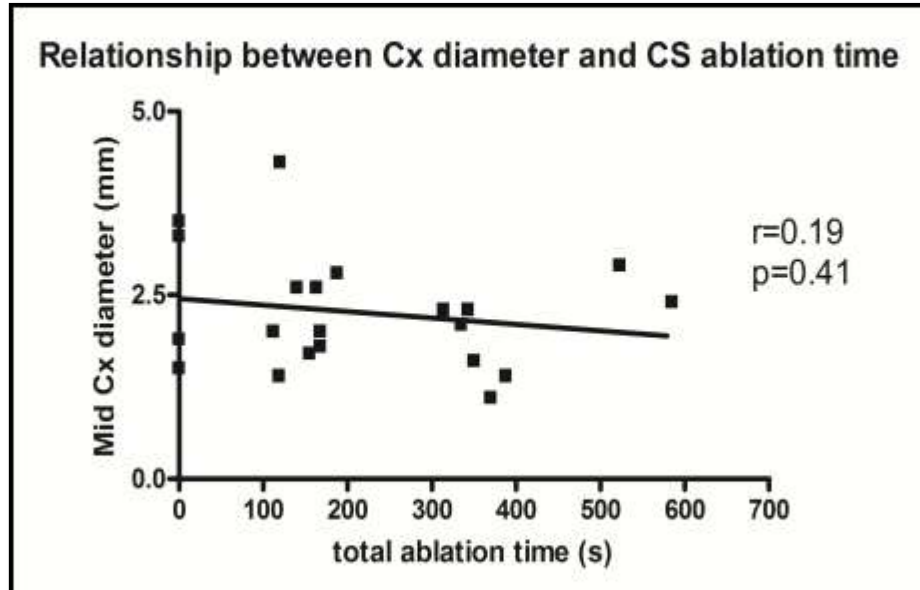
Correlation of CS diameter with total MI ablation and CS ablation times



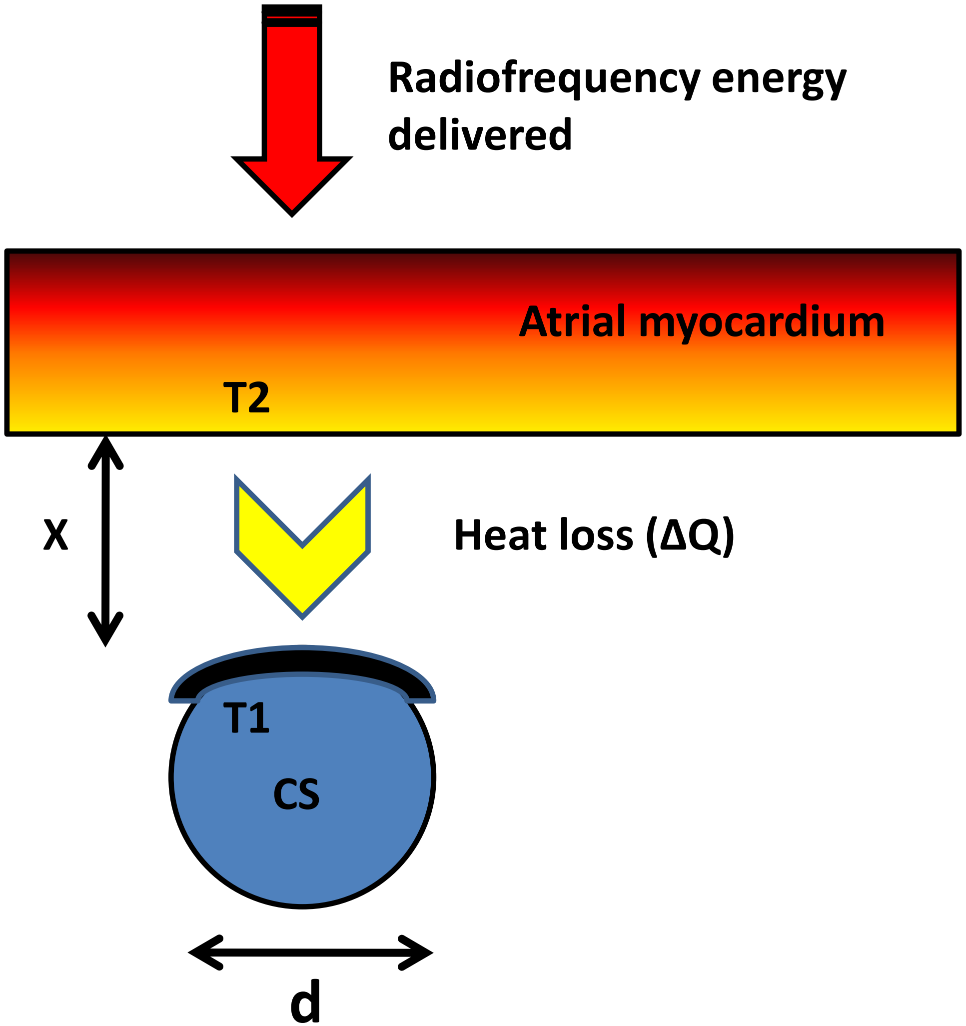


Cx diameter not correlated with ablation times





Fourier law of heat conduction



$$\frac{\Delta Q}{\Delta t} = \frac{-kA(T2-T1)}{x}$$

where

- $\Delta Q/\Delta t$ is the heat flow rate,
- k is the coefficient of heat conductivity,
- A is the cross sectional area (vessel)
- $T2-T1$ is the temperature gradient and
- x is the distance.

Why CS and not Cx?

- Difference in diameter (6.3 vs 2.2 mm)

TABLE 4 Histologic Analysis of Hepatic Vein Injury and Heat Sink Effect

	Endothelial Injury of Portal Vein				Heat Sink Effect[a]	
Vessel Size (mm)	Complete	Partial	No Injury	Thrombus[b]	No	Yes
<2	48	—	—	48	48	—
2–3[c]	7	—	—	3	7	—
3–4	6	1	—	4	6	1
4–5	2	—	—	1	2	—
5–6	—	2	—	1	—	2
6–7	—	1	—	—	—	1
7–8	—	1	—	—	—	1
8–9	—	1	—	—	—	1
9–10	—	—	—	—	—	—
>10	—	—	2	—	—	2

Lu et al. American Journal of Radiology 2002

- Cx may have a more ventricular and epicardial position relative to the CS at the lateral mitral annulus
(El-Maasarany et al. Europace 2005; West et al. Heart Rhythm 2008)

Study limitations

- Small single centre study
- Full thermodynamic modelling not performed:
  - distance from the endocardial surface and of the mitral isthmus to the CS and Cx vessels,
  - blood flow rates and temperature measurements
- Confounding factors not excluded
- Findings only applicable to our technique and ablation power settings

Conclusion

- Patients who needed additional CS ablation to achieve mitral isthmus block had significantly larger CS diameters
- CS diameter greater than 5.9mm predicted the need for CS ablation with a high specificity
- CS diameter but not Cx artery diameter was significantly correlated with total mitral isthmus ablation time and CS ablation time

Support the hypothesis that the “heat sink” effect secondary to CS (but not Cx) blood flow may hinder effective mitral isthmus ablation.

Acknowledgement

- Medical team: T Betts, K Rajappan, Y Bashir, M Jones, N Qureshi, J De Bono, P Sadarmin
- Arrhythmia nurses: A Griffiths, T Meredith
- Physiologists: J Cole, T Webb, H Tumman
- Catheter laboratory nursing staff
- Radiographers

MI length correlated with total MI ablation time but not CS ablation time