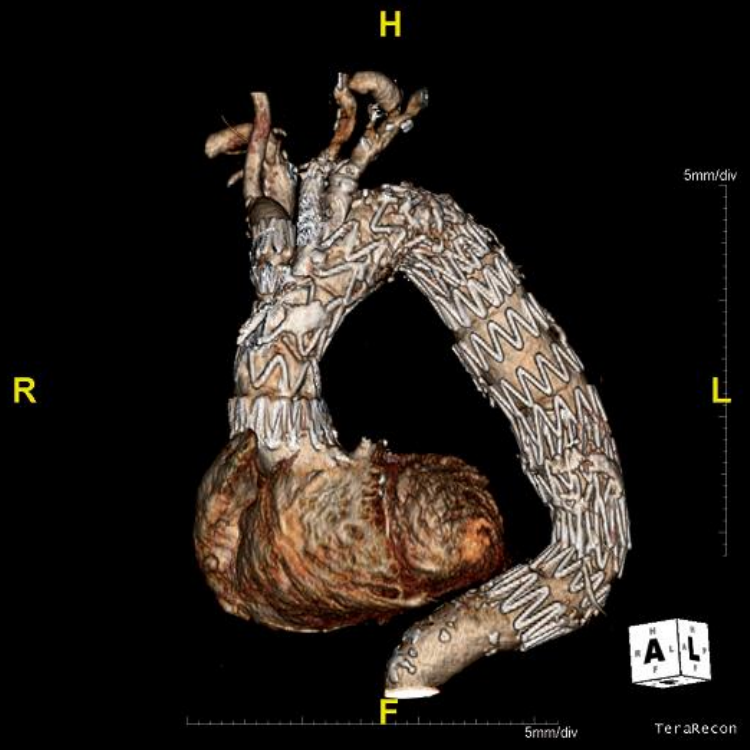
16TH INTERNATIONAL EXPERTS SYMPOSIUM

CRITICAL ISSUES

in aortic endografting 2012



May 24 & 25

LILLE, FRANCE 2012

Predicting type B aortic dissection outcomes with computational flow analysis

Richard Gibbs

Imperial Vascular Unit

St Mary's Hospital

London UK

Faculty Disclosure

Richard Gibbs

*I have **no financial relationships** to disclose.*

Objectives

Who needs early intervention to prevent acute complications?

Who needs early intervention to prevent long term dilatation?

Imperial College Healthcare NHS
NHS Trust

Survival of patients with type B dissection

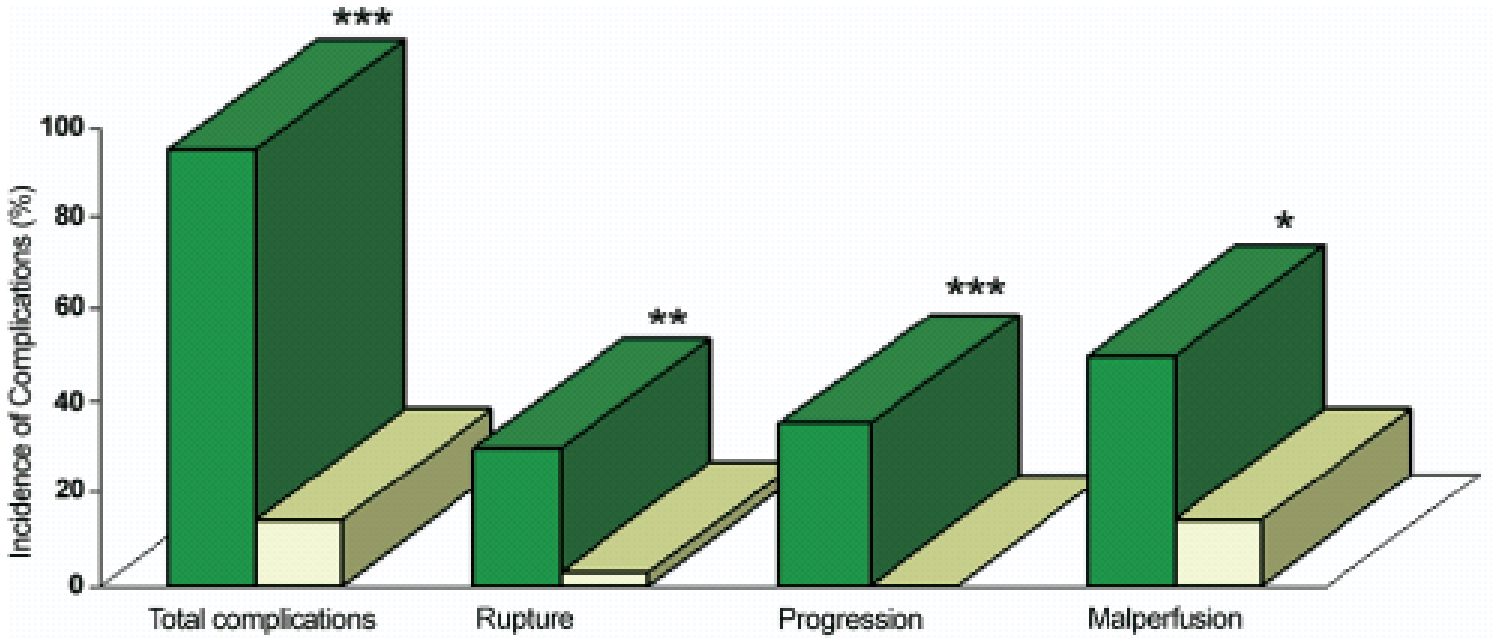
International registry of acute aortic dissection

uncomplicated complicated

Treatment	Medical	Surgical	Stent
n	78%	11%	11%
In hosp mortality	23/240 (10%)	12/42 (29%)	4/36 (11%)
1 year survival discharged alive	90.3%	95.8%	88.9%
3 year survival discharged alive	77.6%	82.8%	76.2%

Predicting the need for intervention:

Influence of maximal false lumen area on acute complications



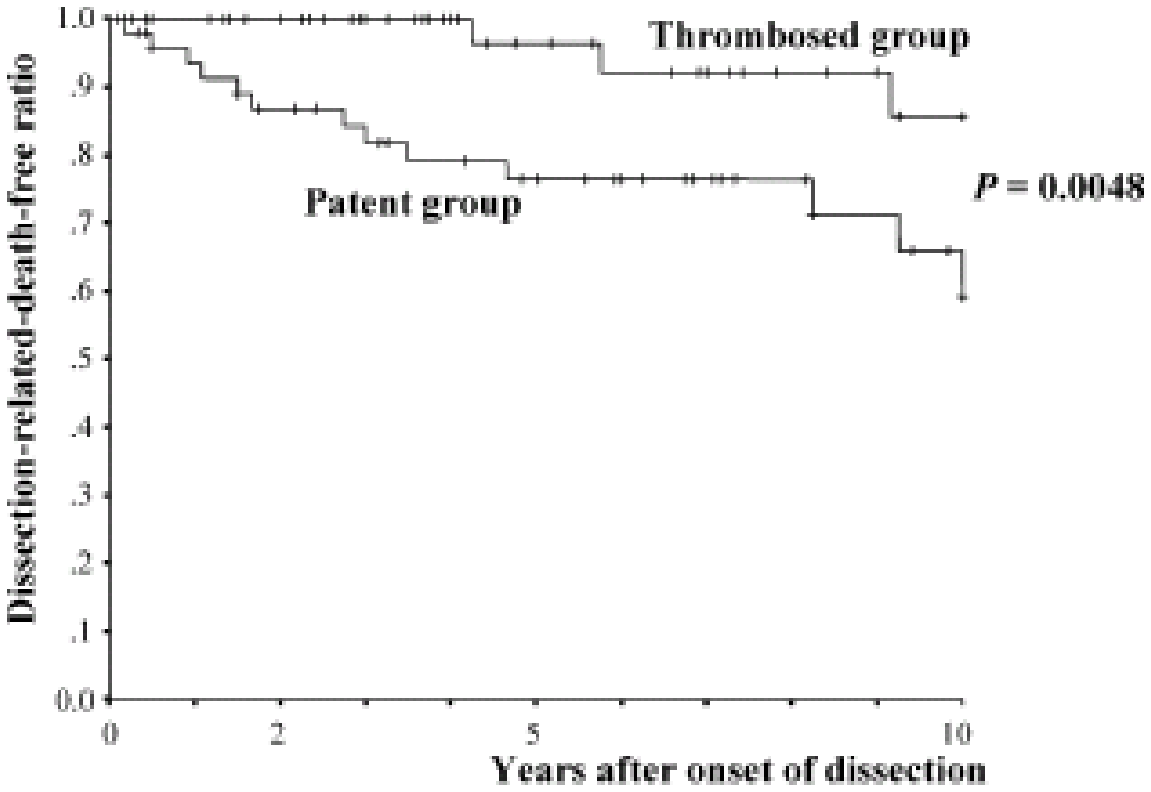
MFLA >922mm^2

MFLA <922mm^2

Chang *et al.* JACC 2008

Predicting the need for intervention:

Influence of patent false lumen on long term complications



Akutsu *et al.* EJCVS 2004

Predicting the need for intervention:

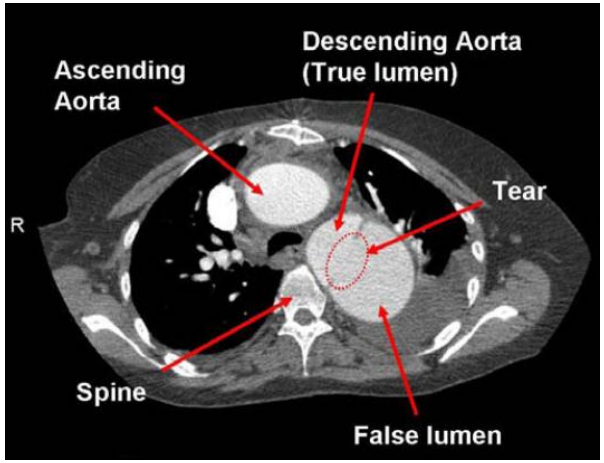
Influence of patent false lumen on future dilatation

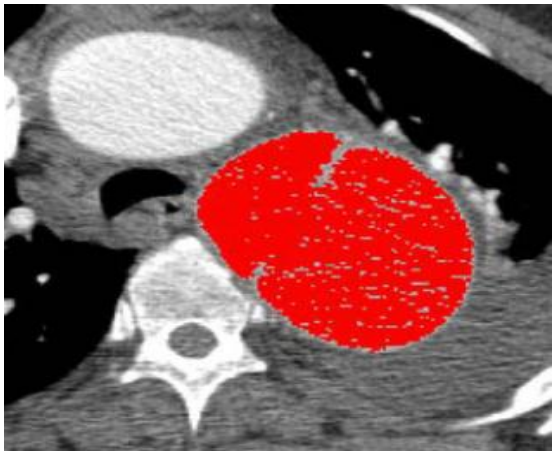
Risk Factors for Increase in Diameter

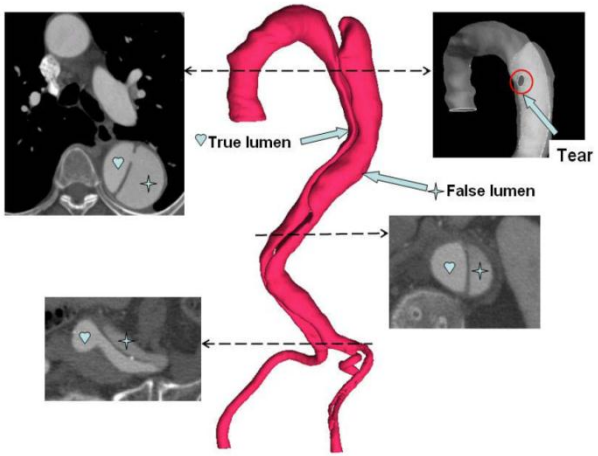
Patient Characteristics	Increase (n=132)	No Increase (n=45)	Univariate		Multivariate		
			χ^2	*P*	*P*	95%CI	OR
Gender, male, n (%)	79 (59.8)	33 (73.3)	2.08	0.1492	0.5762	0.205–2.415	0.703
Age <60 y, n (%)	79 (59.8)	35 (77.8)	4.71	0.0301	0.4556	0.257–1.839	0.688
Diabetes mellitus, n (%)	8 (6.1)	6 (13.3)	1.55	0.2138	0.9537	0.217–4.215	0.957
Atherosclerotic disease, n (%)	27 (20.5)	9 (20.0)	0	>0.9999	0.9313	0.328–2.779	0.954
Smoking <20 y, n (%)	23 (17.4)	13 (28.9)	2.06	0.1508	0.8632	0.306–2.701	0.909
Presence of blood flow in false lumen, n (%)	112 (85.6)	13 (28.9)	49.92	<0.0001	<0.0001	5.525–35.282	13.961
Entry site in arch, n (%)	117 (84.8)	37 (82.2)	1.22	0.2691	0.2729	0.662–4.293	1.686
Initial diameter <40 mm, n (%)	22 (16.7)	7 (15.6)	0	>0.9999	0.3074	0.565–6.112	1.859
COPD, n (%)	20 (15.2)	2 (4.4)	3.35	0.0654	0.1261	0.673–24.913	4.093
BP <140 mm Hg during follow-up period, n (%)	9 (6.8)	1 (2.2)	0.61	0.4192	0.3571	0.226–61.591	3.733

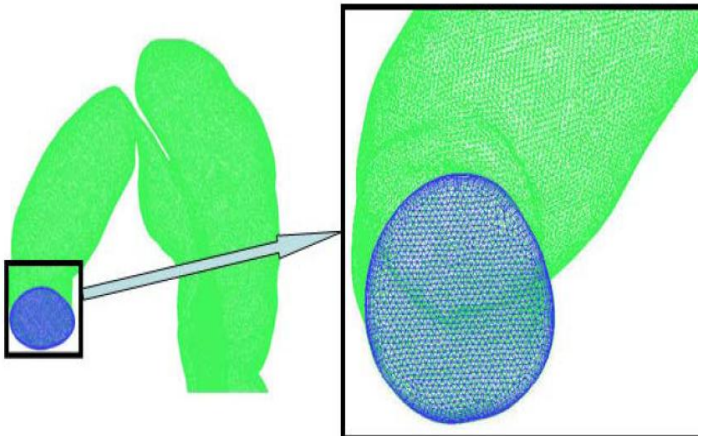
Sueyoshi E *et al.* Circulation 2004

Methods: Computational Fluid Dynamic Reconstructions





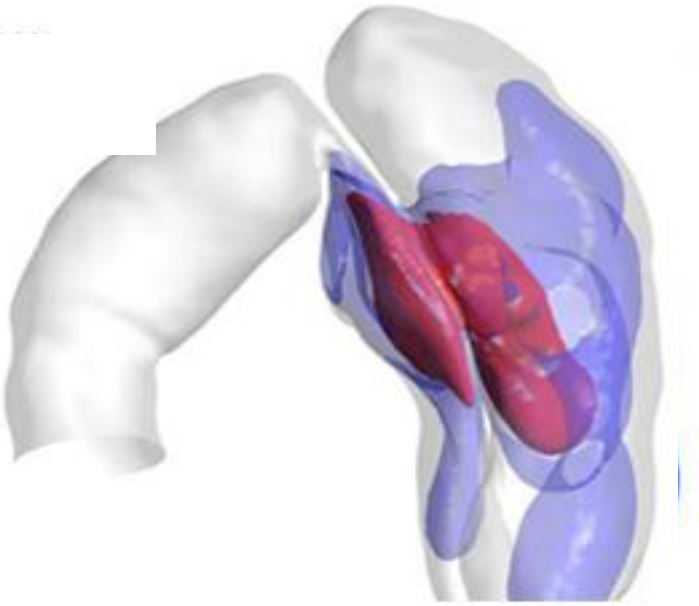




'Analysis of Flow Patterns in a Patient-specific Aortic Dissection Model'. Z. Cheng, F.P.P. Tan, C.V. Riga, C.D. Bicknell, M.S. Hamady, R.G.J. Gibbs, N.B. Wood, X.Y. Xu. ***Journal of Biomechanical Engineering***. 132(5), 2010

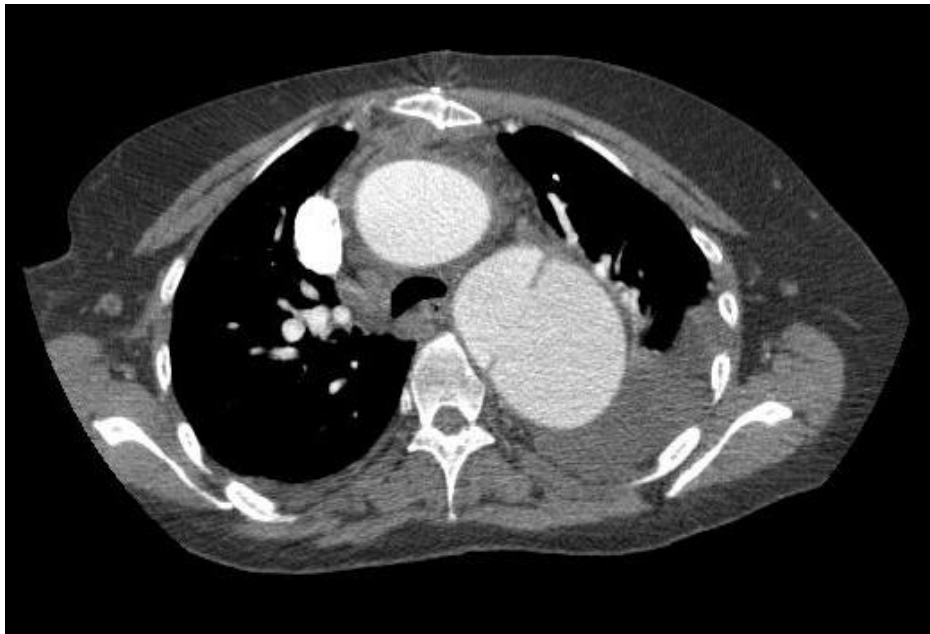
Methods: Computational Fluid Dynamic Reconstructions

- Aortic Morphology
- Entry Tear morphology
- Flow Velocity
- Wall Shear Stress
- Turbulence
- OSI



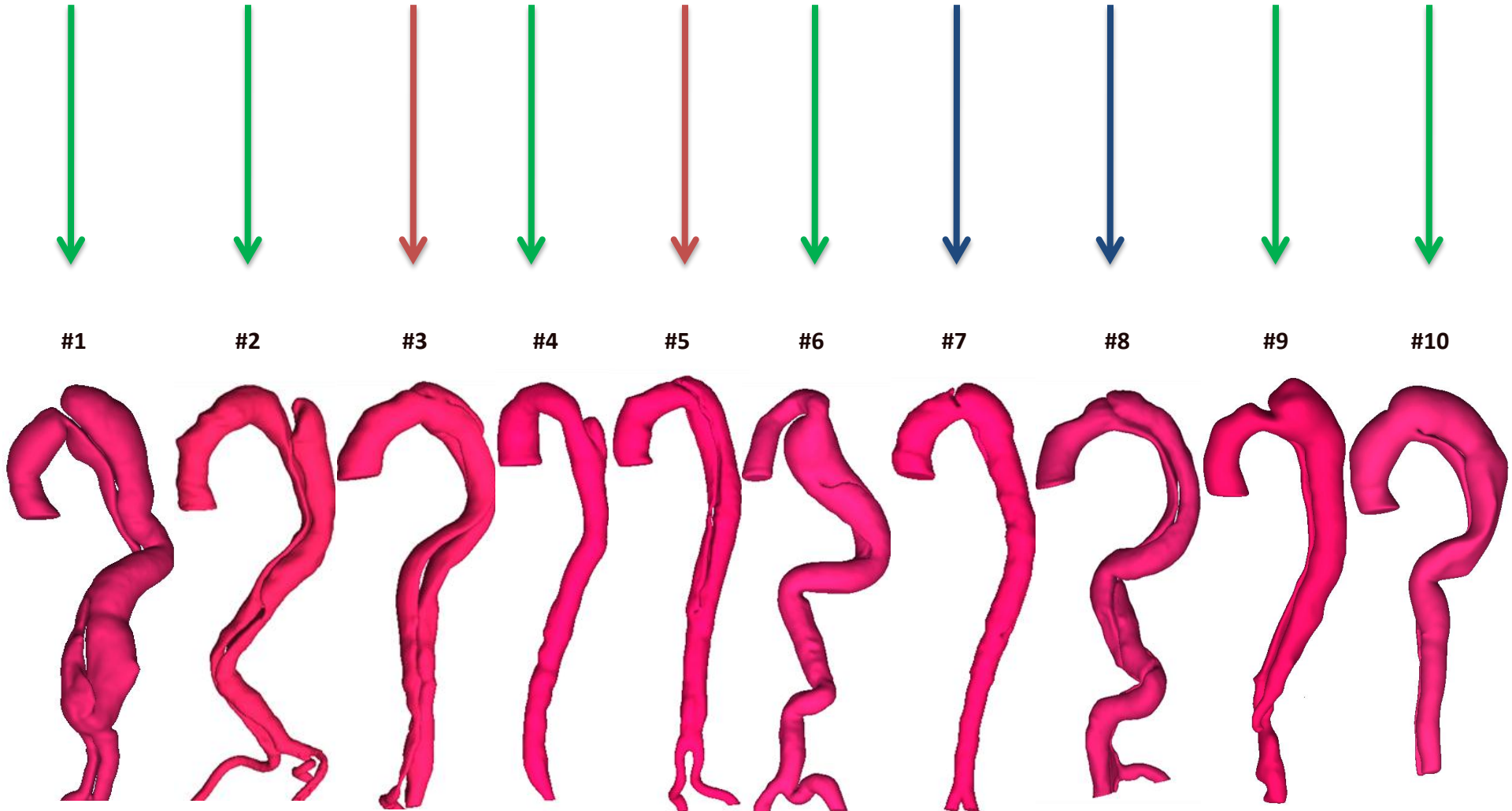
Methods: Subjects (n=10)

- 2/10: Acute complicated type B dissection -TEVAR
- 2/10 : Acute uncomplicated dissections medically managed
- 6/10 : Late complications of chronic Type B dissection- TEVAR



Imperial College Healthcare NHS
NHS Trust

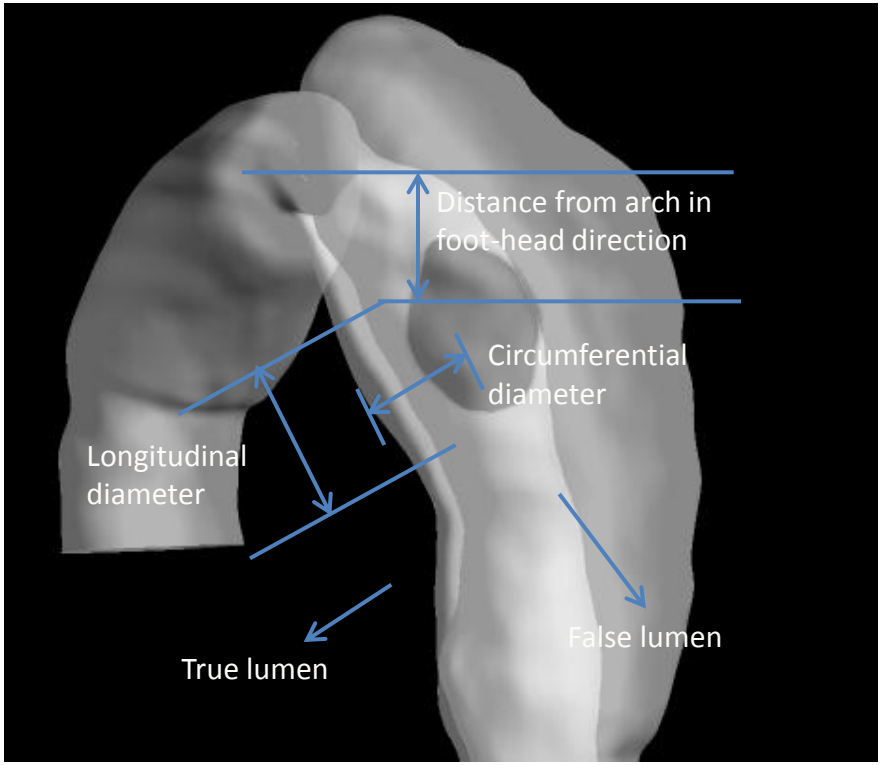
Method: Subjects



Imperial College Healthcare NHS
NHS Trust

Imperial College London

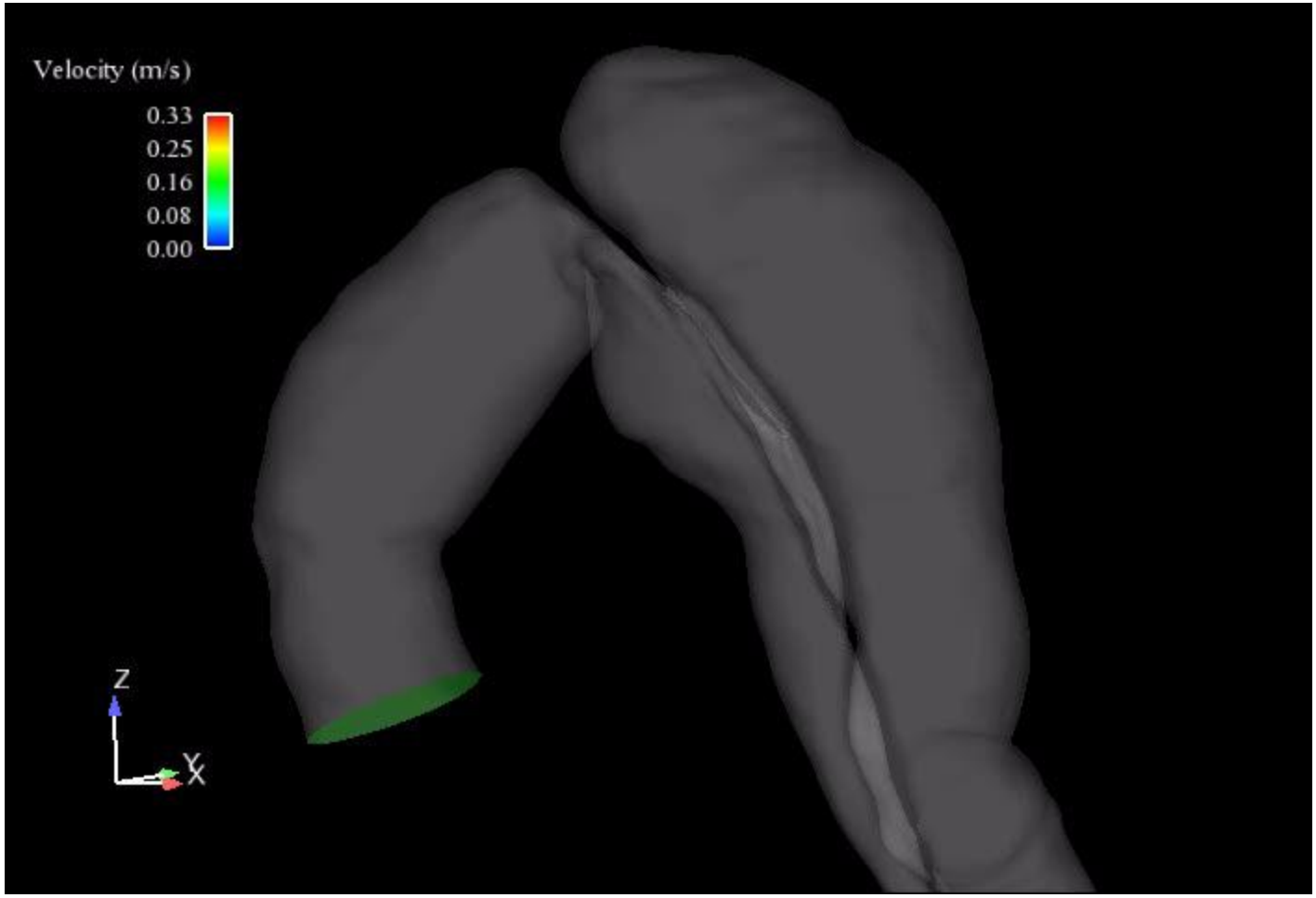
Parameters Examined



- Geometric Features
  - Circumferential diameter:
  - Longitudinal diameter:
  - Tear location: distance from arch top
- Flow rate into false lumen
  - Percentage of flow rate at tear
- Disturbed flow and turbulence in flow domain
  - Turbulence Intensity (Tu)
- Wall Shear Stress (WSS)

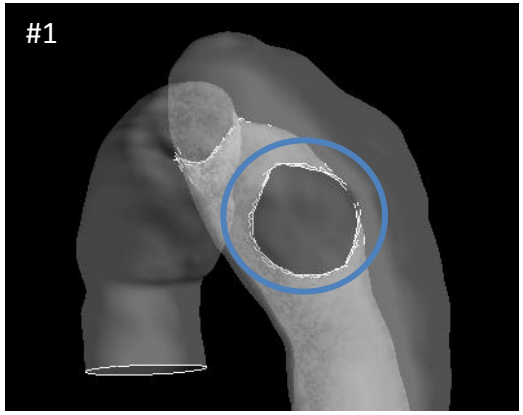
Results: Tear Size and Position

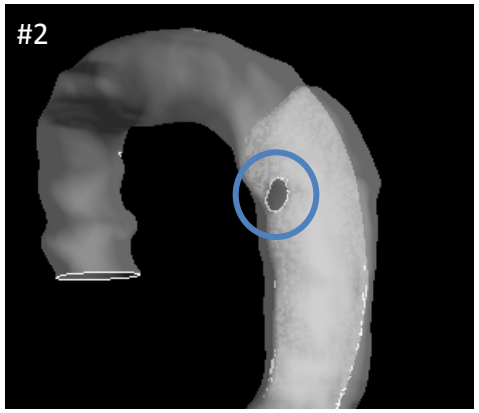
Subject No.	Primary Tear Dimensions (mm)			Distance of Primary Tear from Arch Top (mm)
	Longitudinal	Cirumferential	Ratio (tear/true lumen diameter)	
1	37.3	38	73%	21
2	13.5	8	21%	54
3	33	36	93%	8
4	24	20	58%	45
5	28.8	19.6	82%	1.2
6	15.4	32.4	29%	99
7	24	9	31%	12
8	18	10.8	32%	20
9	38.5	24	55%	0.6
10	38.5	35.4	88%	10

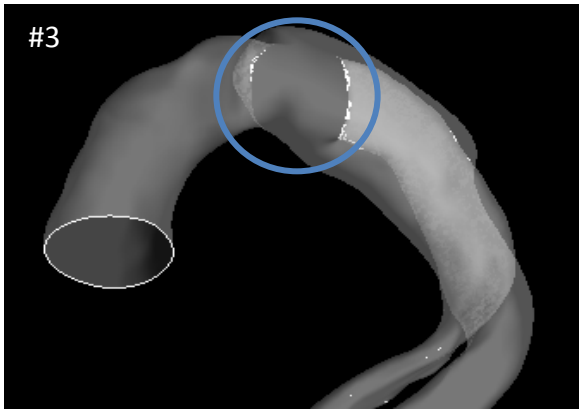

Velocity (m/s)
0.33
0.25
0.16
0.08
0.00
Z
X

Results: Entry Tears

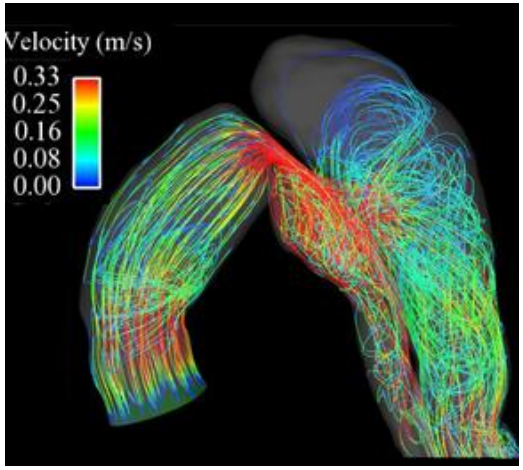
Different geometric characteristics of entry tear among patients

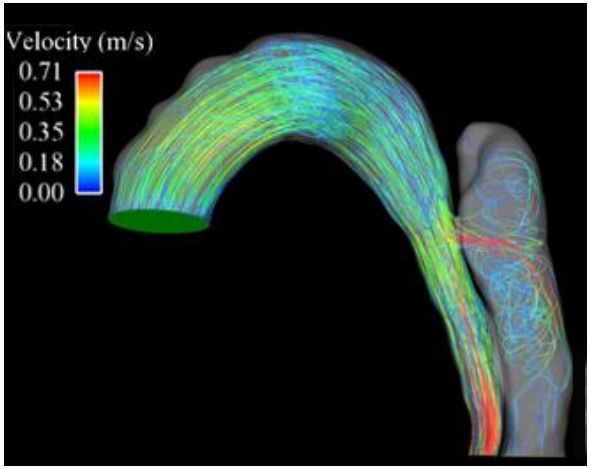


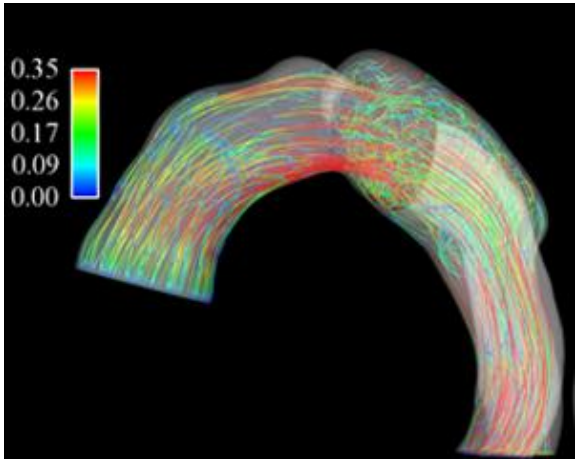




Particle Tracking: Flow patterns in dissected aorta

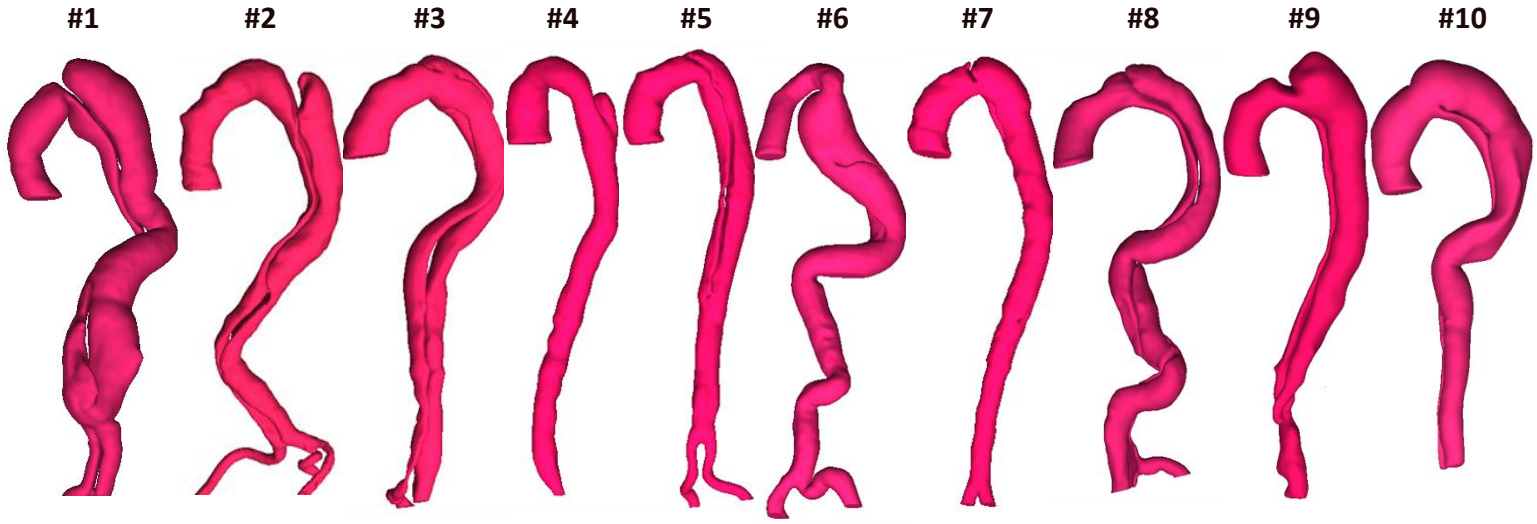






Results: Flow Rate into FL

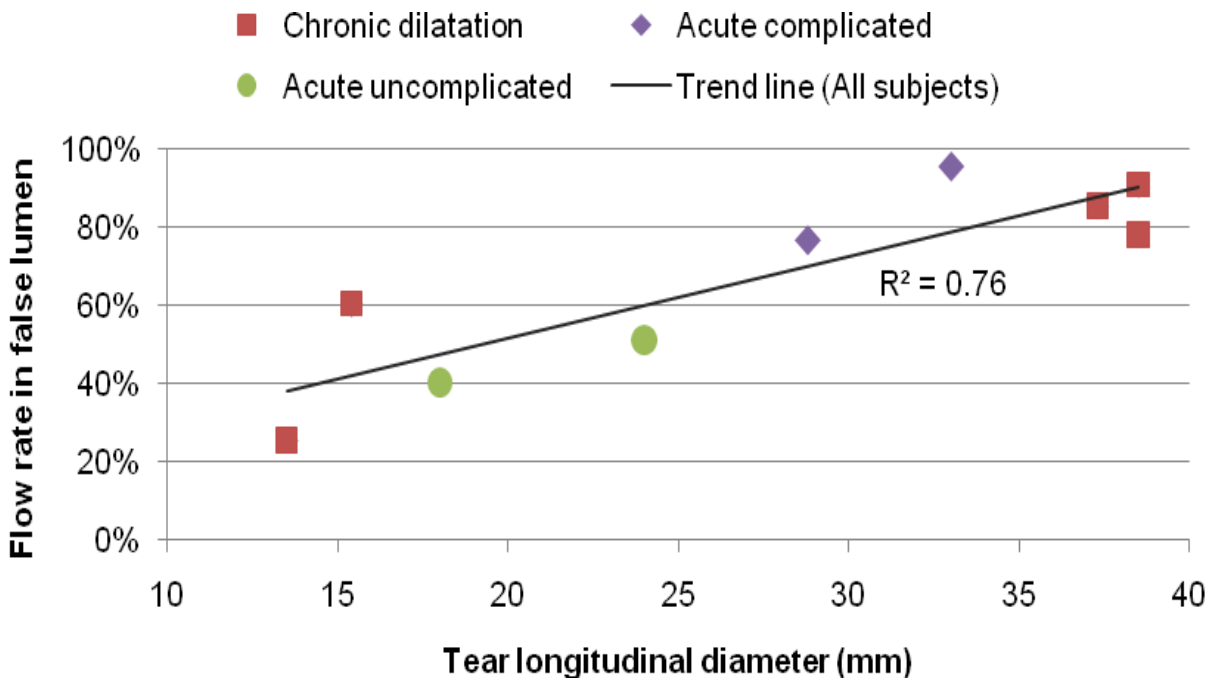
Subject No.	1	2	3	4	5	6	7	8	9	10
% Flow rate into false lumen	85.3%	25.6%	95.5%	N/A*	76.7%	60.4%	51%	40.3%	78%	90.8%



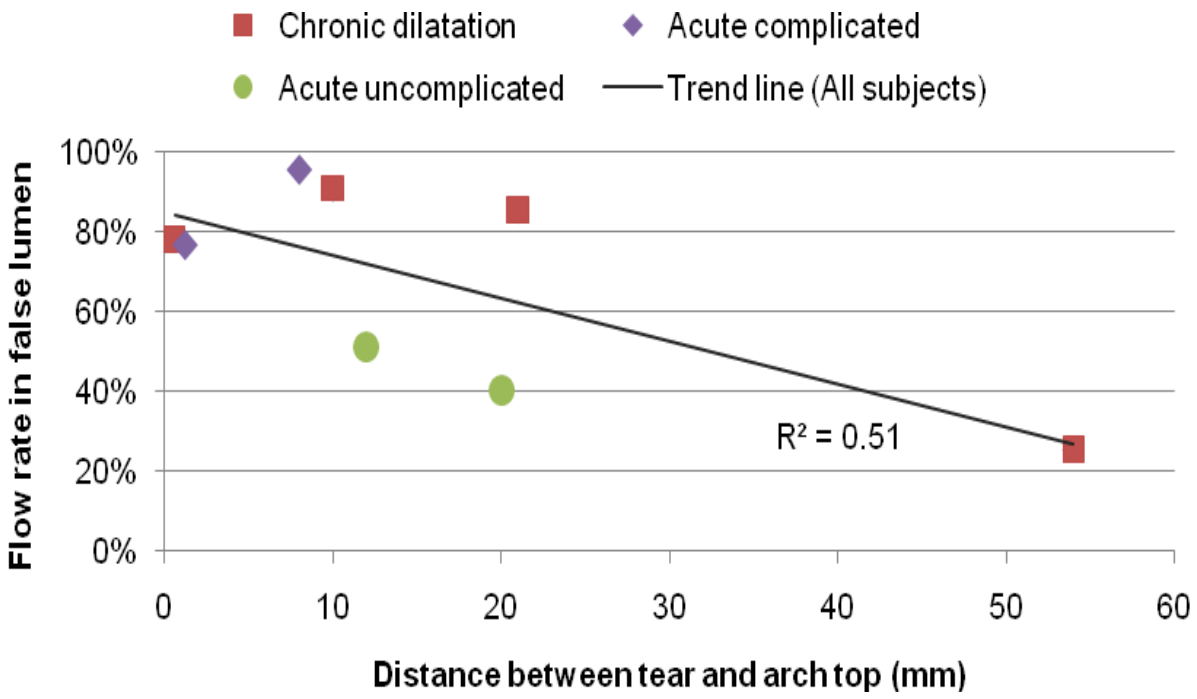
Imperial College Healthcare NHS Trust

Imperial College London

Results: Flow Rate into FL vs Tear Size



Results: Flow Rate into FL vs Tear Location

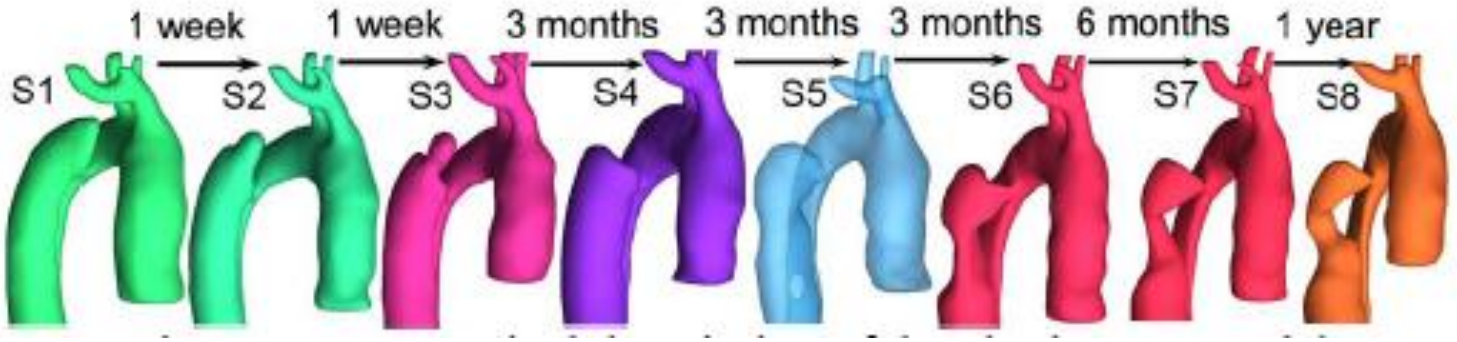


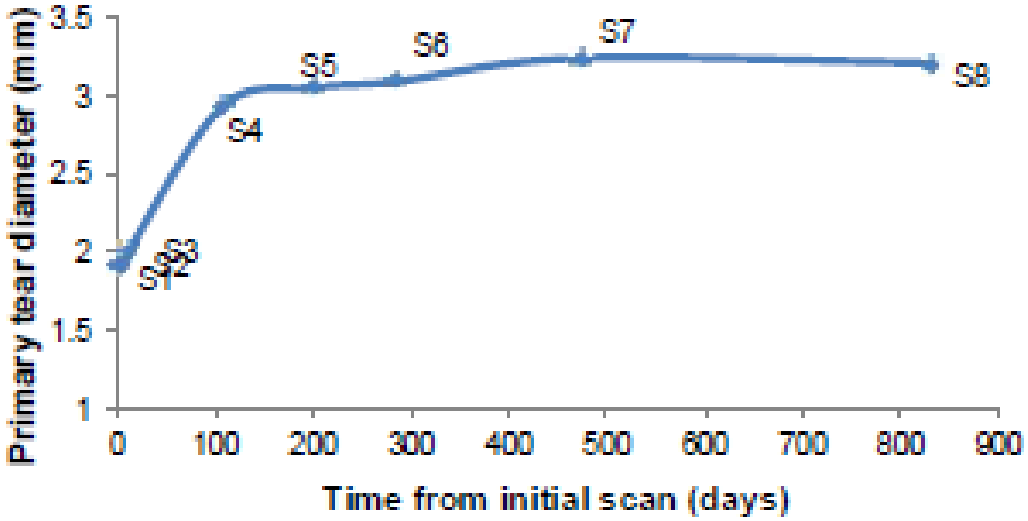
Subject No.	1	2	3	4	5	6	7	8	9	10
Flow rate at FL	85.3%	25.6%	95.5%	N/A	76.7%	60.4%	51%	40.3%	78%	90.8%
Distance of tear from arch (mm)	21	54	8	45	1.2	99	12	20	0.6	10

Imperial College Healthcare NHS
NHS Trust

Imperial College London

Londitudinal Follow up Type B Dissection

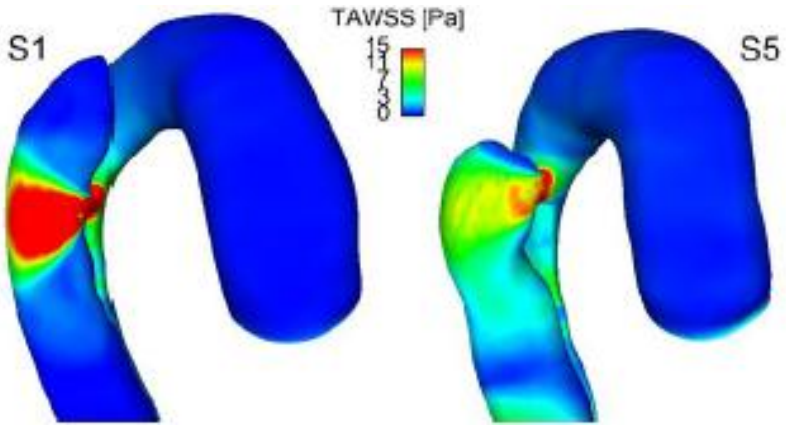




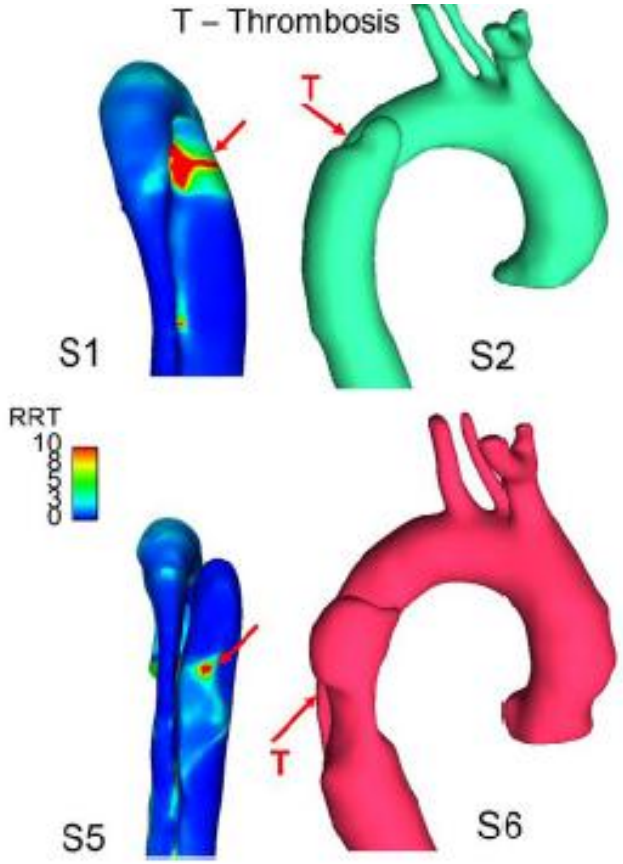
Imperial College Healthcare NHS
NHS Trust

Imperial College London

TAWSS; RRT; FL Thrombosis



TAWSS on aortic wall at different time periods



RRT Contours and Thrombosis of FL

Conclusions

Small tear area
Low tear location

Limited flow rate into false lumen

Limited flow rate into false lumen
Low wall shear stress
Low turbulence intensity

Thrombosis of false lumen

Stable Status

Large tear area
Proximal Tear location

High wall shear stress
High turbulence intensity

Maintainance FLP

Acute Complications
? Chronic dilatation