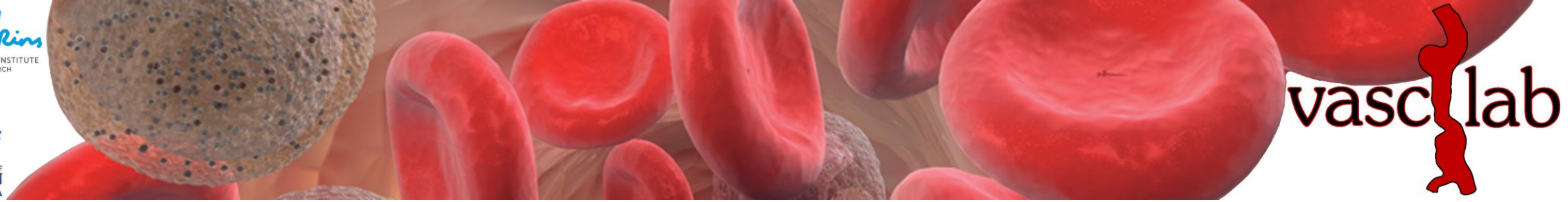

Biomechanical modelling and PET/CT in TBAD: Development of the 'Perth-Liège Risk Score'

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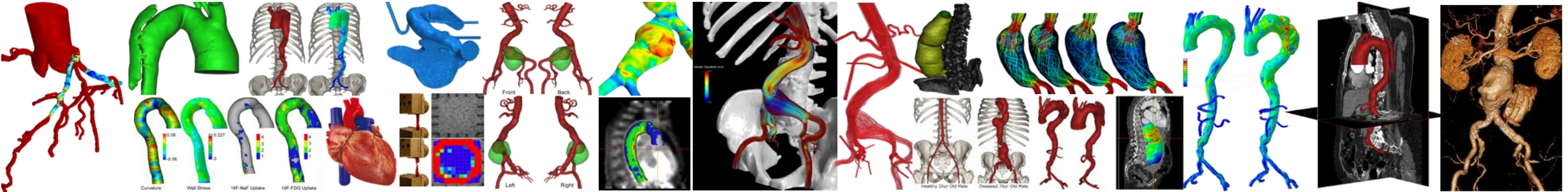


No conflicts of interest to disclose

Risk factors considered

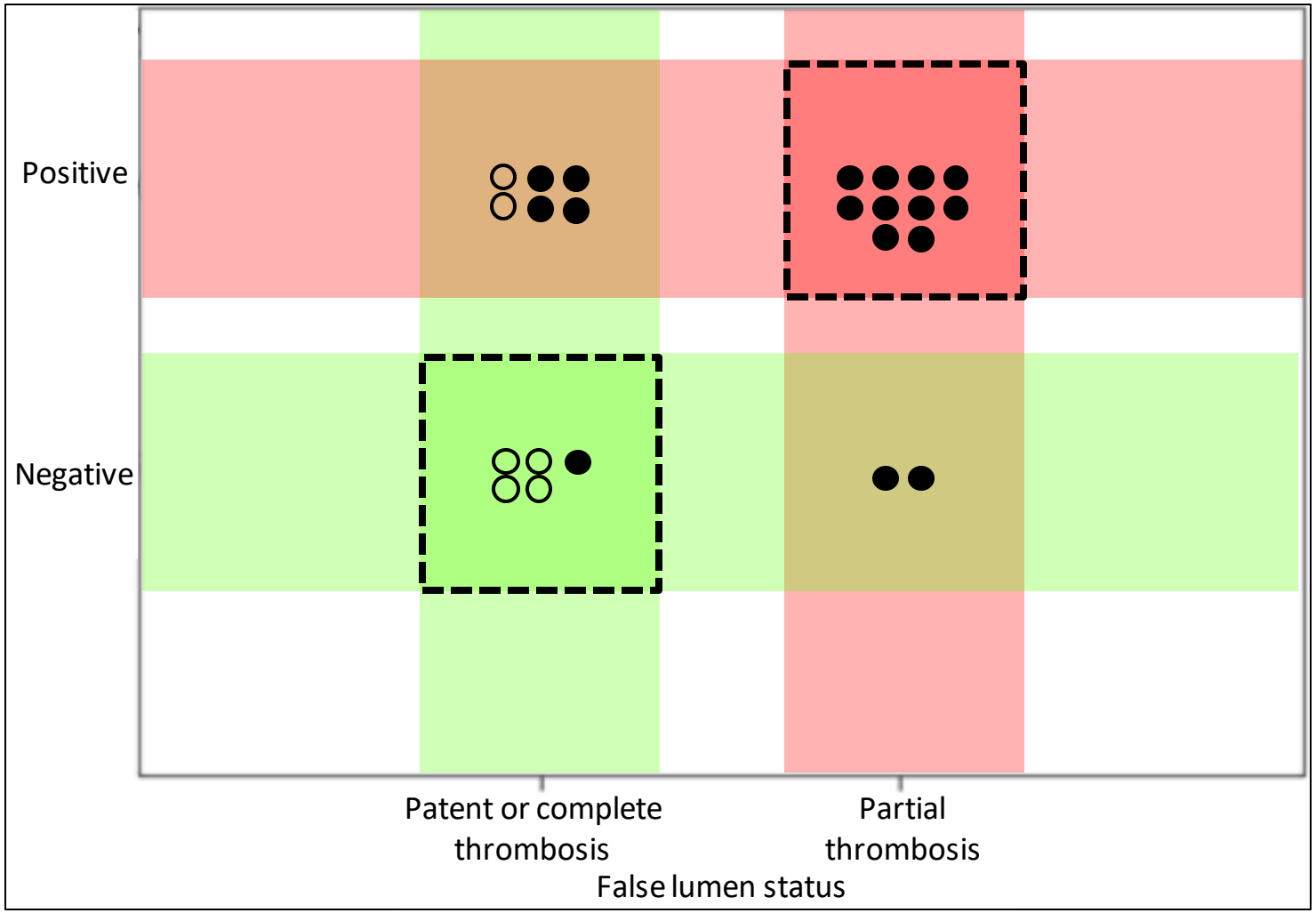
1. Peak FDG SUV in the dissected aorta Sakalihasan et al. EHJ-CVI 2015
2. False lumen thrombosis Tsai et al. NEJM 2007

Louis Parker

FDG PET/CT to predict complication

Natzi Sakalihasan

- ● Complicated
- ○ Uncomplicated

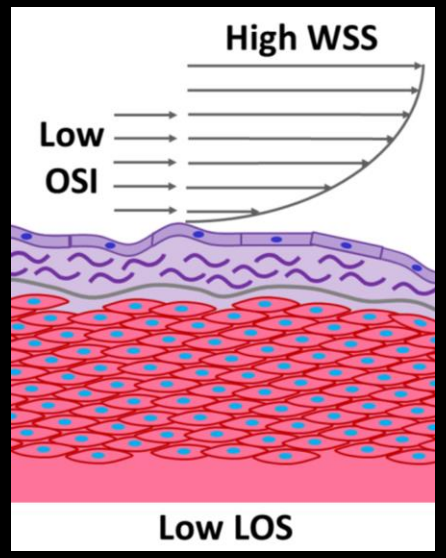


Sakalihasan et al. Eur Heart J Cardiovasc Imaging 2015;16:626-33

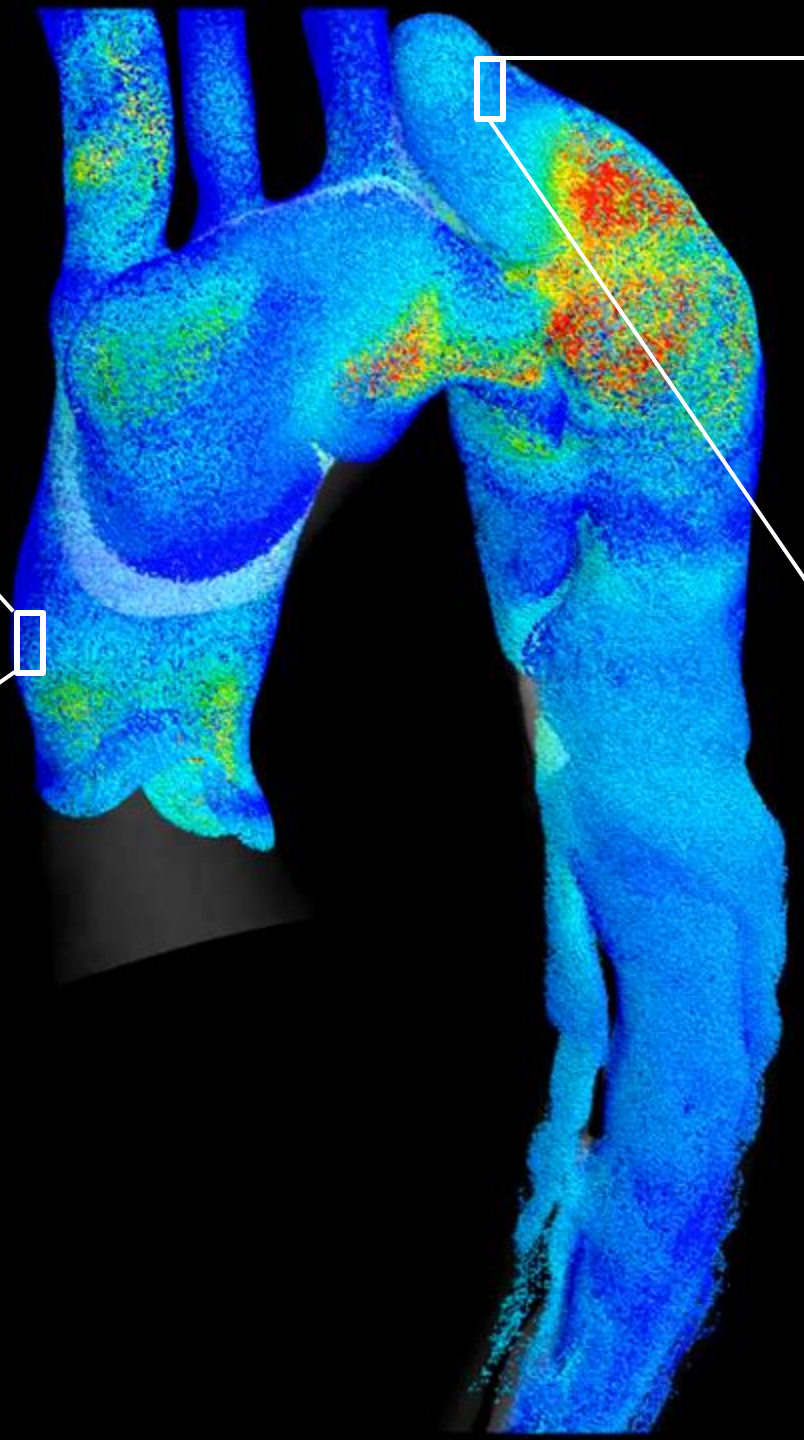
Risk factors considered

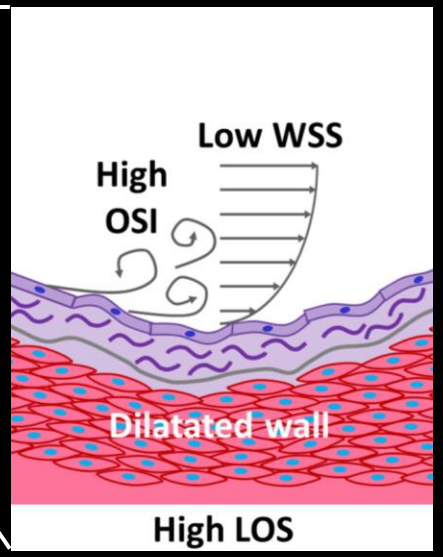
1. Peak SUV in the dissected aorta — Sakalihasan et al. EHJ-CVI 2015
2. False lumen thrombosis — Tsai et al. NEJM 2007
3. Maximum diameter (true + false lumen) — Reutersberg et al. JVS 2018
4. Pressure difference between true and false lumen — Tsai et al. JVS 2008; Zhang et al. Cardiology 2014
5. False lumen low and oscillatory shear (LOS)

Computational haemodynamics



Low LOS is good





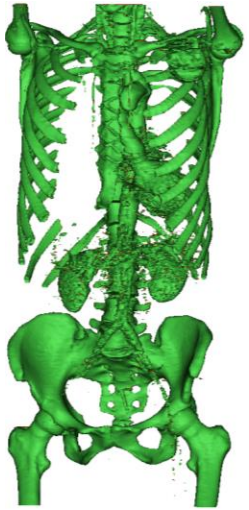
High LOS is bad

$$LOS = \frac{OSI}{TAWSS}$$

Computational modelling workflow

CTA

3D reconstruction



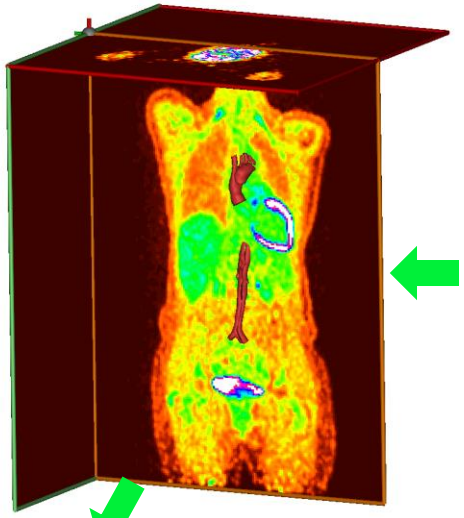
CAD file to CFD model

Patient info from Liège:
Blood pressure & heart rate

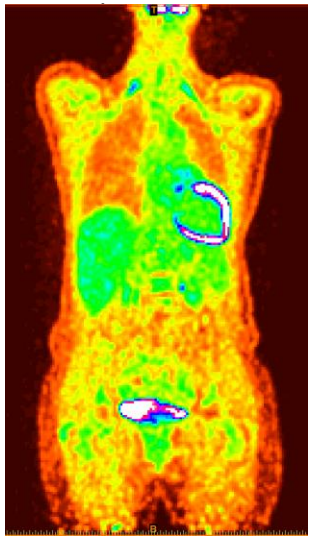
Supercomputer simulation

Simulated cardiac flow for 10 cycles

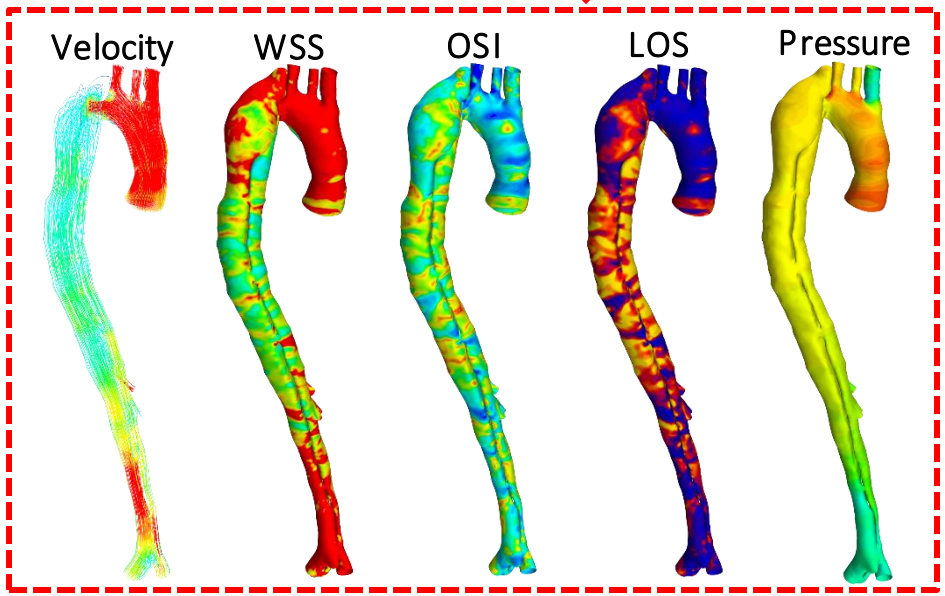
Co-registration with CAD



18F-FDG PET/CT



Biomechanical data



Scaled relative to the SUV of the liver & mapped to 3D geometry

Risk factors considered

1. Peak SUV in the dissected aorta Sakalihasan et al. EHJ-CVI 2015
2. False lumen thrombosis Tsai et al. NEJM 2007
3. Maximum diameter (true + false lumen) Reutersberg et al. JVS 2018
4. Pressure difference between true and false lumen Tsai et al. JVS 2008; Zhang et al. Cardiology 2014
5. False lumen low and oscillatory shear (LOS)

Developed using 15 cases of TBAD from Liège

Ranked each case according to total risk score

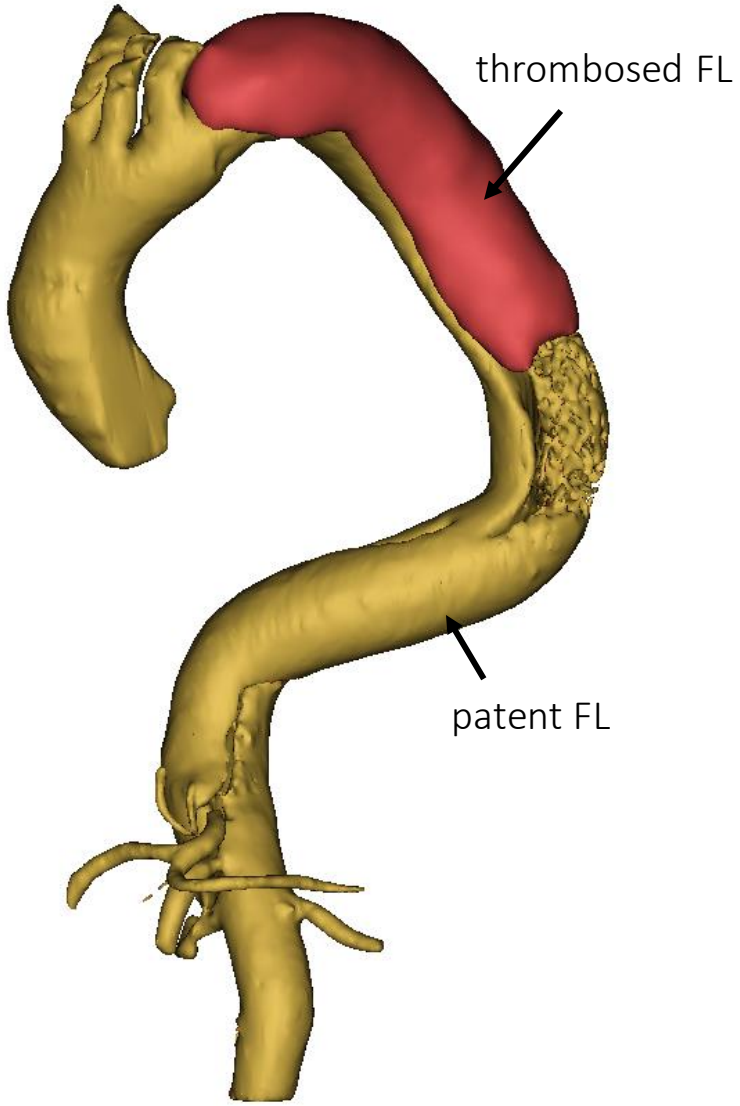
We were blind to outcome (i.e. complicated vs uncomplicated)

Scoring process

Case	Peak SUV	FL thrombosis	Max diameter	LOS	Pressure difference	Total
A	High = **2**	Partial = **2**	≥ 46 mm = **2**	High = **2**	High FL pressure = **2**	**10**
B	Medium = **1**	Patent FL = **1**	41-46 mm = **1**	Medium = **1**	Equal pressure = **1**	**5**
C	Low = **0**	Full = **0**	≤ 41 mm = **0**	Low = **0**	High TL pressure = **0**	**0**

Score ≥ 5 = at risk

Example risk factor: False lumen thrombosis



Case	% FL thrombosis
14	79
13	67
15	67
11	58
3	54
2	36
4	34
12	29
1	0
5	0
6	0
7	0
10	0
8	100
9	100

$$\frac{\text{false lumen thrombus volume}}{\text{entire false lumen volume}}$$

Partial FL thrombosis increases risk of complication

Patent FL at lower risk of complication

Full FL thrombosis is at lowest risk of complication

Initial scores

Case	Peak SUV	FL thrombosis	Max diameter	LOS	Pressure difference	Total
15	1	2	1	1	2	7
2	0	2	2	2	0	6
3	0	2	1	2	1	6
11	2	2	0	2	0	6
13	2	[illegible]	[illegible]	[illegible]	0	6
14	1	[illegible]	[illegible]	[illegible]	2	6
1	1	[illegible]	[illegible]	[illegible]	1	5
4	1	[illegible]	[illegible]	[illegible]	0	5
10	0	1	2	1	1	5
7	2	1	0	1	0	4
8	2	0	2	0	0	4
9	1	0	2	0	0	3
12	0	2	1	0	0	3
5	0	1	0	0	1	2
6	0	1	1	0	0	2

Discrepancy between our SUV analysis (SUV in FL only) and the method used in Liege (SUV in full dissected aorta)

High risk

At risk

Low risk

Final risk scores

Gender did not influence ranking when included as risk factor

Case	Peak SUV	FL thrombosis	Max diameter	LOS	Pressure difference	Total
2	2	2	2	2	0	8
3	2	2	1	2	1	8
15	1	2	1	1	2	7
10	2	1	2	1	1	7
11	2	2	0	2	0	6
13	2	2	0	2	0	6
14	1	2	0	1	2	6
1	1	1	1	1	1	5
4	1	2	2	0	0	5
7	2	1	0	1	0	4
8	2	0	2	0	0	4
9	1	0	2	0	0	3
12	0	2	1	0	0	3
5	0	1	0	0	1	2
6	0	1	1	0	0	2

High risk

At risk

Low risk

Risk scores compared with outcome

Case	Total	Outcome
2	8	Complicated
3	8	Complicated
15	7	Complicated
10	7	Complicated
11	6	Complicated
13	6	Uncomplicated
14	6	Uncomplicated
1	5	Complicated
4	5	Complicated
7	4	Complicated
8	4	Complicated
9	3	Uncomplicated
12	3	Uncomplicated
5	2	Uncomplicated
6	2	Uncomplicated

High risk

At risk

Has 3 risk factors

Low risk

Risk scores compared with outcome

Case	Total	Outcome
2	8	Complicated
3	8	Complicated
15	7	Complicated
10	7	Complicated
11	6	Complicated
13	6	Uncomplicated
14	6	Uncomplicated
1	5	Complicated
4	5	Complicated
7	4	Complicated
8	4	Complicated
9	3	Uncomplicated
12	3	Uncomplicated
5	2	Uncomplicated
6	2	Uncomplicated

High risk

Low risk

Risk score predicted **11/15** cases correctly

In summary

- A new risk score for TBAD is under development
- Preliminary data is promising
  - 11/15 correct predictions
- More work needed to refine the model and understand what risk factors are most important

What's next?

- Try develop a risk model based on CTA-only data
- Develop alongside other risk scores
- Test in more cases and cohorts

Risk scores without including FDG

Score ≥ 4 = at risk

Case	FL thrombosis	Max diameter	LOS	Pressure difference	Total
2	2	2	2	0	6
3	2	1	2	1	6
15	2	1	1	2	6
10	1			1	5
14	2				5
11	2				4
13	2				4
1	1				4
4	2				4
12	2			0	3
7	1	0	1	0	2
8	0	2	0	0	2
9	0	2	0	0	2
5	1	0	0	1	2
6	1	1	0	0	2

Risk score predicted **10/15** cases correctly

High risk

At risk

Low risk

Acknowledgements

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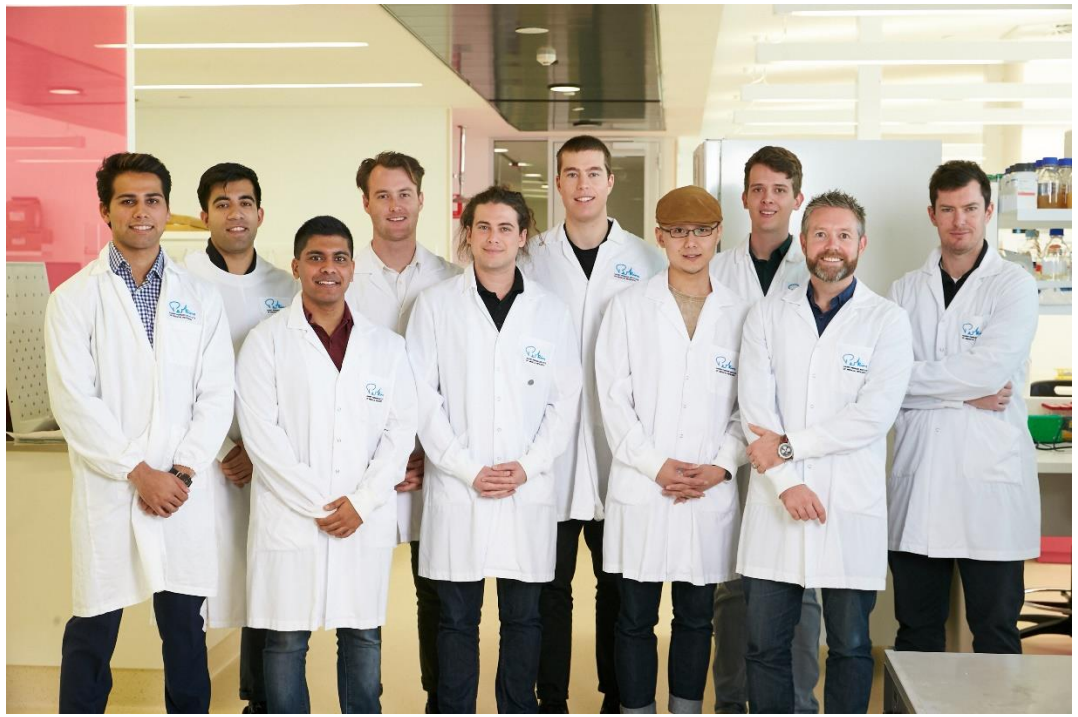

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Roland Hustinx

& thank you for listening!

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Risk scores without FDG

Case	FL thrombosis	Max diameter	LOS	Pressure difference	Total
2	2	2	2	0	6
3	2	1	2	1	6
15	2	1	1	2	6
10	1	2	1	1	5
14	2	0	1	2	5
11	2	0	2	0	4
13	2	0	2	0	4
1	1	1	1	1	4
4	2	2	0	0	4
12	2	1	0	0	3
7	1	0	1	0	2
8	0	2	0	0	2
9	0	2	0	0	2
5	1	0	0	1	2
6	1	1	0	0	2

High risk

At risk

Low risk