

**Erasmus MC**

Universitair Medisch Centrum Rotterdam



## **Bioresorbable Vascular Scaffolds**

# **Insights from Serial Intravascular Imaging Studies**

**E. Regar,  
prepared with A. Karanasos  
Thoraxcenter  
Erasmus Medical Center  
Rotterdam, NL**

# BVS -Insights from intravascular imaging

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**BVS evolved from an experimental therapy into a commercially available product in many parts of the world with a considerable number of real-world registries ongoing**



# BVS -Insights from intravascular imaging

## Imaging studies of BVS:

<b>Trial name</b>	<b>Device studied</b>	<b>Study device: eluted drug</b>	<b>Study device: backbone</b>	<b>Follow-up interval</b>	<b>Imaging modalities</b>
<b>ABSORB A</b>	ABSORB BVS 1.0	Everolimus	PLLA, PDLLA coating	<b>5 years</b>	<b>QCA, vasomotion, IVUS, IVUS-VH, palpography, echogenicity, OCT</b>
<b>ABSORB B</b>	ABSORB BVS 1.1	Everolimus	PLLA, PDLLA coating	<b>3 years</b>	<b>QCA, vasomotion, IVUS, OCT</b>



# BVS -Insights from intravascular imaging

## What did we learn?

### BVS perform well in simple lesions: COHORT A

Hierarchical	6 Months 30 Patients	12 Months 29 Patients**	18 Months 29 Patients**	2 Years 29 Patients**	3 Years 29 Patients**	5 Years 29 Patients**
Ischemia Driven MACE (%)	<b>3.3% (1)*</b>	<b>3.4% (1)*</b>	<b>3.4% (1)*</b>	<b>3.4% (1)*</b>	<b>3.4% (1)*</b>	<b>3.4% (1)*</b>
Cardiac Death (%)	0.0% (0)	0.0% (0)	0.0% (0)	0.0% (0)	<b>0.0% (0)</b>	<b>0.0% (0)</b>
MI (%)						
Q-Wave MI	0.0% (0)	0.0% (0)	0.0% (0)	0.0% (0)	<b>0.0% (0)</b>	<b>0.0% (0)</b>
Non Q-Wave MI	<b>3.3% (1)*</b>	<b>3.4% (1)*</b>	<b>3.4% (1)*</b>	<b>3.4% (1)*</b>	<b>3.4% (1)*</b>	<b>3.4% (1)*</b>
Ischemia Driven TLR (%)	0.0% (0)	0.0% (0)	0.0% (0)	0.0% (0)	<b>0.0% (0)</b>	<b>0.0% (0)</b>
by PCI	0.0% (0)	0.0% (0)	0.0% (0)	0.0% (0)	<b>0.0% (0)</b>	<b>0.0% (0)</b>
by CABG	0.0% (0)	0.0% (0)	0.0% (0)	0.0% (0)	<b>0.0% (0)</b>	<b>0.0% (0)</b>

**No scaffold thrombosis up to 5 years**



# BVS -Insights from intravascular imaging

## What did we learn?

### BVS perform well in more complex lesions: EXTEND

#### Lessons learned from acute and late scaffold failures in the ABSORB EXTEND trial

Yuki Ishibashi<sup>1</sup>, MD, PhD; Yoshinobu Onuma<sup>2</sup>, MD; Takashi Muramatsu<sup>1</sup>, MD, PhD; Shimpei Nakatani<sup>1</sup>, MD; Javaid Iqbal<sup>3</sup>, MRCP, PhD; Hector M. Garcia-Garcia<sup>4</sup>, MD, PhD; Antonio L. Bartorelli<sup>5</sup>, MD; Robert Whitbourn<sup>6</sup>, MD; Alexander Abizaid<sup>7</sup>, MD, PhD; Patrick W. Serruys<sup>1</sup>, MD, PhD, on behalf of the ABSORB EXTEND Investigators

**FUP 12 months**

**N 450 Pts**

**MACE 4.2%**

**TVF 4.7%**

**Scaffold**

**Thrombosis**

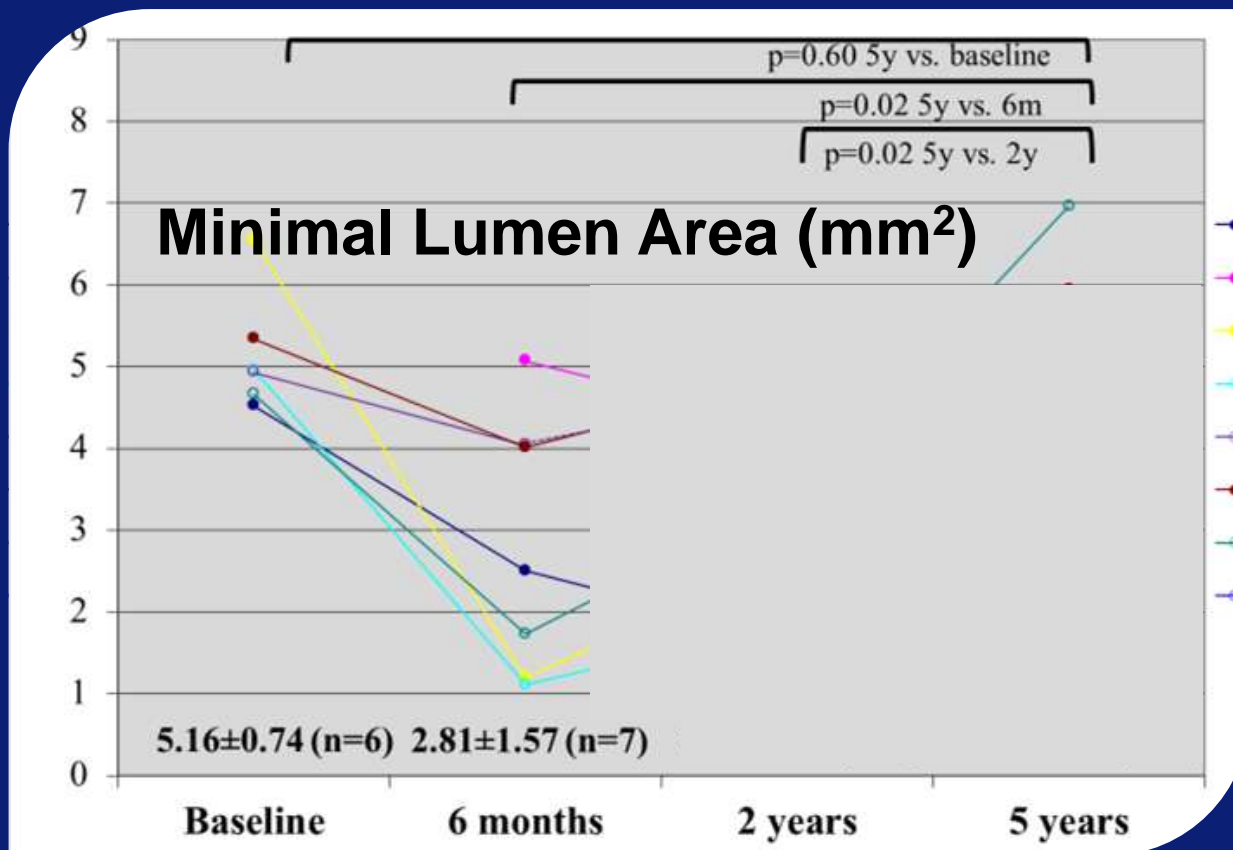
**0.9 %**



# BVS -Insights from intravascular imaging

## What did we learn?

### BVS show moderate acute recoil

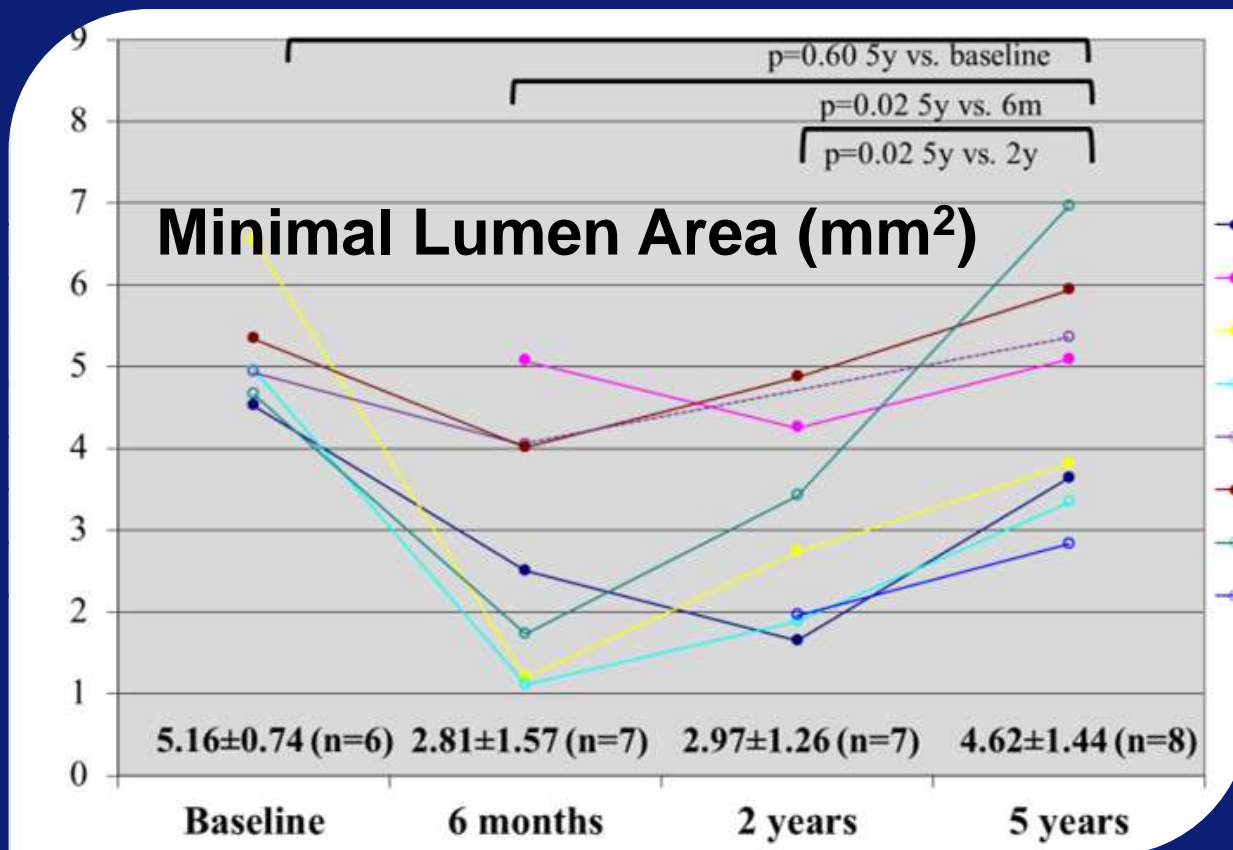




# BVS -Insights from intravascular imaging

## What did we learn?

### BVS show late lumen enlargement



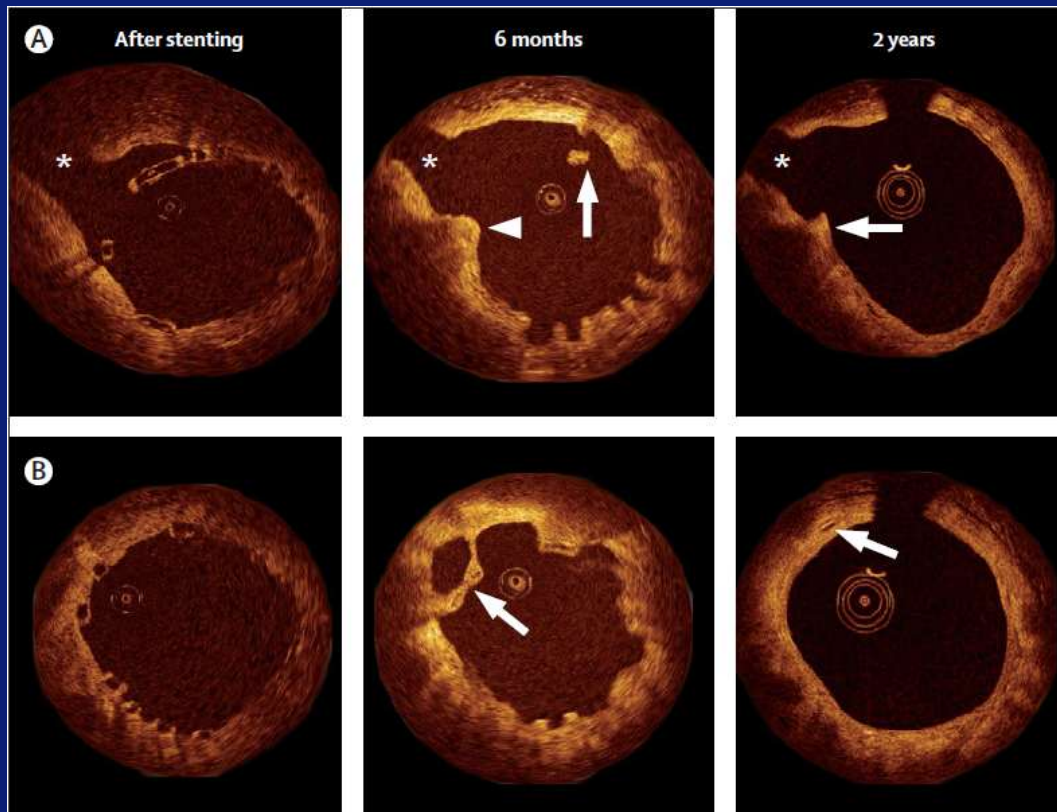
- Consistent late increase in all patients !

# BVS -Insights from intravascular imaging



## What did we learn?

### BVS show good healing & apposition



- At 2 year FUP:  
strut coverage and apposition **100%**
- At 5 year FUP:  
strut resorption **100%**

**BVS Gen 1.0**

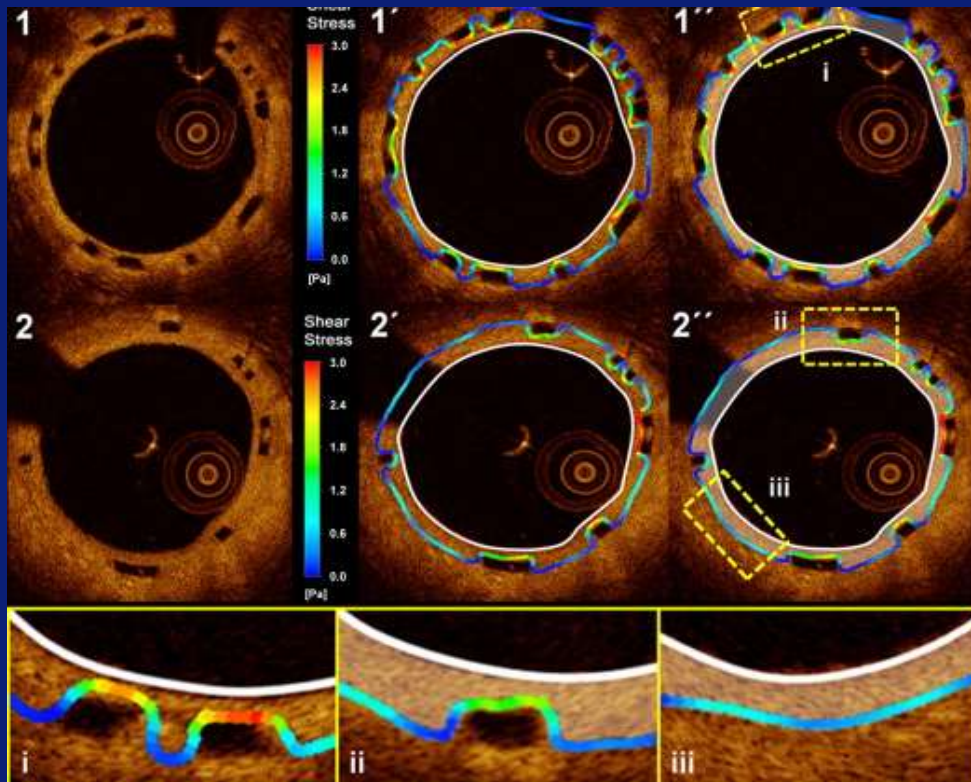




# BVS -Insights from intravascular imaging

## What did we learn?

### BVS show good healing & apposition



- At 3 year FUP:
 

strut coverage	98%
ISA in scaffolds	6%
- Amount of coverage directly related to shear stress

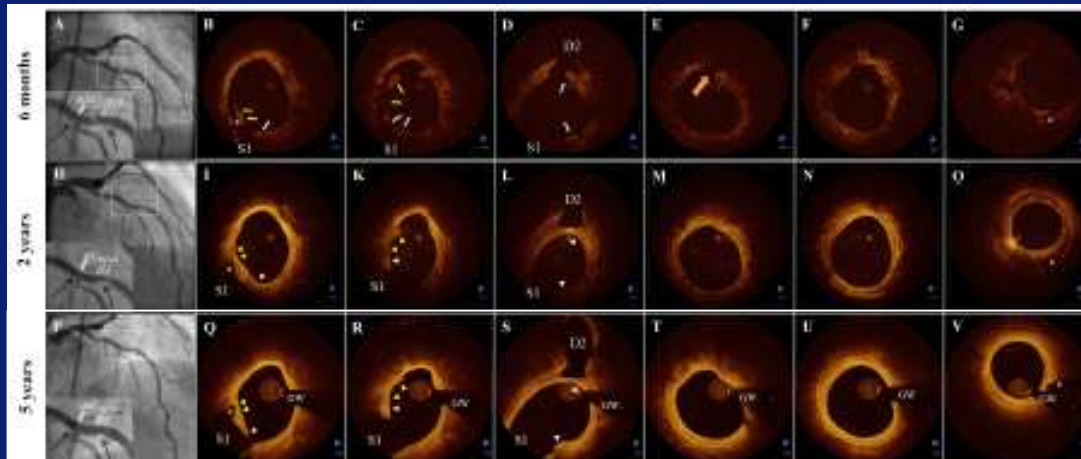
BVS Gen 1.1



# BVS -Insights from intravascular imaging

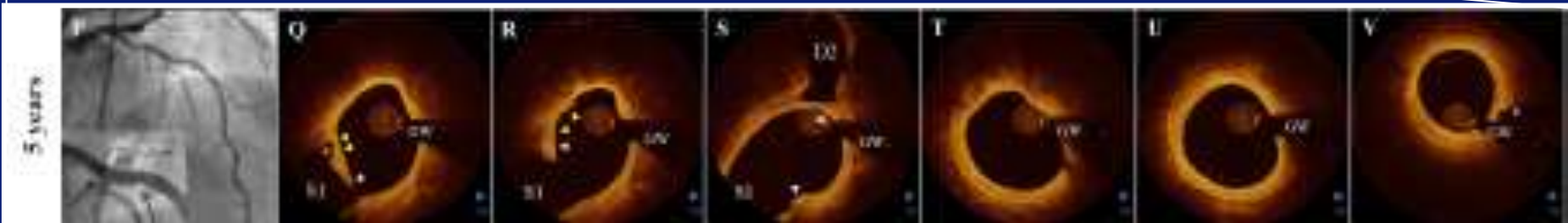
## What did we learn?

**BVS show complete bioresorption over time**



• **OCT:**

Struts no longer discernible

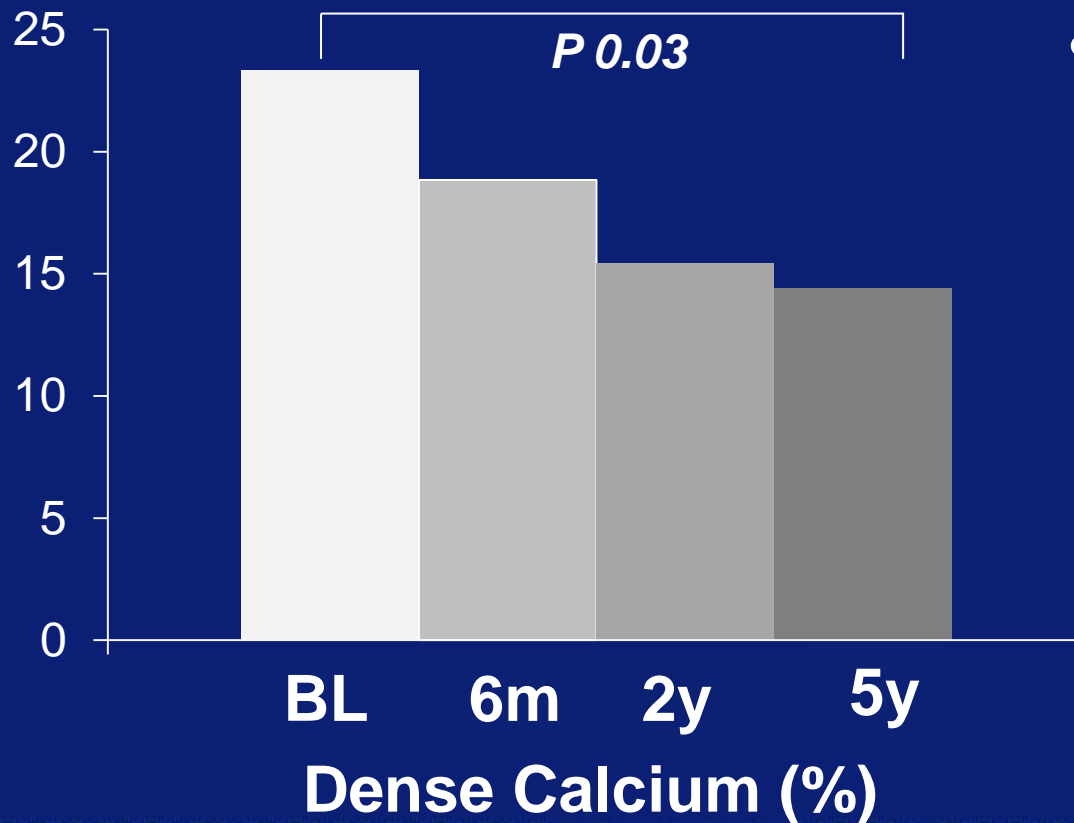




# BVS -Insights from intravascular imaging

## What did we learn?

### BVS show complete bioresorption over time



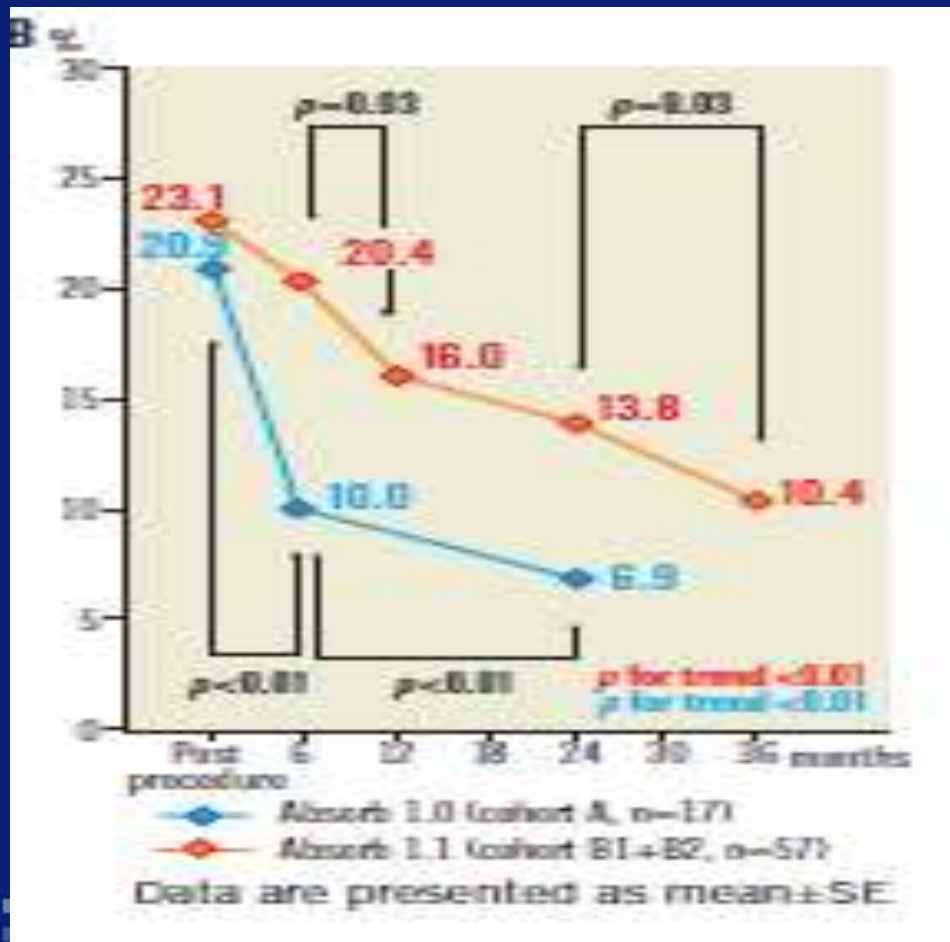
- **VH-IVUS:**  
Reduction of dense calcium  
(indirect sign of  
bioresorption)



# BVS -Insights from intravascular imaging

## What did we learn?

### BVS show complete bioresorption over time



- **VH-IVUS:**

Reduction of dense calcium  
(indirect sign of  
bioresorption)

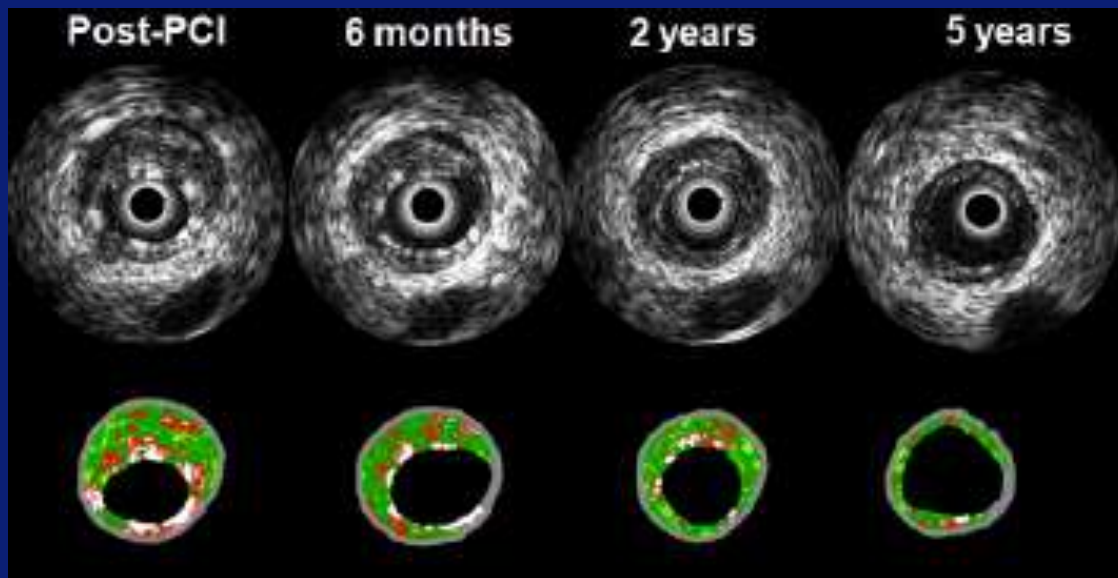
Effect more pronounced  
for **Gen 1.0** than  
for **Gen 1.1** ?



# BVS -Insights from intravascular imaging

## What did we learn?

### BVS allow for reduction of plaque burden



- **IVUS:**  
Lumen area tends to increase, while the vessel area remains stable due to significant decrease in plaque area



# BVS -Insights from intravascular imaging

## What did we learn?

### BVS allow for reduction of plaque burden

	After procedure	6 months	2 years	5 years	P-value after procedure vs. 5 years	P-value 6 months vs. 5 years	P-value 2 years vs. 5 years
<i>N</i>	8	8	7	7			
Grey-scale IVUS							
Vessel area (mm <sup>2</sup> )	15.72 (±3.00)	15.34 (±2.00)	14.09 (±1.66)	14.52 (±1.81)	0.60	0.40	0.75
Average lumen area (mm <sup>2</sup> )	6.95 (±0.63)	6.17 (±0.74)	6.56 (±1.16)	6.96 (±1.13)	0.75	0.06	0.12
Plaque area (mm <sup>2</sup> )	8.78 (±2.83)	9.17 (±1.86)	7.54 (±1.24)	7.57 (±1.63)	0.60	0.03	0.92
Minimum lumen area (mm <sup>2</sup> )	5.81 (±0.62)	4.67 (±0.77)	4.96 (±1.08)	4.81 (±2.04)	0.60	0.74	0.75

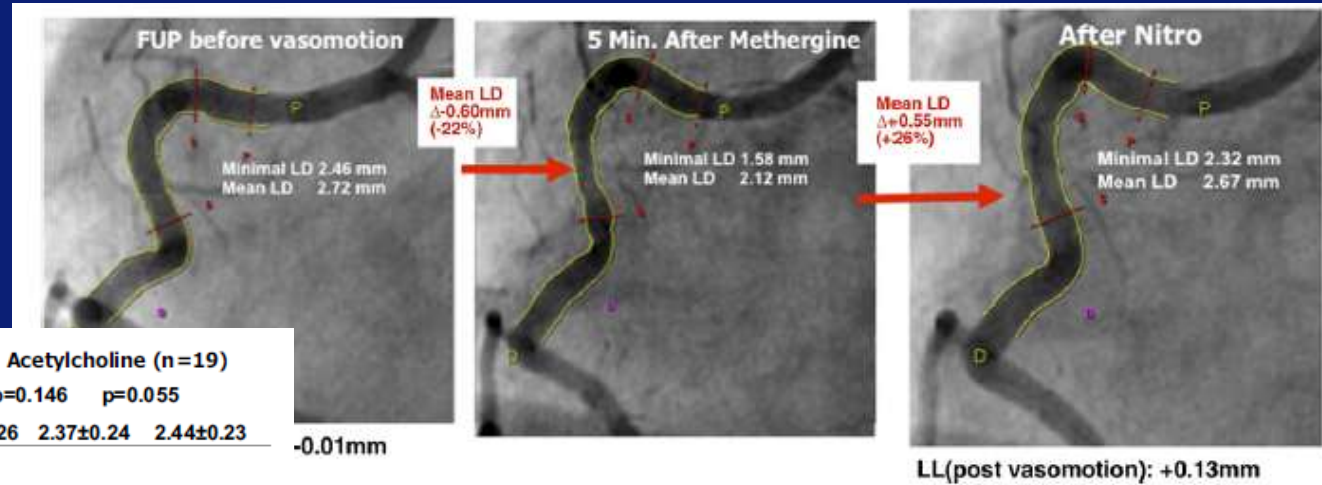
- **IVUS:**  
Lumen area tends to increase, while the vessel area remains stable due to significant decrease in plaque area



# BVS -Insights from intravascular imaging

## What did we learn?

### BVS can restore vasomotion

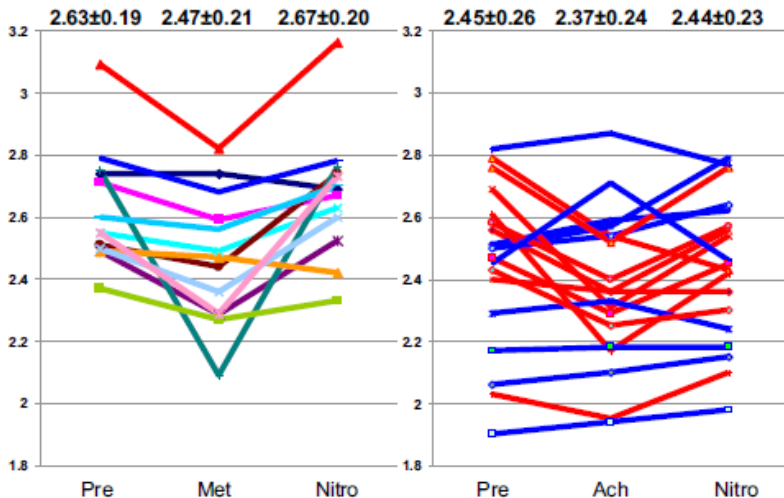


Methergin (n=13)

P<0.001 p=0.001

Acetylcholine (n=19)

p=0.146 p=0.055



### Methergin test

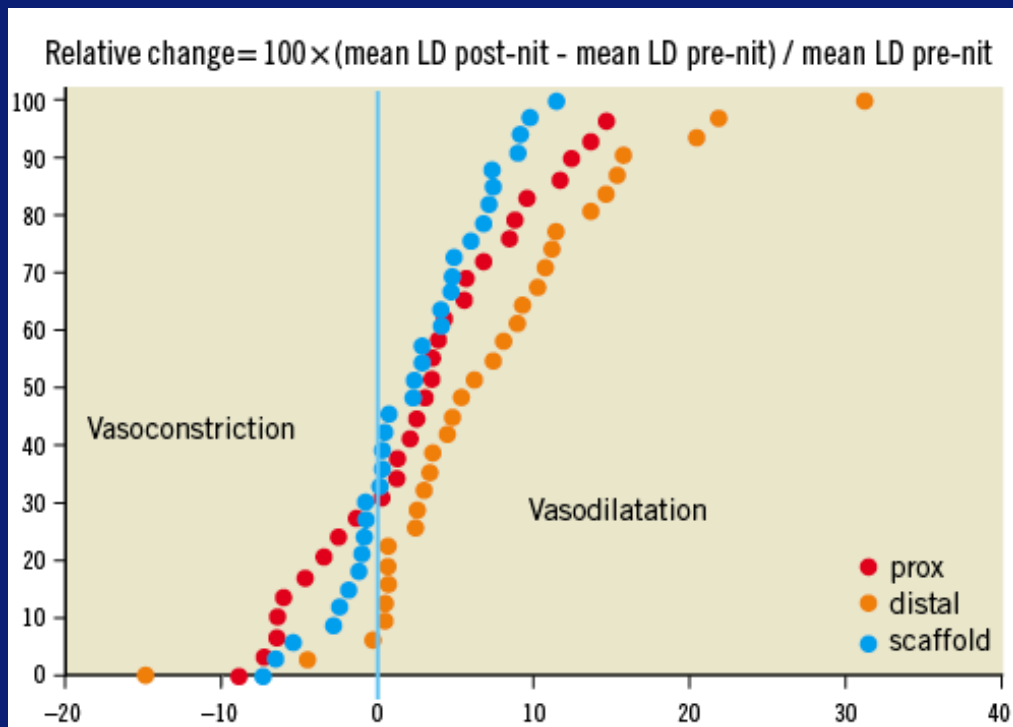
Vasomotive properties are preserved at the segment of the scaffold



# BVS -Insights from intravascular imaging

## What did we learn?

### BVS can restore vasomotion



#### *Reaction to nitrates*

**Vasomotive properties are preserved at the segment of the scaffold**

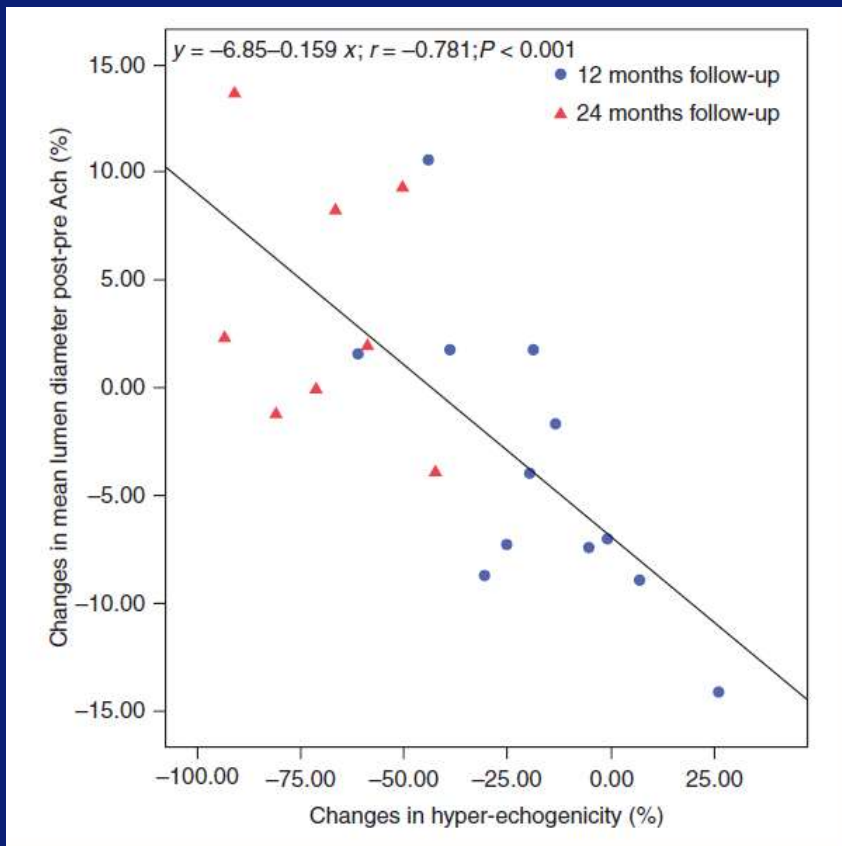




# BVS -Insights from intravascular imaging

## What did we learn?

### BVS might promote favourable plaque modification



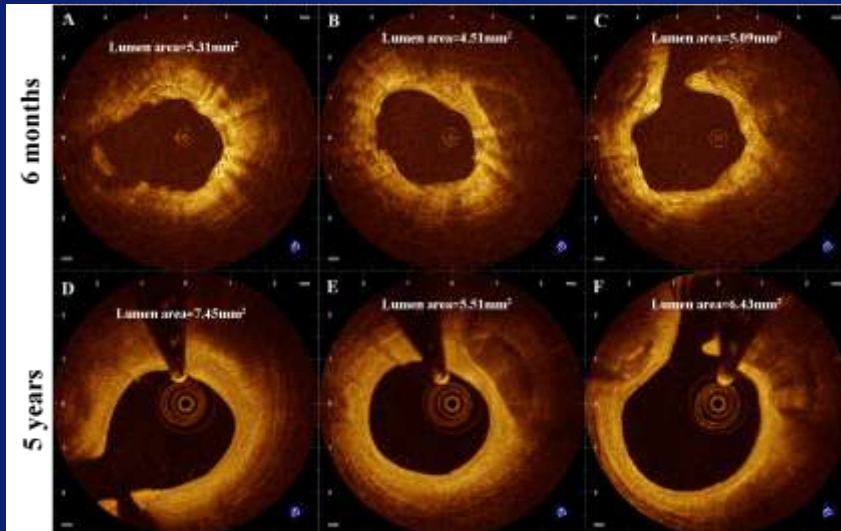
- Improvement of the vasomotor response over time
- Correlation with reduction of hyper-echogenicity by IVUS



# BVS -Insights from intravascular imaging

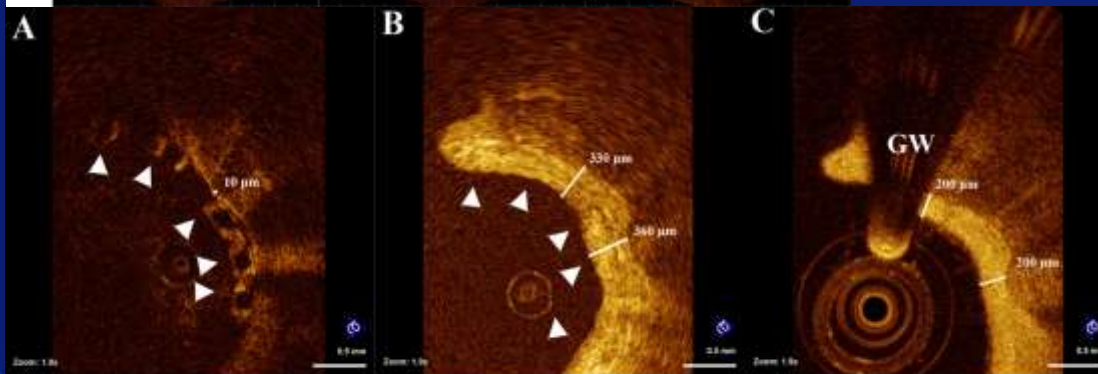
## What did we learn?

### BVS might promote favourable plaque modification



- Late lumen enlargement
- Development of signal-rich layer
- Separation of thrombogenic plaque and lumen

## Sealing layer?



Baseline

6 months

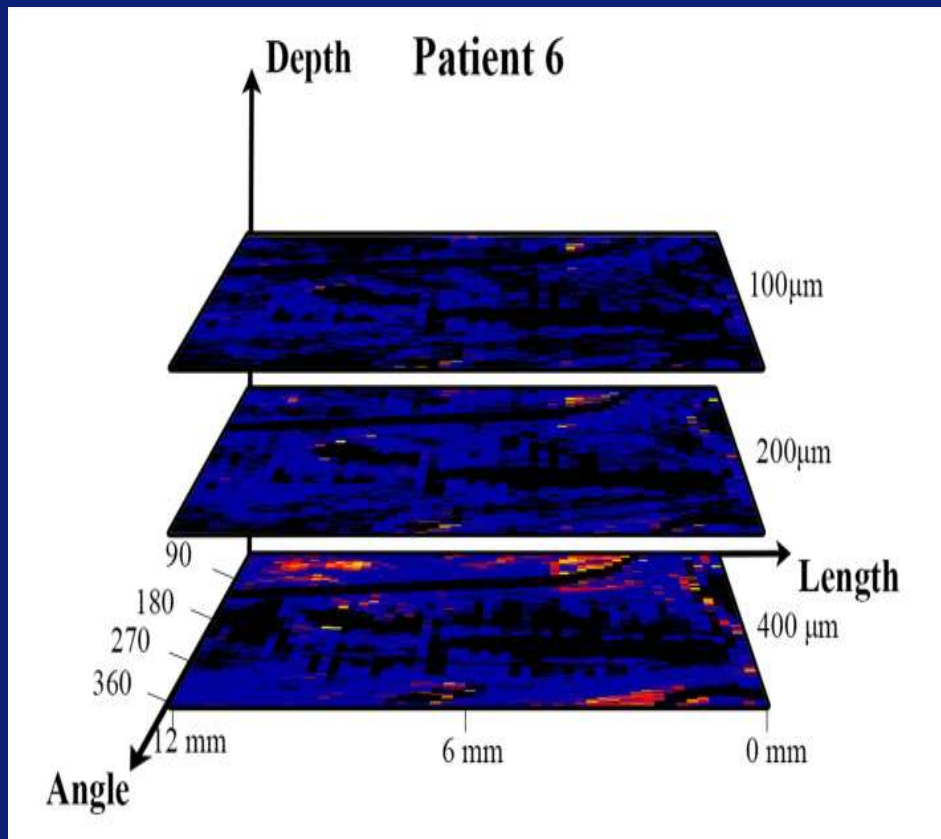
5 years



# BVS -Insights from intravascular imaging

## What did we learn?

### BVS might promote favourable plaque modification



- Late lumen enlargement
- Development of signal-rich layer
- Separation of thrombogenic plaque and lumen

**Sealing layer?**

# BVS -Insights from intravascular imaging

## Some words of caution!

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## Some words of caution!

- **Adequate BVS sizing is crucial**

Key issue with the ABSORB scaffold

Limited range of expansion

2.5 mm scaffold → up to 3.0mm

3.0 mm scaffold → up to 3.5mm

3.5 mm scaffold → up to 4.0mm

Beyond that range, struts can break.

Therefore sizing pre-implantation is of paramount importance.



# BVS -Insights from intravascular imaging

## Some words of caution!

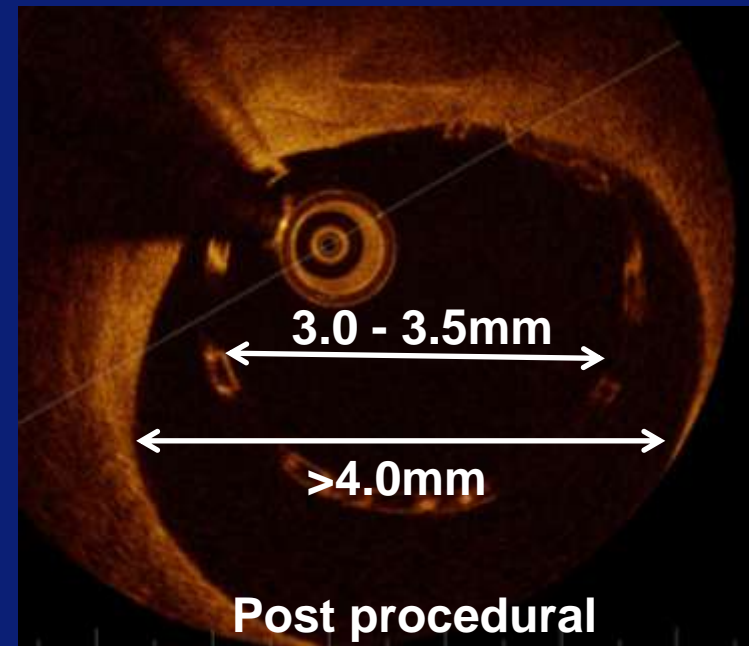
- Adequate BVS sizing is crucial

### Small malapposition

- Correctable by post dilatation
- Resolve at FUP

### Large malapposition

- Uncorrectable (Persistent at FUP)
- Overexpansion by a large balloon  
→ Acute disruption



# BVS -Insights from intravascular imaging



## Some words of caution!

- **Adequate BVS sizing is crucial**

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## Some words of caution!

- **Adequate BVS sizing is crucial**

### Small malapposition

- Correctable by post dilatation
- Resolve at FUP

### Large malapposition

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# BVS -Insights from intravascular imaging

## Some words of caution!

- Adequate BVS sizing is crucial

OCT non-optimal deployment end points				
n=52	DMAX < 2.5 mm (n=13) Small vessel	DMAX 2.5 to 3.3 mm (n=30)	DMAX > 3.3 mm (n=9) Large vessel	p
minSA < 5 mm <sup>2</sup>	31%	10%	0	0.08
RAS > 20%	46%	53%	78%	0.31
Edge dissections†	62%	33%	11%	0.05
ISA struts > 5%	8%	37%	67%	0.02
Acute disruption	0%	7%	11%	0.52



## What did we learn?

- How to Size Adequately?

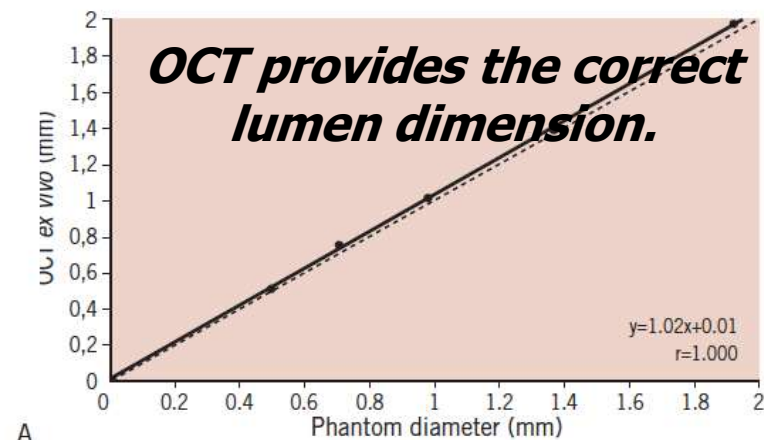
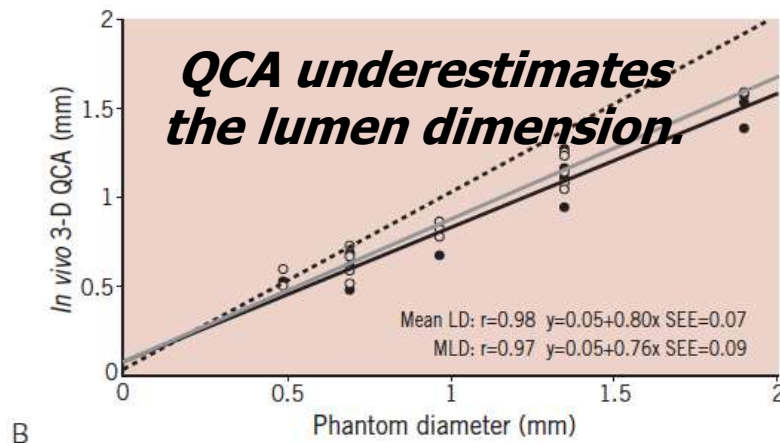
### *In vivo* validation of a novel three-dimensional quantitative coronary angiography system (CardiOp-B™): comparison with a conventional two-dimensional system (CAAS II™) and with special reference to optical coherence tomography

Clinical research

EuroIntervention

Keiichi Tsuchida, MD, PhD; Willem J. van der Giessen, MD, PhD; Mark Patterson, MRCP; Shuzou Tanimoto, MD; Héctor M. García-García, MD, MSc; Evelyn Regar, MD, PhD; Jurgen M. R. Ligthart, BSc; Anne-Marie Maugeness; Gio Maatrijk; Jolanda J. Wentzel, PhD; Patrick W. Serruys\*, MD, PhD, FACC, FESC

Thoraxcenter, Erasmus Medical Center, Rotterdam, The Netherlands





# BVS -Insights from intravascular imaging

## What did we learn?

- **How to Size Adequately?**

	QCA	IVUS	OCT
<b>Dimension assessment</b>	<b>underestimation</b>	<b>overestimation</b>	<b>correct</b>
<b>Detection of malapposition</b>	<b>none</b>	<b>poor</b>	<b>optimal</b>
<b>Detection of fracture</b>	<b>none</b>	<b>none/poor</b>	<b>optimal</b>
<b>Need for coregistration</b>	<b>none</b>	<b>yes</b>	<b>yes</b>
<b>Cost/ procedure time</b>	<b>no</b>	<b>additional</b>	<b>additional</b>
<b>Regulatory labelling</b>	<b>no</b>	<b>yes</b>	<b>yes</b>

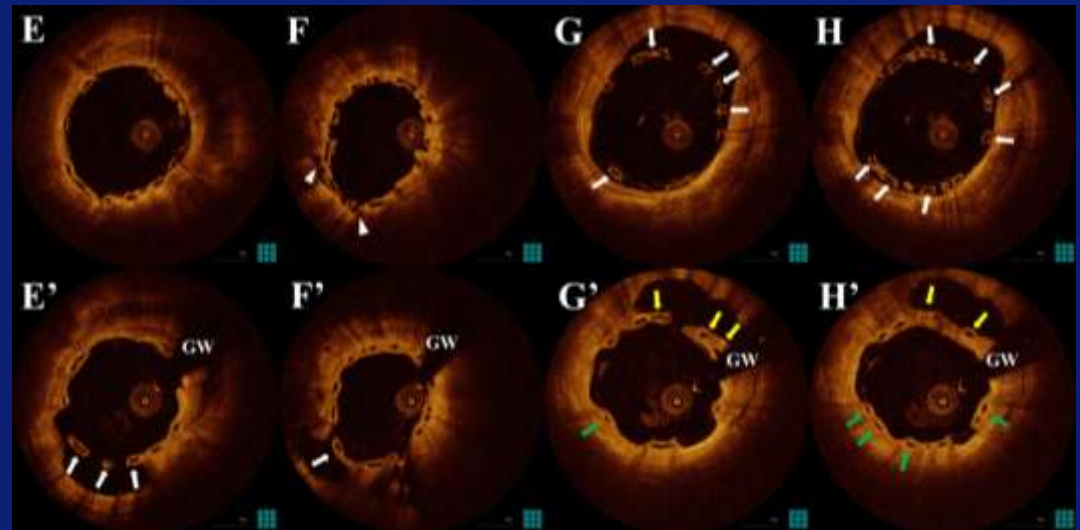


## Some words of caution!

- **Complex lesions?**

- Different healing process after BVS implantation in pts with acute MI?
- At 6 months FUP: Patterns of resolved, persistent, and also late ISA

*Baseline*



*6m FUP*

# BVS -Insights from intravascular imaging



## Some words of caution!

- **Complex lesions?**

- Different healing process after BVS implantation in pts with acute MI?
- At 6 months FUP: Patterns of resolved, persistent, and also late ISA
- More comprehensive ISA score needed?

		<b>ISA score 0:</b> Completely apposed scaffold
		<b>ISA score 1:</b> Presence of evaginations $>0.10\text{mm}^2$
		<b>ISA score 2:</b> Malapposition with complete bridge formation
		<b>ISA score 3:</b> Malapposition with partial bridge formation
		<b>ISA score 4:</b> Isolated malapposed struts

# BVS -Insights from intravascular imaging



## Some words of caution!

- (Very late) Scaffold thrombosis has been reported

### CARDIOVASCULAR FLASHLIGHT

doi:10.1093/eurheartj/ehu031

#### Very late bioresorbable scaffold thrombosis after discontinuation of dual antiplatelet therapy

Antonios Karanasos, Robert-Jan van Geuns, Felix Zijlstra, and Evelyn Regar\*

Department of Interventional Cardiology, Thoraxcentre, BA-585, Erasmus University Medical Centre, 's Gravendijkwal 230, 3015 CE, Rotterdam, the Netherlands

\* Corresponding

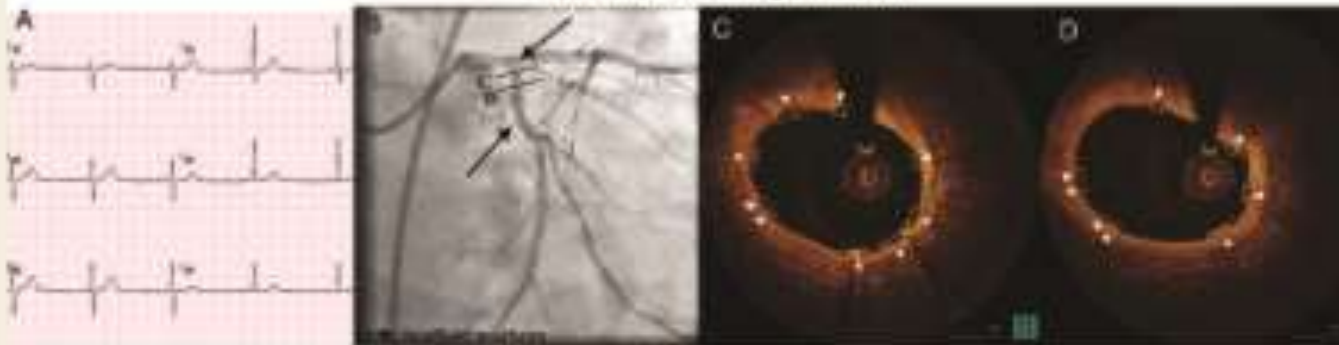
A 57-year-old stable angina patient 30 days after percutaneous coronary intervention (PCI) with a bioresorbable vascular scaffold (BVS; ABSORB, Abbott Vascular, Abbott Park, IL, USA) in the left anterior descending artery (LAD) by everolimus-eluting stents. Fracture of the scaffold was noted at presentation.

To our knowledge, this is the first reported case of very late BVS thrombosis after discontinuation of dual antiplatelet therapy (DAT) in a patient with a BVS implant.

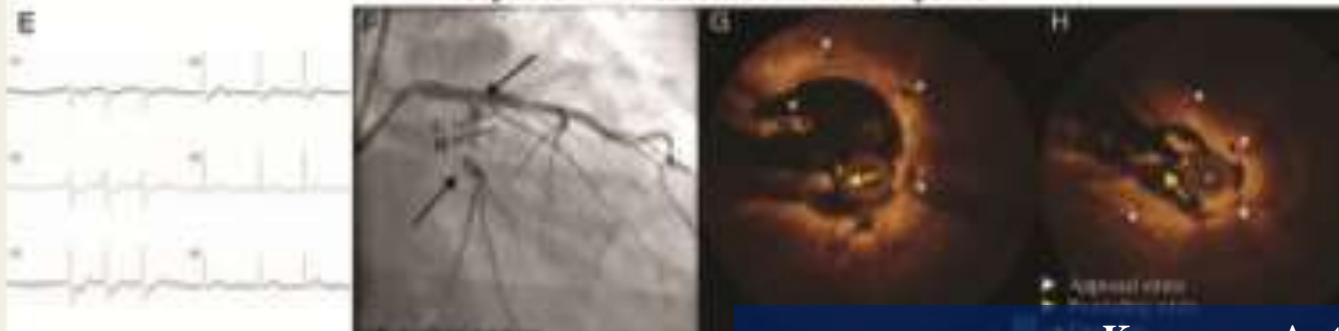
**Funding:** Funding by the Erasmus University Medical Centre, Rotterdam, The Netherlands.

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#### Baseline BVS implantation



#### Very late BVS thrombosis after 2 years





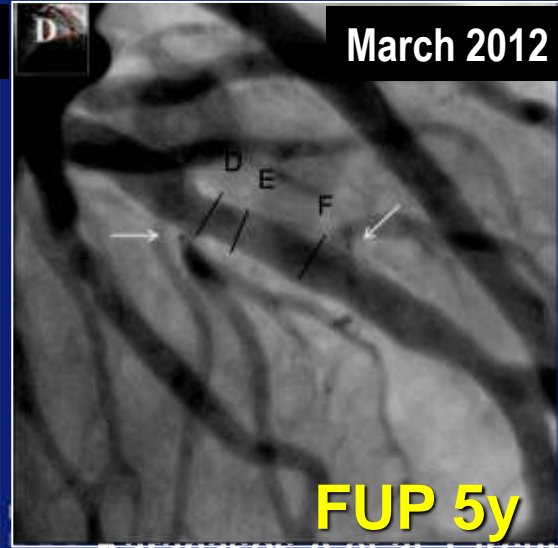
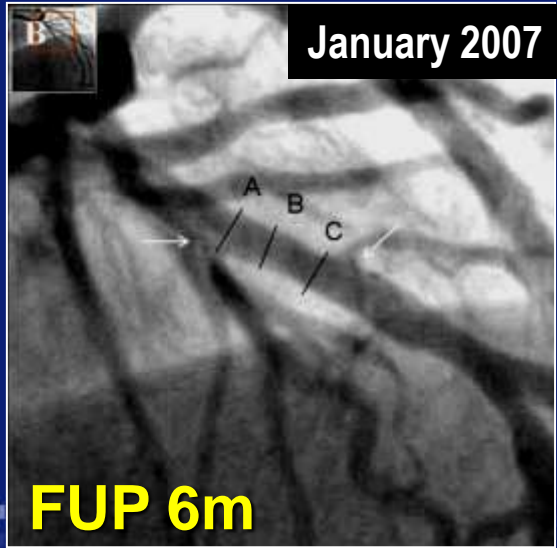
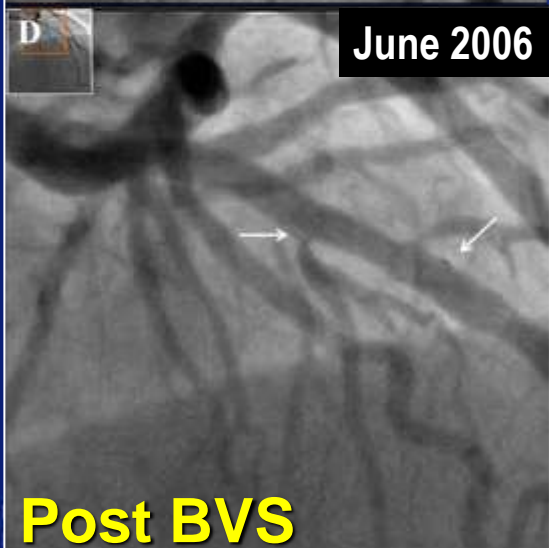
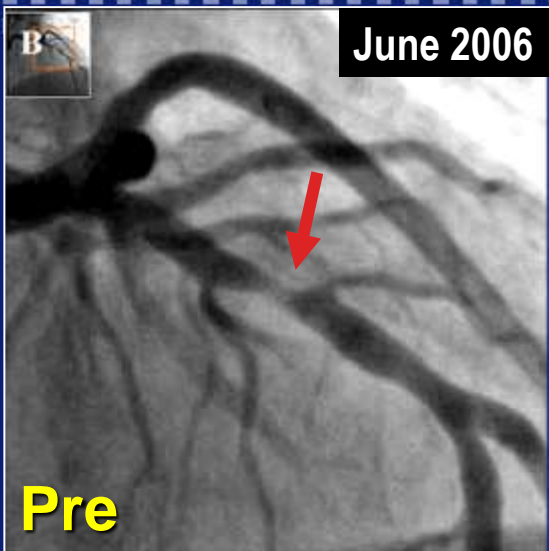
## What did we learn?

### BVS



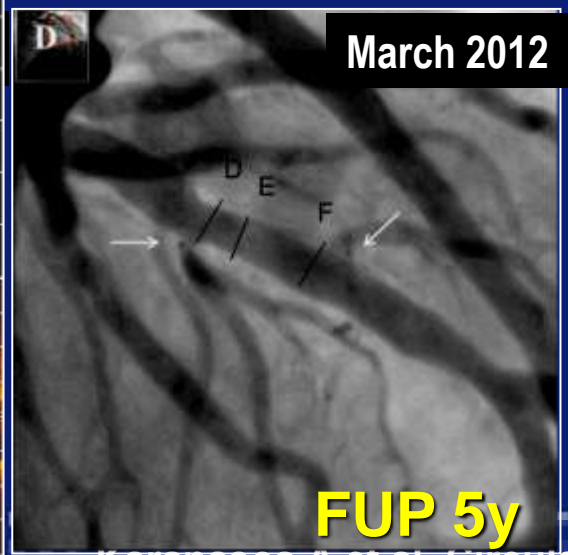
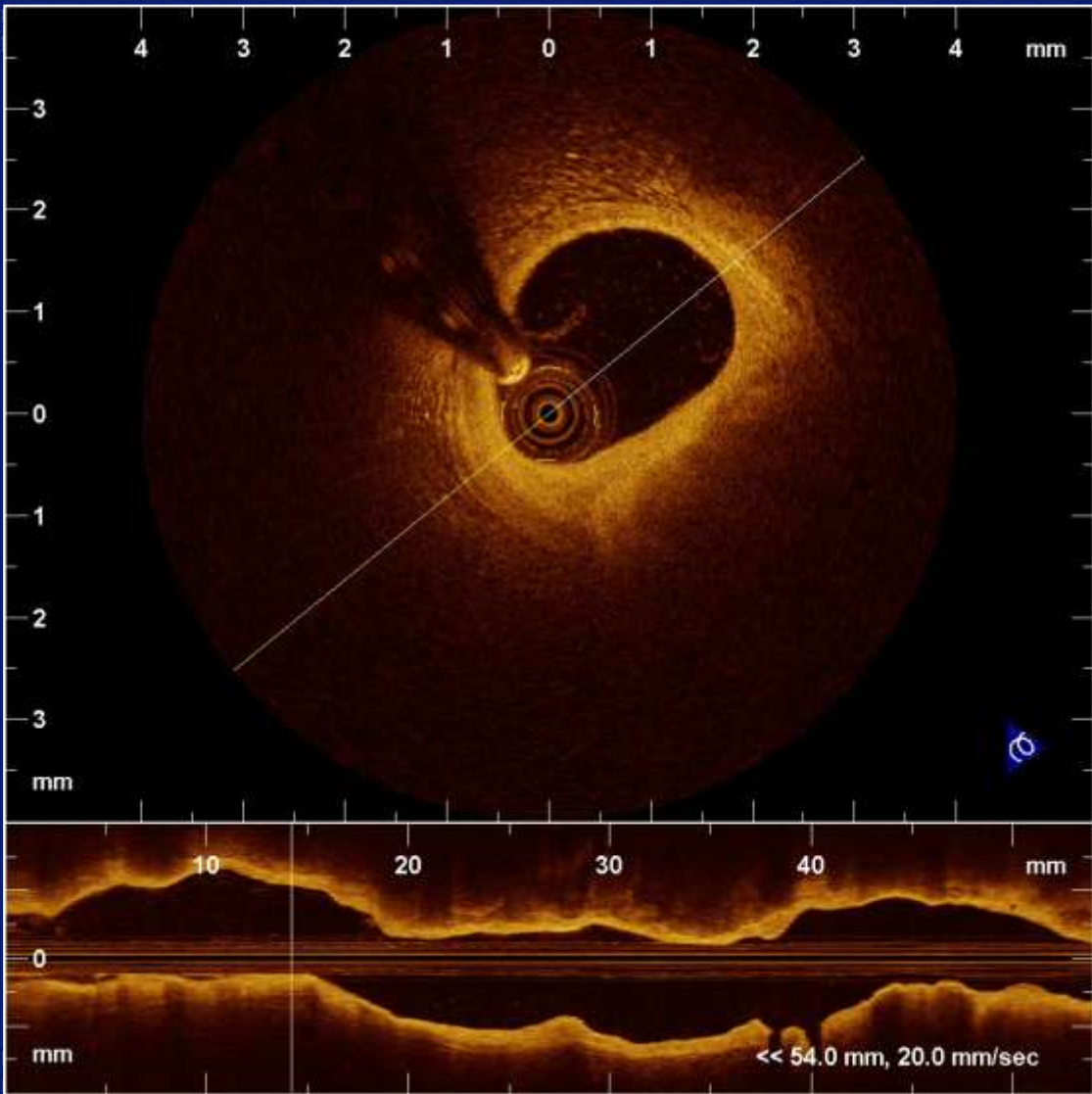
- promote good vascular healing
- show complete bioresorption over time
- allow for late lumen enlargement
- allow for reduction in plaque burden
- allow for restoration of vasomotion
- might promote favourable plaque modification

# ABSORB Cohort A – 5 Year FUP



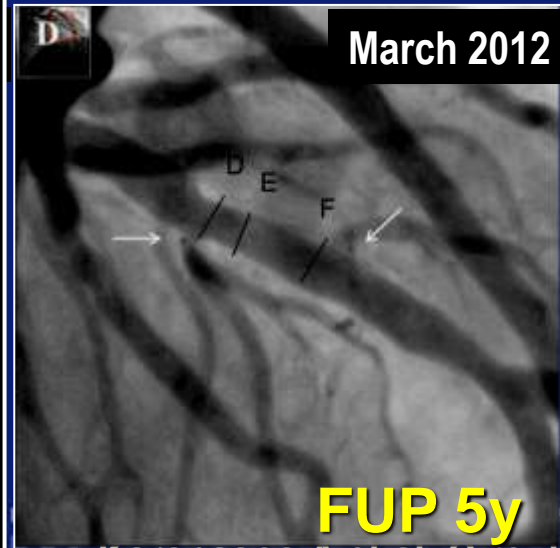
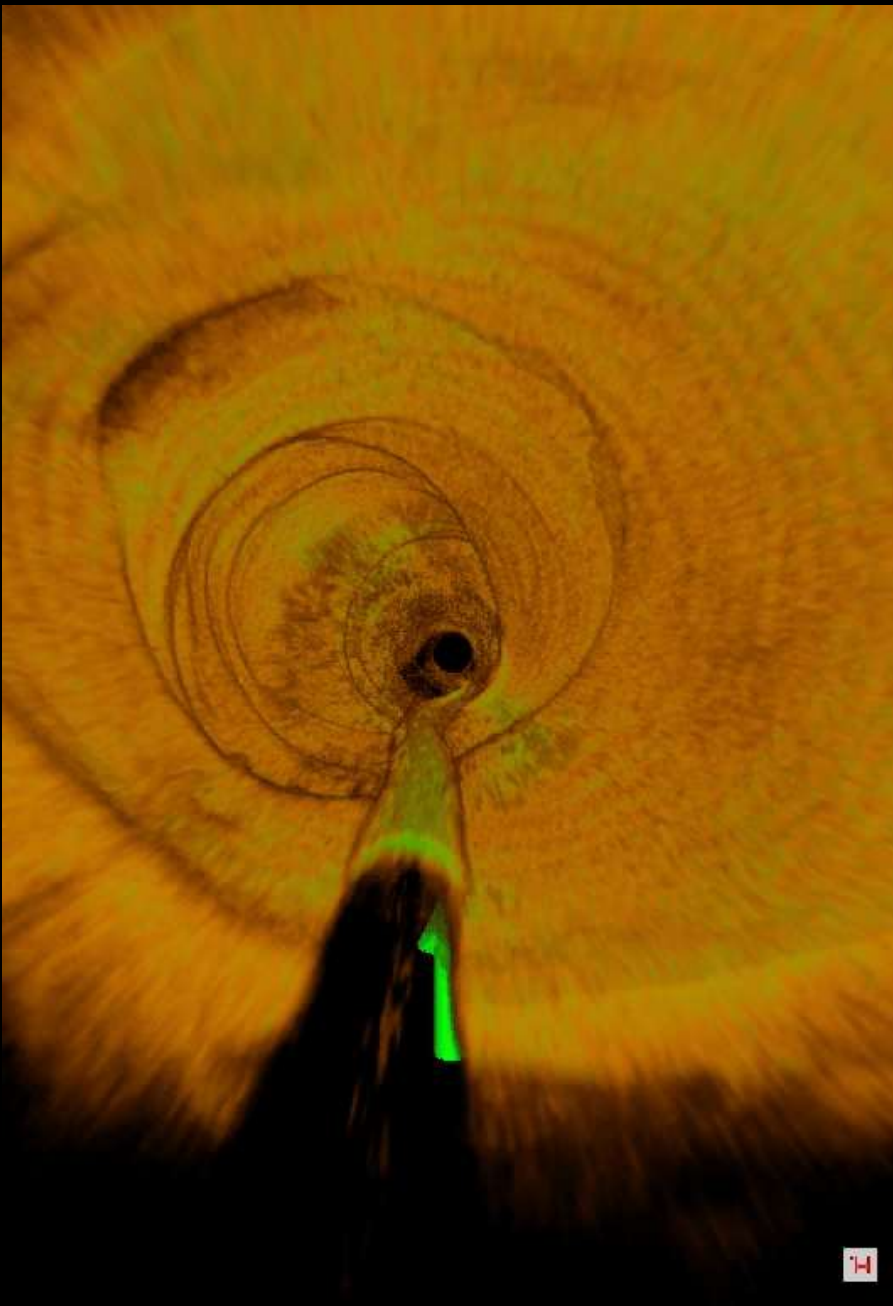


# ABSORB Cohort A – 5 Year FUP





OCT 3D Rendering



# Thank you for your attention!

## **PhD Students**

**A. Karanasos**  
**C. Simsek**  
**N. van Ditzhuijsen**  
**J. van der Sijde**

## **Interventional Cardiology**

**J. Ligthart**  
**K. Witberg**  
**R.J. van Geuns**  
**P. de Jaegere**  
**N. van Mieghem**  
**M. Valgimigli**  
**R. Diletti**  
**F. Zijlstra**

## **Experimental Cardiology**

**H. van Beusekom**

## **Hemodynamics Laboratory**

**J. Wentzel**  
**F. Gijsen**

## **Bioengineering**

**G. van Soest**  
**A.F.W. van der Steen**

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**N. Bruining**  
**K. Sihan**