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IVUS-Guided Stent Optimization from MUSIC to ADAPT-DES



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Disclosure

No conflict of interest.



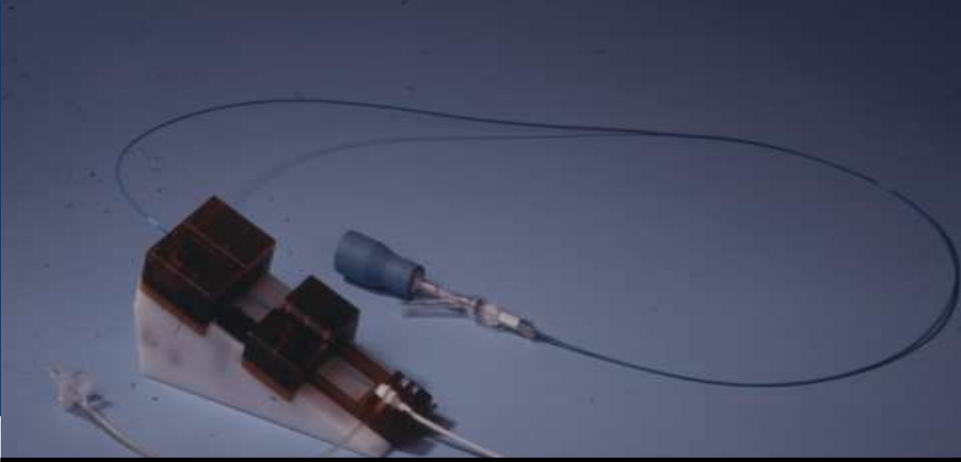
1990ties: IVU

Intravascular scanner

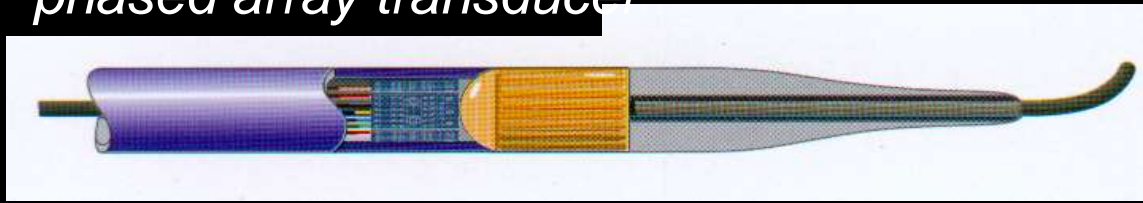
*Intravascular scanner
(1990, DuMed)*



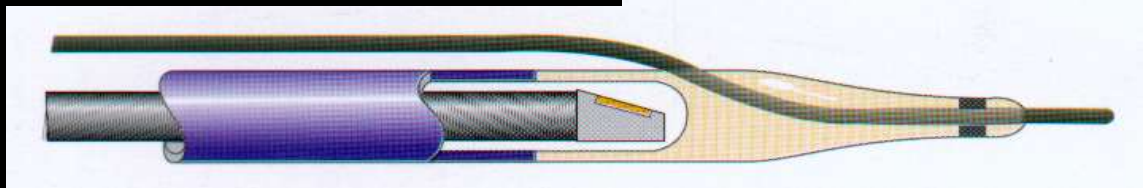
N. Bom



phased array transducer



single rotating transducer



1990ties: IVUS Is Being Invented



N. Bom

Intravascular Ultrasound and Vascular Intervention

ELMA J. GUSSENHOVEN, M.D.,*,‡ SALEM H.K., M.D.,** PATRICK W. SERRUYS, M.D.,*
HERO VAN URK, M.D.,** HERMAN PIETERMAN, M.D.‡ FRANS C. VAN EGMOND,*
JOS R. ROELANDT, M.D.,* CHARLES T. LANCÉE,* I.I WENGUANG,* and YIN ZHONG*

*From the *Thoraxcenter, University Hospital Dijkzigt; Departments of **Vascular Surgery, and †Radiology, Erasmus University Rotterdam; and the †Interuniversity Cardiology Institute, The Netherlands.*

An intravascular ultrasonic imaging device (40 MHz) was used to obtain in vitro ultrasonic images and matching histologic cross-sections, derived from human vascular specimens. The feasibility of assessing vessel wall morphology as well as the ability to accurately document plaque thickness was determined. Based on the echogenicity of the arterial media, intravascular ultrasound could distinguish muscular arteries from elastic arteries, veins, and bypass grafts. The hypochoic media only present in the muscular type of artery proved to be an essential landmark to document superimposed atherosclerosis. Plaque thickness calculated in these arteries showed close relationship with the corresponding histologic cross-section. Using real-time in vivo intravascular imaging (30 MHz), the morphology of the vessels interrogated was studied. The dynamic change of the arterial wall, as well as the outcome after intervention, is discussed.

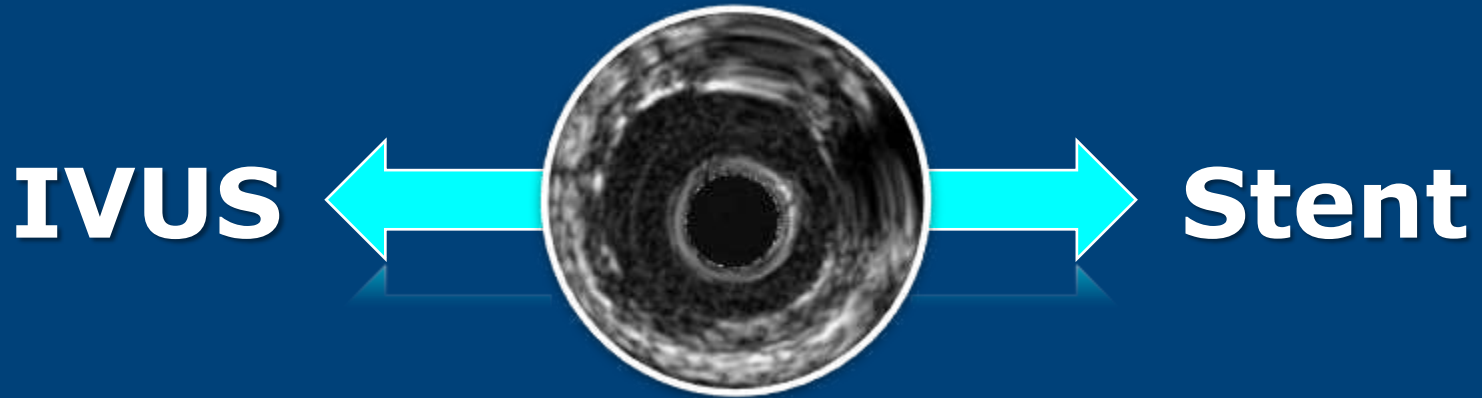
Gussenhoven E et al.

J Interv Cardiol 1991;4(1):41-8.

J Am Coll Cardiol. 1989 Oct;14(4):947-52

Eur J Vasc Surg. 1989 Dec;3(6):571-6.

1990ties: Two Important Innovations



**PIVOTAL QUESTION:
Can IVUS-Guided Stenting
Improve Outcome?**

1990ties: The Role of IVUS

The French Way



Intracoronary stent implantation without ultrasound guidance and with replacement of conventional anticoagulation by anti-platelet therapy.

30-day clinical outcome of the French Multicenter Registry.

Karrillon GJ, Morice MC, Benveniste E, Bunouf P, Aubry P, Cattan S, Chevalier B, Commeau P, Cribier A, Eiferman C, Grollier G, Guerin Y, Henry M, Lefevre T, Livarek B, Louvard Y, Marco J, Makowski S, Monassier JP, Pernes JM, Rioux P, Spaulding C, Zemour G.

Circulation. 1996 Oct 1;94(7):1519-27.

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Anti-platelet regimen

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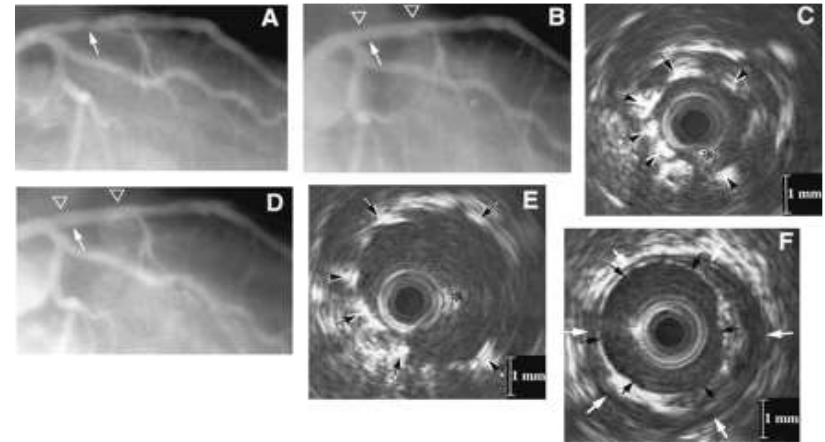
Circulation. 1996 Oct 1;94(7):1519-27.

Anti-platelet regimen

The Italian Way



Intracoronary Stenting
Without Anticoagulation Accomplished
With Intravascular Ultrasound Guidance



Stent expansion

1990ties: The Role of IVUS

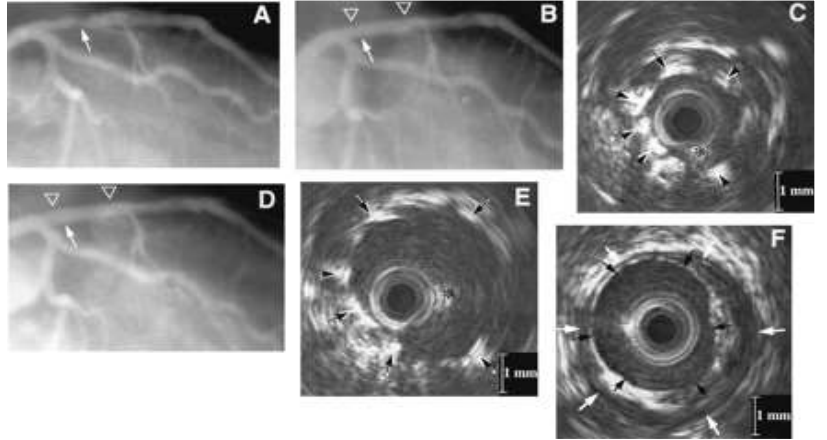
Optimal Stent Expansion:

30% of Lesions

The Italian Way



Intracoronary Stenting
Without Anticoagulation Accomplished
With Intravascular Ultrasound Guidance



Stent expansion

1990ties: The MUSIC Study

**Intravascular ultrasound-guided optimized stent deployment.
Immediate and 6 months clinical and angiographic results from
the Multicenter Ultrasound Stenting in Coronaries Study
(MUSIC Study)**

de Jaegere P, Mudra H, Figulla H, Almagor Y, Doucet S, Penn I, Colombo A, Hamm C, Bartorelli A, Rothman M, Nobuyoshi M, Yamaguchi T, Voudris V, DiMario C, Makovski S, Hausmann D, Rowe S, Rabinovich S, Sunamura M, van Es GA.

Eur. Heart J 1998

IVUS

Prespecified Criteria for Optimal Stent Expansion



Restore Optimal Flow Conditions



Aspirin only

1990ties: The MUSIC Study

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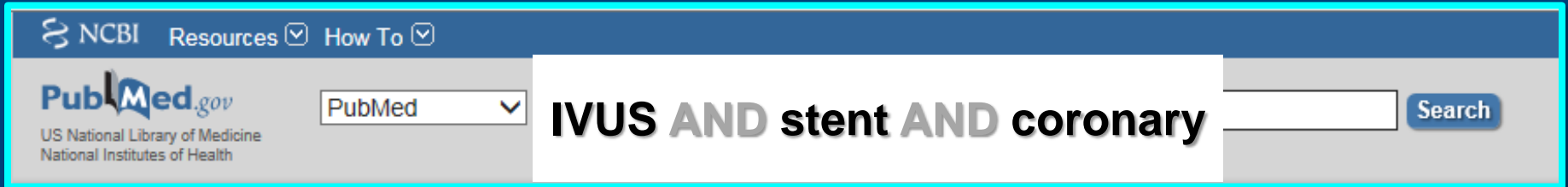
Eur. Heart J 1998

IVUS

guided optimal BMS stent expansion **reduces**

- **the risk of acute stent thrombosis &**
- **the need for dual antiplatelet therapy**

1990ties – Today: **1346** Publications



Search 28.04.2018

- Randomized clinical trials
- Observational clinical trials
- Single-center registries
- Multi-center registries
- Meta-analyses
- HTA-Assessments
- Expert-Consensus
- Guidelines

Across geographies, across devices

1990ties – Today: Various IVUS Criteria

MUSIC - criteria

If minimal stent area $< 9.0 \text{mm}^2$:

Minimal stent area $\geq 90\%$ of the mean reference lumen area

Or Minimal stent area $\geq 100\%$ of lumen lowest reference lumen area.

Prox. stent entrance $\geq 90\%$ of proximal reference lumen area.

If minimal stent area $> 9.0 \text{mm}^2$:

Minimal stent area $\geq 80\%$ of the mean reference lumen area

Or Minimal stent area $\geq 90\%$ of lumen lowest reference lumen area.

Symmetric stent expansion defined by **Stent Dmin/Dmax > 0.7**

Complete stent apposition against the vessel wall.

DeJaegere et al. 1998

1990ties – Today: Various IVUS Criteria

Minimal stent area >80% of the mean reference lumen area

RESIST - criteria
Schiele et al. 1998

Minimal stent diameter 80% of the mean reference diameters
Minimal stent area (MLA) \geq 100% of distal reference lumen area
Complete stent apposition

TULIP - criteria
Oemrawsingh et al. 2003

Minimal stent area >80% of mean reference lumen area
or minimal stent area >7.5 mm² with full stent apposition.

DIPOL-criteria
Gil et al. 2007

Minimal stent area \geq 90% of distal reference lumen area
Stent fully apposed to vessel wall.
Dissections covered by stent.

AVID - criteria
Russo et al. 2009

Minimal stent area > 5mm² or >90% of distal reference lumen area
Apposition of all stent struts
No edge dissections.

HOME DES - criteria
Jakabcin et al. 2010

1990ties – Today: What Did We Learn?

The Reasons For BMS Failure Are:

BMS	EARLY THROMBOSIS	RESTENOSIS
Under-expansion	<ul style="list-style-type: none"> • Cheneau et al. Circulation. 2003;108:43-7 	<ul style="list-style-type: none"> • Kasaoka et al. J Am Coll Cardiol. 1998;32:1630-5 • Castagna et al. Am Heart J. 2001;142:970-4 • De Feyter et al. Circulation. 1999;100:1777-83 • Sonoda et al. J Am Coll Cardiol .2004;43:1959-63 • Morino et al. Am J Cardiol .2001;88:301-3 • Ziada et al. Am Heart J. 2001;141:823-31 • Doi et al. JACC Cardiovasc Interv. 2009;2:1269-75
Edge Problems	<ul style="list-style-type: none"> • Cheneau et al. Circulation. 2003;108:43-7 	<ul style="list-style-type: none"> • Liu et al. Am J Cardiol . 2009;103:501-6
Stent Length		<ul style="list-style-type: none"> • Kasaoka et al. J Am Coll Cardiol . 1998;32:1630-5 • De Feyter et al. Circulation . 1999;100:1777-83

IVUS Predictors of Restenosis & Early Thrombosis

– BMS References

Courtesy G. Mintz

1990ties – Today: What Did We Learn?

The Reasons For DES Failure Are:

DES	EARLY THROMBOSIS	RESTENOSIS
Under-expansion	<ul style="list-style-type: none"> • Fujii et al. <i>J Am Coll Cardiol</i>. 2005;45:995-8 • Okabe et al. <i>Am J Cardiol</i>. 2007;100:615-20 • Liu et al. <i>JACC Cardiovasc Interv</i>. 2009;2:428-34 • Choi et al. <i>Circ Cardiovasc Interv</i>. 2011;4:239-47 	<ul style="list-style-type: none"> • Sonoda et al. <i>J Am Coll Cardiol</i> . 2004;43:1959-63 • Hong et al. <i>Eur Heart J</i>. 2006;27:1305-10 • Doi et al. <i>JACC Cardiovasc Interv</i>. 2009;2:1269-75 • Fujii et al. <i>Circulation</i>. 2004;109:1085-1088 • Kang et al. <i>Circ Cardiovasc Interv</i> . 2011;4:9-14 • Choi et al. <i>Am J Cardiol</i>. 2012;109:455-60 • Song et al. <i>Catheter Cardiovasc Interv</i>. 2014;83:873-8
Edge Problems	<ul style="list-style-type: none"> • Fujii et al. <i>J Am Coll Cardiol</i>. 2005;45:995-8 • Okabe et al. <i>Am J Cardiol</i>. 2007;100:615-20 • Liu et al. <i>JACC Cardiovasc Interv</i>. 2009;2:428-34 • Choi et al. <i>Circ Cardiovasc Interv</i>. 2011;4:239-47 	<ul style="list-style-type: none"> • Sakurai et al. <i>Am J Cardiol</i> . 2005;96:1251-3 • Liu et al. <i>Am J Cardiol</i> . 2009;103:501-6 • Costa et al, <i>Am J Cardiol</i>. 2008;101:1704-11 • Kang et al. <i>Am J Cardiol</i> . 2013;111:1408-14 • Kobayashi et al. ACC2014
Stent Length		<ul style="list-style-type: none"> • Hong et al. <i>Eur Heart J</i>. 2006;27:1305-10

IVUS Predictors of Restenosis & Early Thrombosis

– DES References

Courtesy G. Mintz

1990ties – Today: What Did We Learn?

ADAPT-DES

Assessment of **D**ual **A**nti**P**latelet **T**herapy with **D**rug-**E**luting **S**tents

Prospective, multicenter, real-world study

N=8,583 patients

No clinical or anatomic exclusion criteria

Successful and uncomplicated PCI with ≥ 1 DES

Pre-specified IVUS sub-study:

IVUS

n=**3,361** pts (39%)

No IVUS

n=**5,221** pts (61%)

Clinical FU

30d

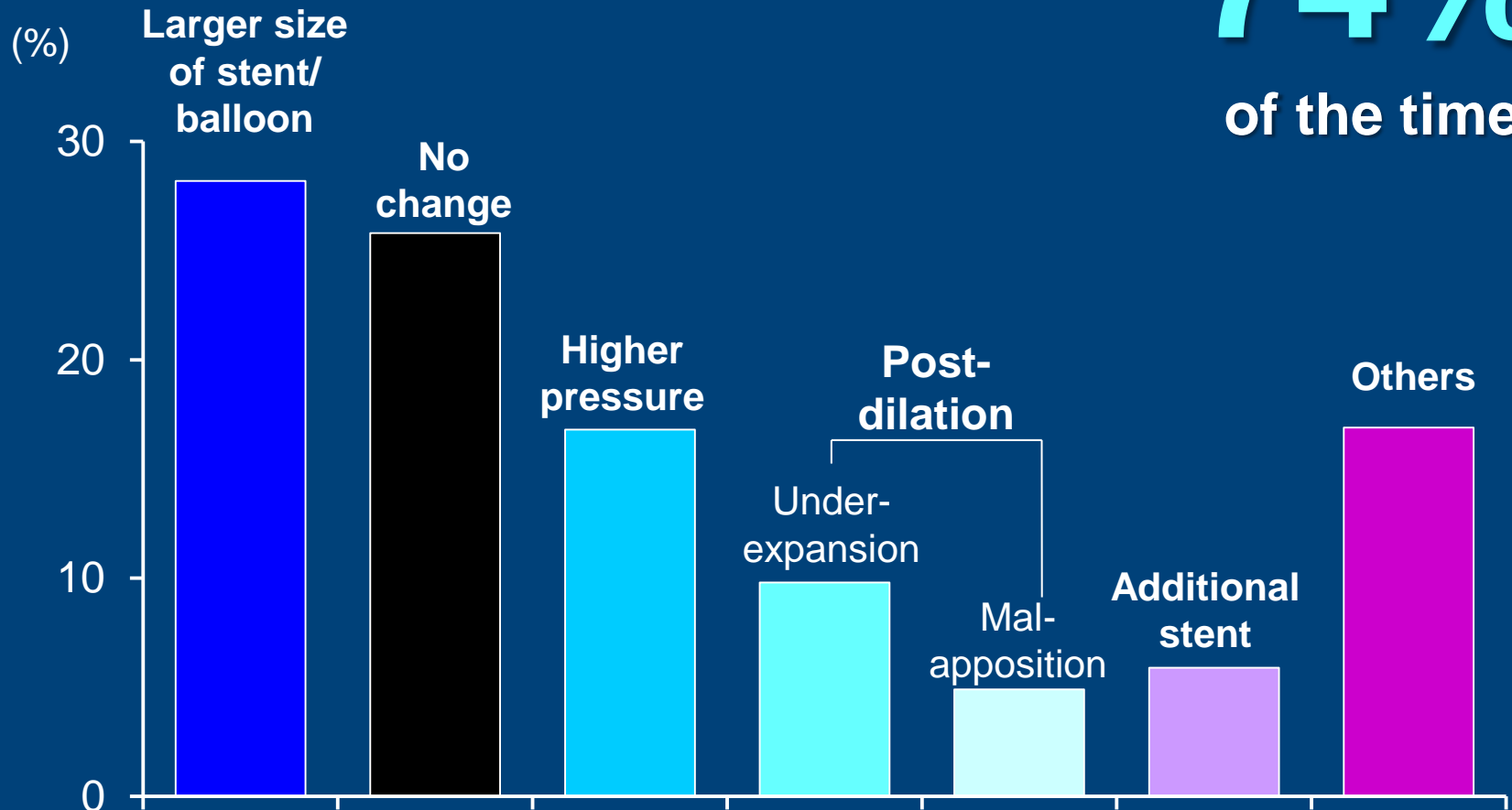
1yr

2yr

1990ties – Today: What Did We Learn?

ADAPT-DES

IVUS Changed the Procedure: 74% of the time



1990ties – Today: What Did We Learn?

ADAPT-DES

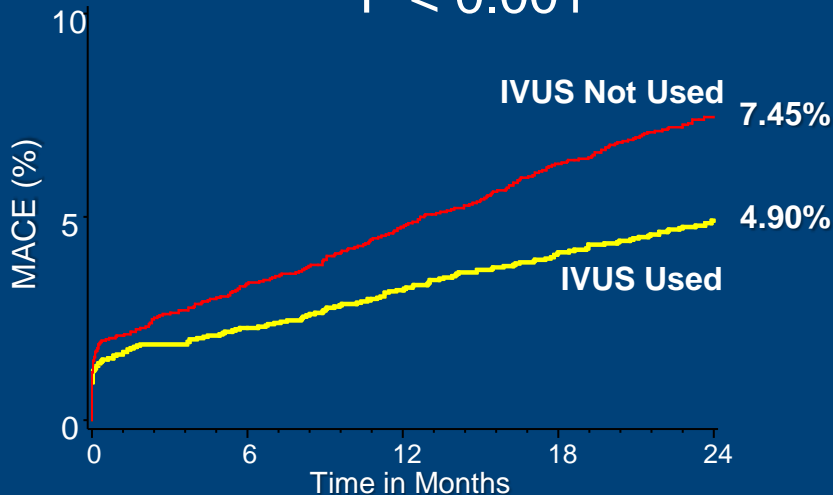
Significantly Lower Event Rates with IVUS

MACE

(Cardiac Death, MI, Definite/Probable ST)

HR: **0.65** [95% CI: 0.54, 0.78]

P < 0.001



Number at risk:

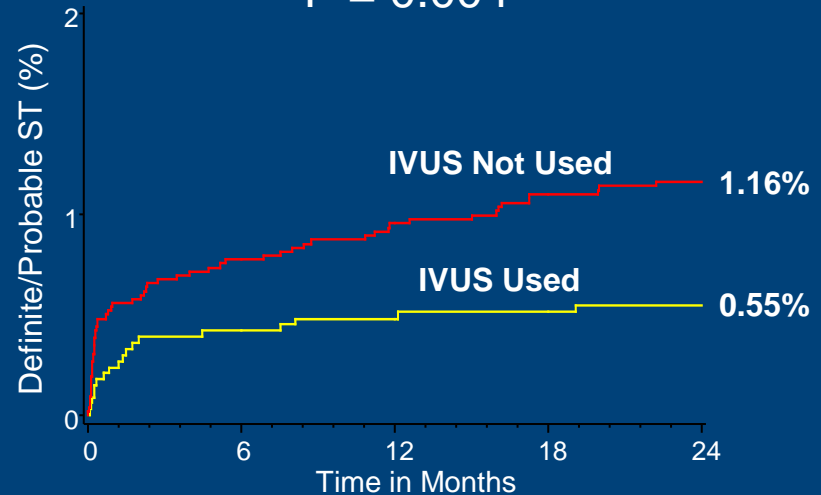
	0	6	12	18	24
IVUS Used	3361	3206	3117	2988	1739
IVUS Not Used	5221	4912	4740	4537	2177

Stent Thrombosis

(ARC Definite or Probable)

HR: **0.47** [95% CI: 0.28, 0.80]

P = 0.004



Number at risk:

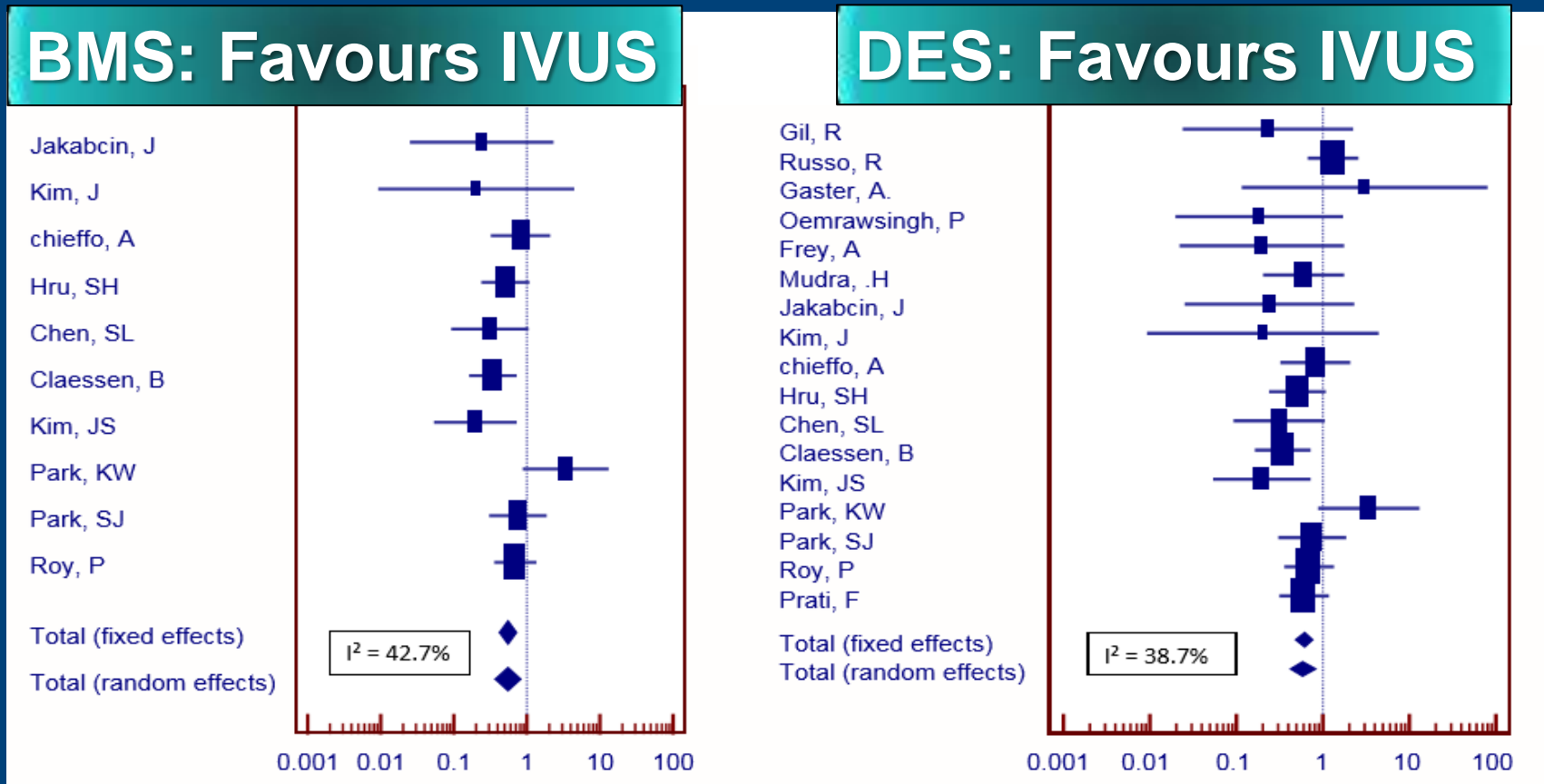
	0	6	12	18	24
IVUS Used	3361	3260	3182	3065	1791
IVUS Not Used	5221	5019	4886	4713	2279

1990ties – Today: What Did We Learn?

IVUS Reduces Hard Clinical Endpoints

Meta-analysis n= 14,197 pts Imaging-guided vs. Angiography-guided PCI

Difference: Myocardial Infarction



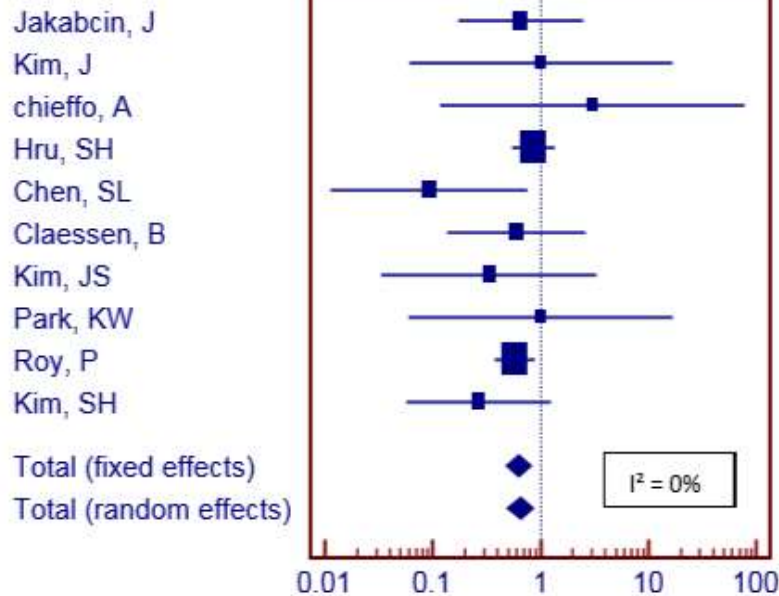
1990ties – Today: What Did We Learn?

IVUS Reduces Hard Clinical Endpoints

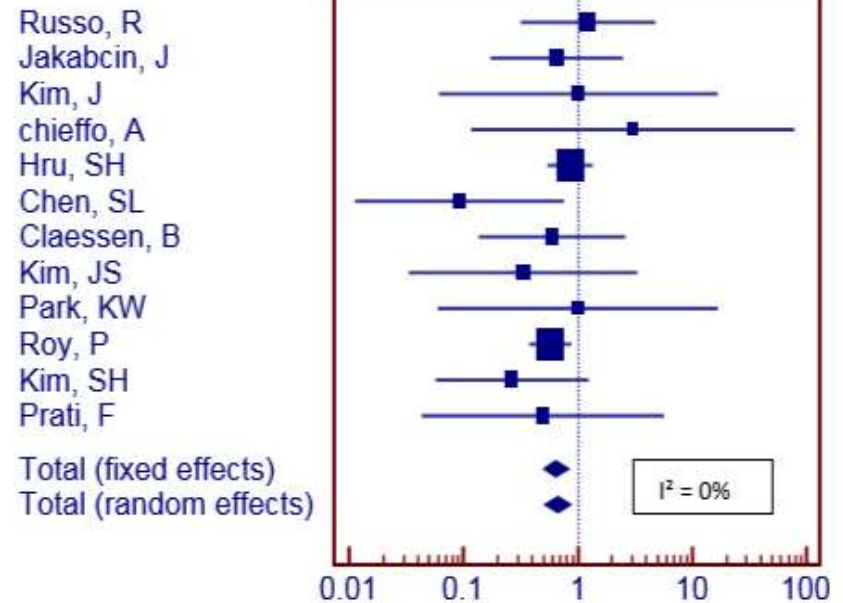
Meta-analysis n= 14,197 pts Imaging-guided vs. Angiography-guided PCI

Difference: Stent Thrombosis

BMS: Favours IVUS



DES: Favours IVUS

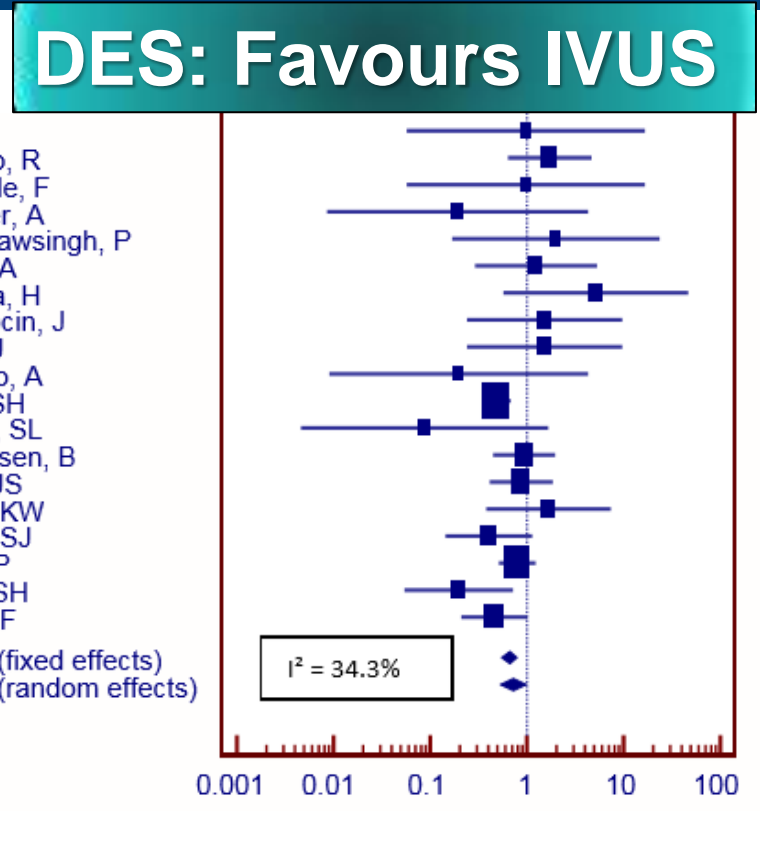
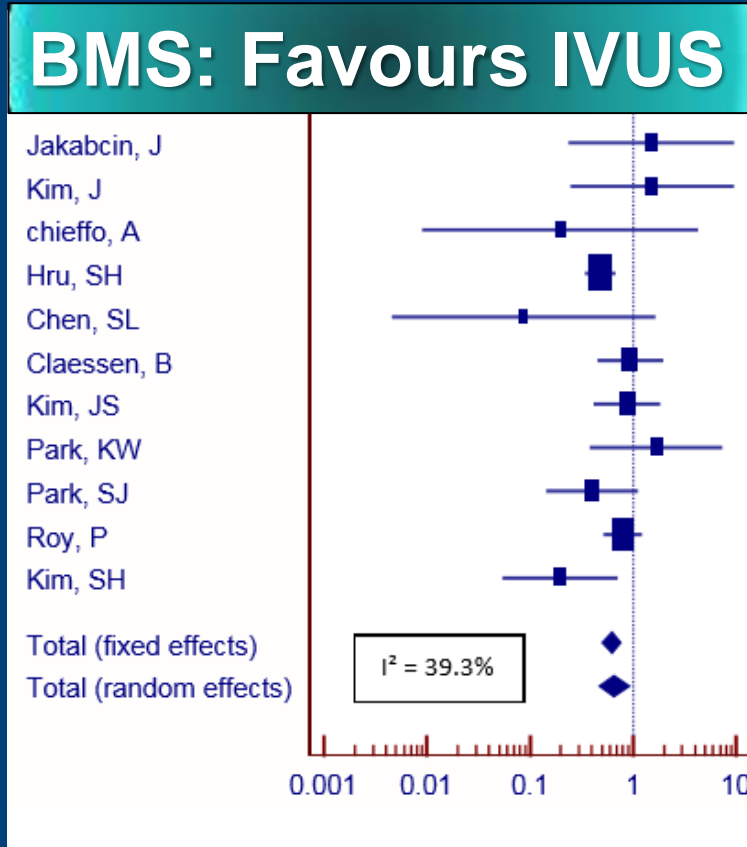


1990ties – Today: What Did We Learn?

IVUS Reduces Hard Clinical Endpoints

Meta-analysis n= 14,197 pts Imaging-guided vs. Angiography-guided PCI

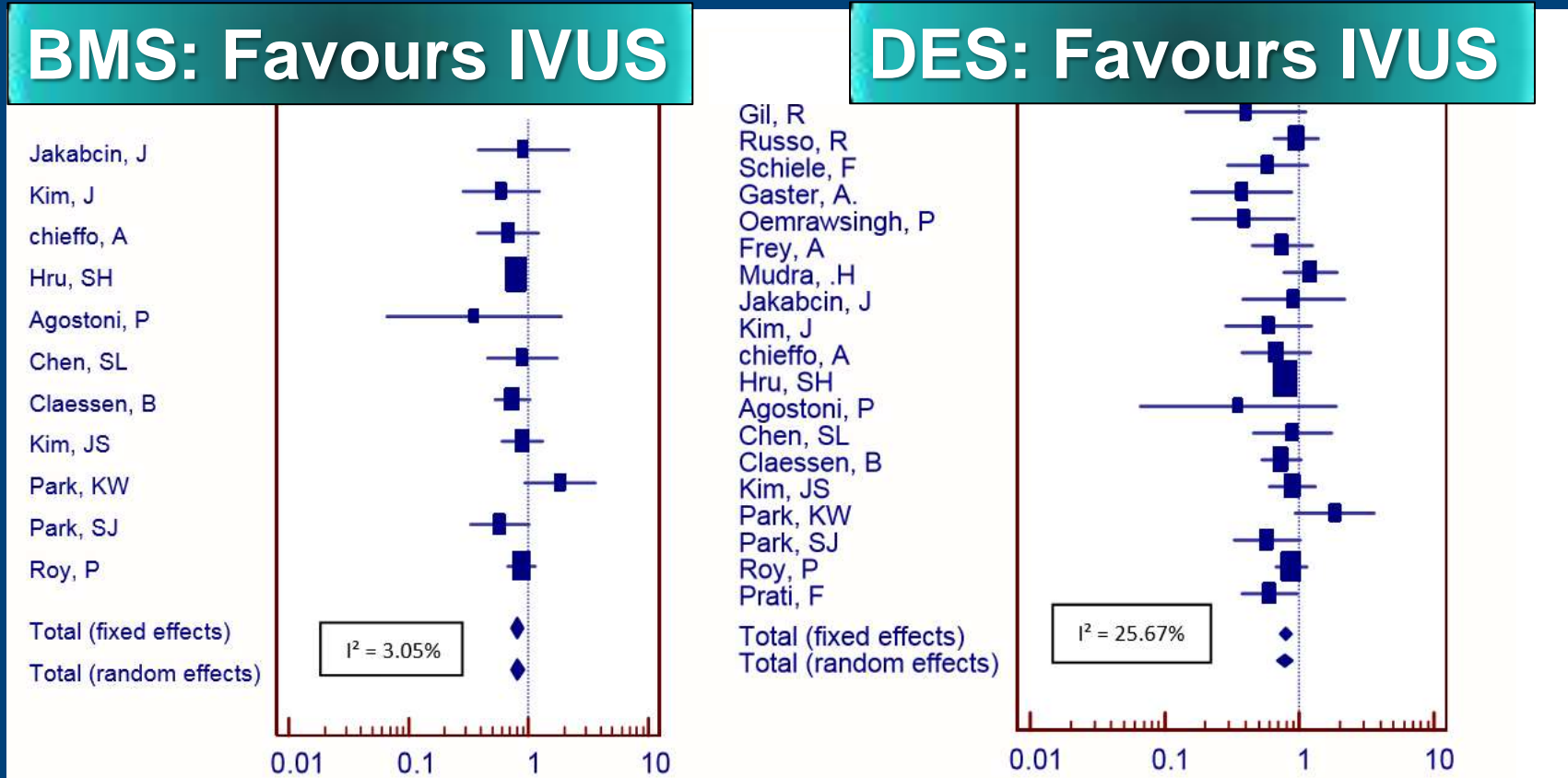
Difference: Death



1990ties – Today: What Did We Learn? IVUS Reduces Hard Clinical Endpoints

Meta-analysis n= 14,197 pts Imaging-guided vs. Angiography-guided PCI

Difference: MACE



IVUS Guided Stenting Practical Implications

**In stenting,
outcome depends on implantation technique!**

Stent diameter must not be too SMALL

Stent diameter must not be too LARGE

Stent length must not be too SHORT

Stent expansion must be OPTIMAL

IVUS Guided Stenting Practical Implications

In order to achieve optimal stenting

Pre-interventional imaging is key!

or before placing a stent

IVUS Guided Stenting Practical Implications

In order to achieve optimal stenting

Pre-interventional imaging is key!

Allows for efficient procedure planning

All metrics easily at hand

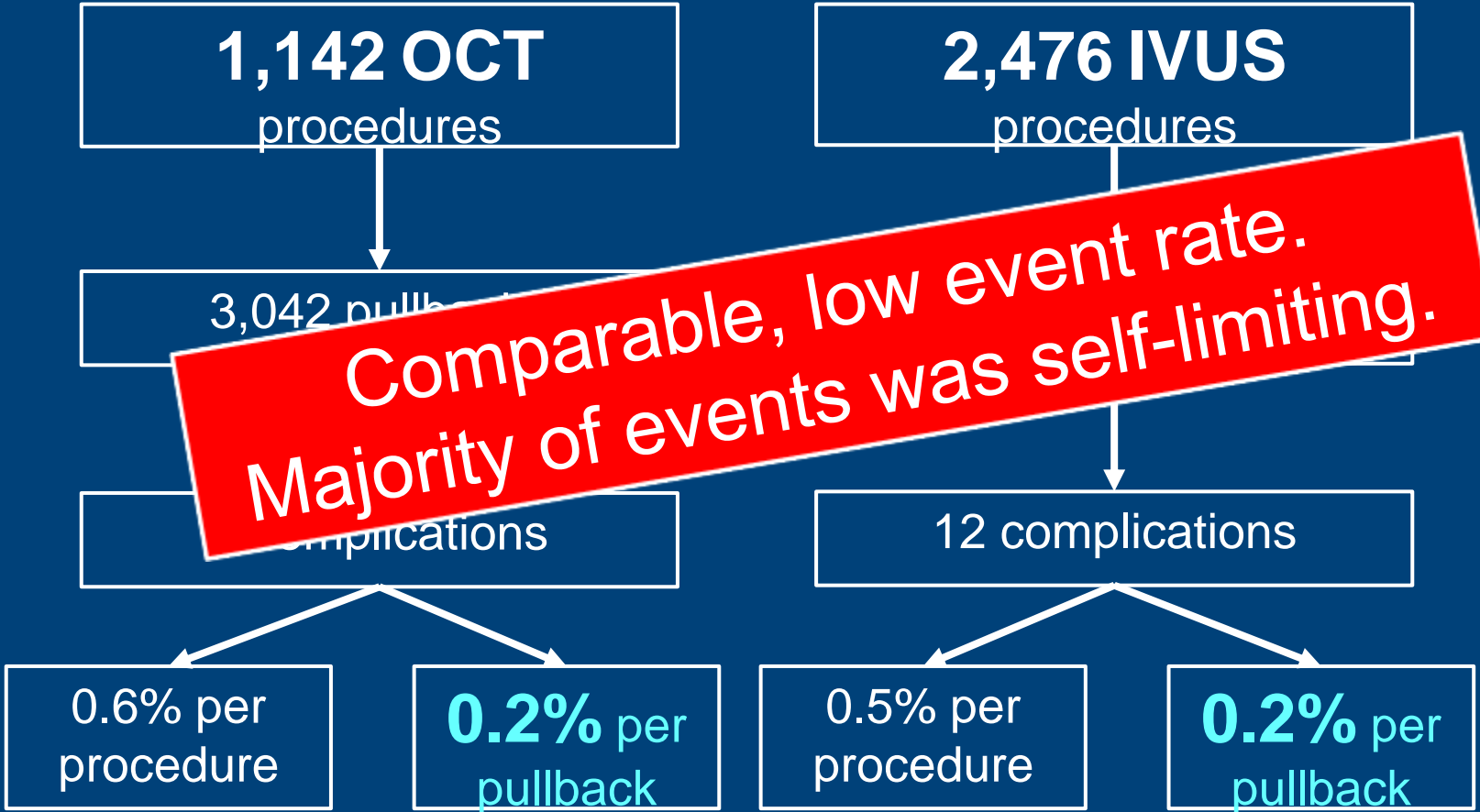
Assessment of plaque composition

**which is a major driver for the need
for lesion preparation & postdilation**

Intracoronary Imaging is a Safe Procedure

Thoraxcenter

Consecutive patients undergoing invasive-imaging



**Comparable, low event rate.
Majority of events was self-limiting.**

1990ties – Today: What Did We Learn?

IVUS Imaging Improves Prognosis !

1990ties – Today: What Did We Learn?

IVUS Imaging Improves Prognosis !

**IVUS-guided PCI
significantly reduces the risk of**

- **Death**
- **MI**
- **Stent thrombosis**
- **MACE**

IVUS Imaging – Future Directions

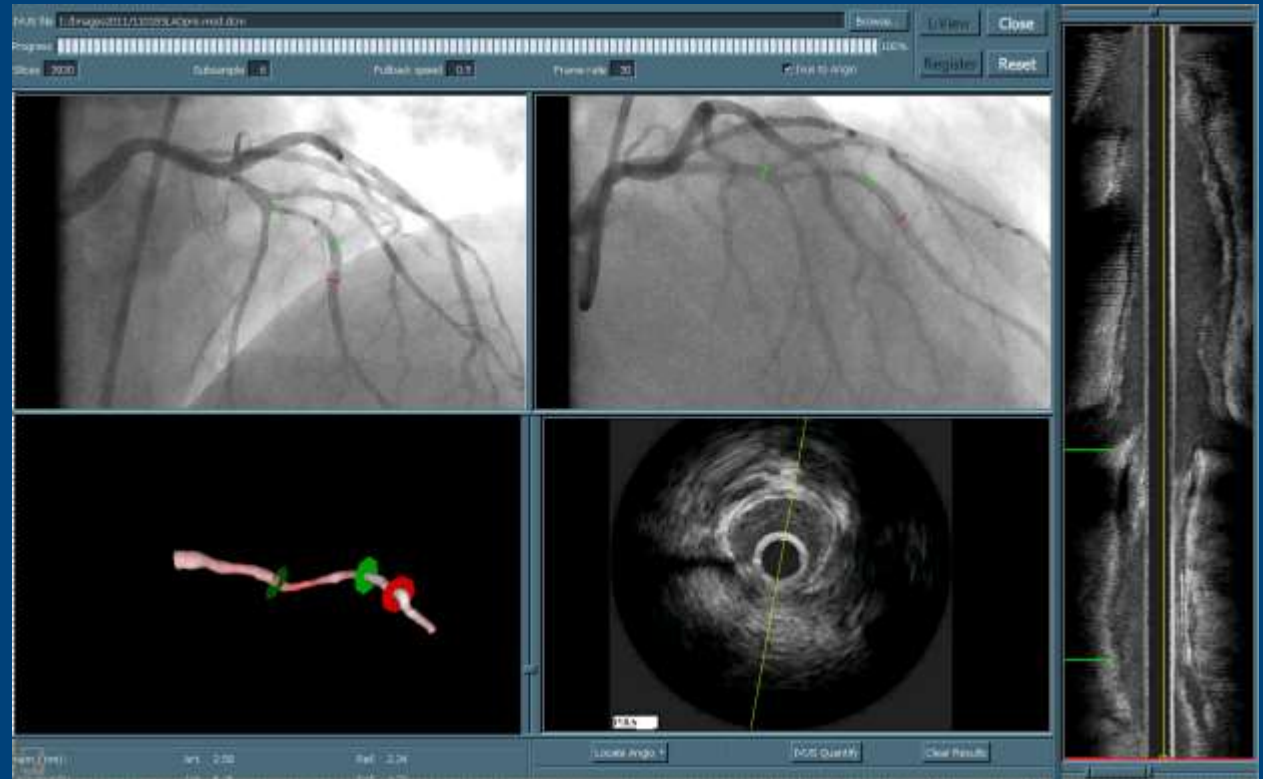
IVUS needs to be improved

- **Image quality**
- **Pullback speed**
- **User-friendliness**
- **Automated analysis**

IVUS Imaging – Future Directions

IVUS needs to be improved

Online coregistration with angiography is mandatory

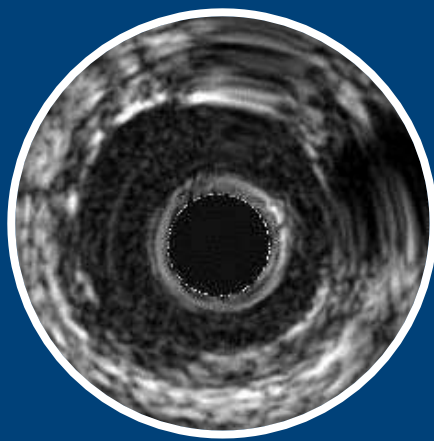
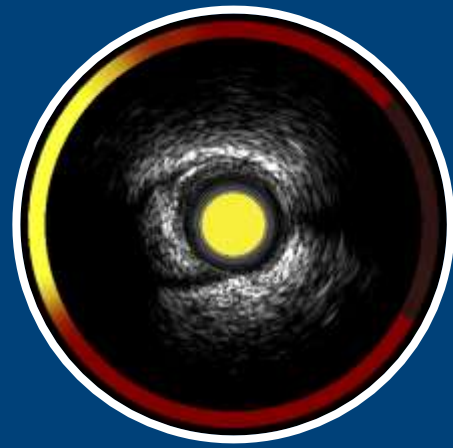


Intravascular Imaging

Which To Choose?

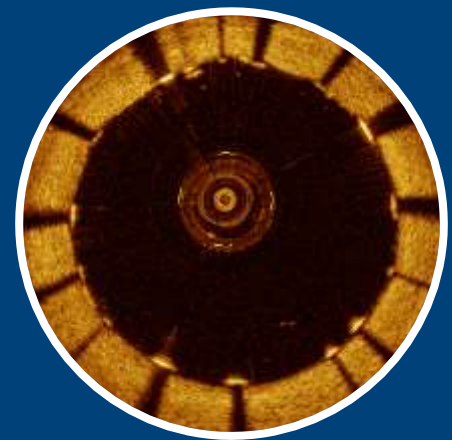
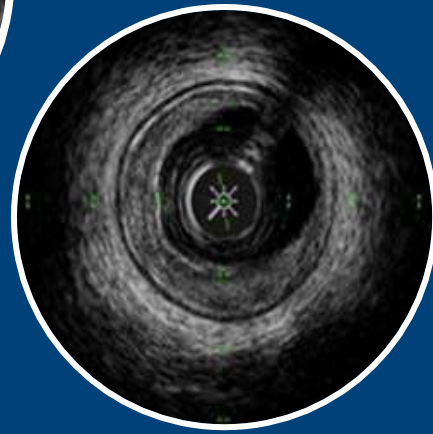
Follow your taste

NIR IVUS



IVUS

HD IVUS



OCT

any invasive imaging modality is better than angiography alone!