When you’re sure, you can reassure

IVUS, FFR and IFR help you to confirm your decisions, optimizing outcomes for you and your patient.

IVUS

Role of IVUS in PCI
- Clinical applications
- Products
- Summary
- Multi-modality approach
Why perform IVUS in coronary artery disease?

- An angiogram only provides a 2D image of the vessel lumen, referred to as lumen imaging\(^1\)
  - The clinical problem involves a 3D vessel and lesion
- With 2D coronary angiography:
  - Depending on the angle of the x-ray arm producing the angiogram, a value for % stenosis may be established that does not reflect the true narrowing of the vessel\(^2\)
  - An under- or over-estimation of a lesion's severity may result\(^2\)
- As a 3D modality, IVUS can accurately identify disease, assess its significance and provide valuable additional information\(^3\)
  - Assess plaque burden and lesion morphology\(^4\)
  - Detect acute complications\(^5\)
  - Provide accurate measurements for device selection\(^4\)
  - Assess adequacy of stent deployment\(^6\)

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IVUS
**IVUS Basic**  *How does it work?*

- The transducer emits a sound pulse and then quiets itself and waits for the signal (backscatter) to return
- The time it takes to return is a measure of distance
- The intensity of the signal relies on:
  - Intensity of transmitted signal
  - Attenuation
  - Distance and angle from transducer to target
  - Density (reflectivity) of the tissue

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**Imaging Orientation**

Cut-away sketch of artery and IVUS catheter

- IVUS catheter
- Image Slice
- Atherosclerotic Plaque Burden

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VOLCANO
Clinical evidence of IVUS in PCI supported by a wealth of studies

**Studies in over 26,000 patients**

**IVUS Procedure**
- Change in PCI strategy with IVUS
  - ADAPT-DES Study

**IVUS Outcomes**
- IVUS vs angiography-guided PCI
  - Significant reductions in MI, TLR, stent thrombosis and death
  - Meta-analysis of 17 studies and 26,503 patients

**IVUS Society consensus**
- IVUS should be considered
  - To assess severity and optimize treatment of left main lesions
  - In selected patients to optimize stent implantation
  - To detect stent-related mechanical problems
  - To assess mechanisms of stent failure
  - ESC/EACTS Guidelines

FACTS: European Association for Cardio-Thoracic Surgery; ESC, European Society of Cardiology; MI, myocardial infarction; PCI, percutaneous coronary intervention; TLR, target lesion revascularization.


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**IVUS provides information for pre-, peri- and post-procedural treatment decisions**

**Decide**
- Identify disease location and significance

**Guide**
- Select appropriate treatment strategy and use of devices

**Confirm**
- Post-treat assessment to optimize procedural outcomes

- Pre-procedure
- Peri-procedure
- Post-procedure
Pre-procedural IVUS Identifies disease location and significance

- Lesion severity
- Cross sectional lumen area, vessel diameter
- Plaque burden
- Calcification
- Sub-intimal thickening
- Thrombus
- Side-branches
- Presence of vascular remodeling
- In case of ambiguous angiogram
  - Diffuse reference vessel disease
  - Lesion foreshortening
  - Angulations
  - Eccentricity
  - Hazy lesions

Identify disease, assess significance\textsuperscript{1,2}

Detect acute complications\textsuperscript{2,3}

- Plaque rupture
- Spontaneous dissection

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Peri-procedural IVUS helps to select the appropriate treatment strategy and use of devices

Assess lesion morphology and identify the need for pre-treatment\textsuperscript{1}

- Superficial or deep calcification through grayscale and VH imaging modes
- Lesion tissue types to identify thin-cap fibroatheroma

Perform measurements to help select appropriate device(s)\textsuperscript{1}

- Vessel and lumen diameter and area, and lesion length
- Lesion preparation
- Define appropriate landing zones
- Stent selection and sizing

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Post-procedural IVUS helps to optimize procedural outcomes

- Assess adequacy of stent expansion and apposition, and mechanical complications and mechanisms
  - Geographical miss
  - Major edge dissections
  - Apposition
  - Plaque protrusion

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**IVUS**

**Clinical applications**
- Left Main coronary artery disease
- Diffuse, long lesions
- Chronic Total Occlusion
- Bifurcation lesions
- Ostial lesions
- Bioresorbable scaffold (BRS) procedures
- Ambiguous Angiogram

**Role of IVUS in PCI**

**Products**

**Summary**

**Multi-modality approach**
ADAPT-DES

Study data reported IVUS guidance was associated with:

- **PCI Strategy in 74% of cases**
- Change in strategy (%74)
- No change (26%)

**Change in PCI Strategy in 74% of cases**

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**ADAPT-DES**

How investigators reported IVUS changed their procedure:

- No change (26%)
- Change in strategy (74%)

**Investigators were asked if and how IVUS changed their procedure.**

*"Others" category may include a combination of "Higher Pressure", "Under Expansion", "Malapposition", and "Additional Stent".*

ADAPT-DES

Study data reported IVUS Guidance was associated with:

34% Reduction in MACE at 2 yrs
(4.9% vs. 7.4%, p<0.001)

IVUS is a valuable tool for complete anatomic assessment of coronary arteries:

- Left Main artery disease
- Diffuse, long lesions
- Chronic Total Occlusion
- Bifurcation lesions
- Ostial lesions
- Ambiguous Angiogram
Eagle Eye Platinum: Our top selling IVUS brand

Only Philips Volcano uses a digital solid state transducer design, enabling fast, plug and play simplicity not offered by any other company.

Plug into PIM and go, No motor drive or pullback device required
- No finding, plugging in, and bagging the device
- Reduced footprint at the bed
- Workflow further improves with co-registration

Single standard flush, No complicated priming
- Digital transducer design does not require priming in order to image

2 Models Available
- Standard model
- Short tip which may be helpful for highly stenosed lesions, bifurcations, and distal anatomy

1. Indicated for coronary and peripheral applications.
2. Data on file at Volcano Corporation.
Eagle Eye Platinum catheter

Multi-Modality Imaging

Grayscale IVUS
- Lesion Assessment
- Stent Sizing

ChromaFlo Imaging
- Easy image interpretation
- Lumen borders, stent apposition, dissection, bifurcations, and more

VH IVUS Imaging
- Plaque characterization for complete lesion assessment

Only Philips Volcano offers three imaging modalities on a single catheter
Eagle Eye Platinum catheters
Choice of Two Tip Options
Standard tip is for users who prefer a gradual taper

Short tip model offers a 2.5 mm tip-to-imaging distance, the shortest available, which may be helpful in certain clinical scenarios.

Eagle Eye Platinum ST catheter
Potential Advantages of the Short Tip

Closer visualization to highly stenosed lesions, bifurcations, & distal anatomy

Improved deliverability through tortuosity


PHILIPS
**ESC GUIDELINES 2014**

<table>
<thead>
<tr>
<th>Recommendation (actual wording)</th>
<th>Class</th>
<th>Level of Evidence</th>
</tr>
</thead>
<tbody>
<tr>
<td>IVUS to assess severity and optimize treatment of unprotected left main lesions.</td>
<td>IIa</td>
<td>B</td>
</tr>
<tr>
<td>IVUS in selected patients to optimize stent implantation</td>
<td>IIa</td>
<td>B</td>
</tr>
<tr>
<td>IVUS and/or OCT should be considered to detect stent-related mechanical problems.</td>
<td>IIa</td>
<td>C</td>
</tr>
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<td>C</td>
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**Normal Artery Wall**

3 Layers
Coronary Artery Disease (CAD)

Boundaries defined by internal and external elastic lamina (IEL and EEL) due to high elastin content

Vessel Borders

IVUS Image Morphology

Vessel wall composition

Boundaries defined by internal and external elastic lamina (IEL and EEL) due to high elastin content
IVUS imaging interpretation

Original vessel
Lumen
Catheter

Never interpret IVUS in complete isolation.
Always use the history and angiogram to your aid
Normal three layer appearance

Adventitial layer - EEM
Media - Echo lucent layer
Intimal layer - Echo dense (IEL)
Lumen - Echo free
Ring-down - "Halo"
Dead zone - catheter

Normal artery

media

lumen
Abnormal three layer appearance

Plaque

Adventitial layer – EEL (echo dense)

Media - Echo lucent layer

Intimal layer - Echo dense (IEL)

Lumen - Echo free

Ring-down - “Halo” – not seen

Dead zone – catheter – not seen

PLAQUE GEOMETRY

• ECCENTRIC

– OFTEN AT SIDE BRANCH OPENING
– HIGHER RESTENOSIS
– ASSOCIATED WITH POSITIVE REMODELING
PLAQUE COMPOSITION

- Calcified
- Fibrocalcific
  - "Fibrotic"
- Fibrous
- Fibrofatty
  - "Soft"
- Fatty

- Definition should be determined by looking over entire segment, not just the image slice with the smallest lumen CSA.

Lesion Characterization

Fibro Fatty  Fibrous  Calcified
Soft Plaque

- Less intense than adventitia
- Full signal penetration without attenuation
- Soft is an echolucent pattern, not a physical characteristic (as firm to touch as “hard plaques”)

Soft Plaque

- Eccentric plaque between 10 o’clock and 6 o’clock
- Note intimal thickening between 6 and 10 o’clock
- Good integrity with some questionable area at 2 o’clock
IVUS soft plaque

IVUS : Fibrous plaque
Fibrocalcific Plaque

• Concentric lesion

Calcium

• Arc measured in degrees, 30 degrees per “hour”.
• Depth superficial (closer to intima), deep (to EEM) or mixed.
• Shadowing may occur without any obvious calcification as the calcium may be out of plane and not visualized unless hit by the IVUS beam in a perpendicular fashion.
• Look for reverberation, side lobes and microcalcifications.
Calcium and Depth

Ultrasound Evaluation: Depth of Calcium

Superficial vs Deep

Calcium I

- Mixed morphology plaque
- Concentric
- Calcium deep

90 Degrees
CALCIUM II

- Deep and superficial
- Reverb 6 o’clock
- Eccentric

Calcified plaque

Accoustic shadow

Lumen
Thrombus

Image interpretation

Plaque Rupture
Dissection with Chroma Flo

![Image of dissection with Chroma Flo]

Iatrogenic

- Incomplete apposition
- Inadequate expansion
- Stent edge dissection
Stent

- Stent - 9 struts
- Adventitia layer (EEM)
- Media - Echo lucent layer
- Lumen - Echo free
- Ringdown - “Halo”
- Dead zone - catheter

Stent

- ISR
Well apposed stents

Free floating mal-apposed stent
Plaque protrusion through stent struts

Soft plaque with positive remodeling

Undersized stent

Undersized stent post high pressure inflations
Common artefacts

- Non uniform rotational distortion (NURD)
- Ringdown artefact
- Near Vu artefacts
- Air bubbles in the catheter
- Contrast artefact
- Reverberation
- Stitch artefact
- Guiding catheter
- Guidewires
- Side lobes
NURD

Causes:
Bend in a mechanical IVUS catheter that causes unnecessary friction
Too strong tension on the Y-connector
Severe angle e.g. from LMS to Cx
Guide catheter too small
Kinking of sheath
Tortuosity of vessels

Ringdown artefact
Contrast artefact

Reverberation artefact

Secondary false echoes
Lie along axial path of beam
Caused by echogenic objects e.g. calcium
Guide wires

Don’t confuse with stent struts

Calcium
What does it look like on IVUS?

Calcification is seen in 60-80% of target lesions using IVUS compared to 30-40% by angiography.

180 degrees of vascular circumference must be calcified before it can be visualized by angiography.

Impact of calcium on PCI

- Limit stent expansion: restenosis, thrombosis
- Acute malapposition (circumferential arc rather than depth)
- Calcium deposits / transition from calcified to non-calcified plaque (or to normal vessel wall) are foci for balloon dilation-associated dissection
- No clear guidance or index to guide when plaque modification devices should be used
- Easier to prevent under-expansion than treat under-expansion