MRA Data And A Computerized Program Allows Non-Invasive Estimation Of Pressure Gradients Across Equivocal Iliac Artery Stenoses

The DETECT-PAD study

J.P.P.M. de Vries, G.H. Heinen, D.A.F. van den Heuvel
Deps Vascular Surgery and Interventional Radiology
St. Antonius Hospital, Nieuwegein, The Netherlands

Problem

• Equivocal iliac artery stenoses (50-75%)
  - Hard to predict clinical relevance
  - No non-invasive tools to predict pressure drop
  - No tools to predict outcome of PTA
  - Multiple stenoses:
    • Is treatment of all stenoses needed, or selective treatment?

Solution

Non-invasive, patient specific, predictive model to determine pressure drop over equivocal stenosis

Disclosures

• None

Invasive pressure measurements

• Advantages
  Gold standard to determine significance of stenosis.

• Disadvantages
  Invasive
  Time consuming
  Expensive

Literature

• Physiology
  Lumen area reduction ≠ pressure gradient\(^1\)
    - Pearson Correlation (0.01-0.17)
  Lumen area reduction not sufficient in patients with equivocal iliac artery stenoses (50-75%)

• Hemodynamics
  Pressure drop depends on reduction in lumen area and flow rate\(^2\)

\(^1\) Tetteroo et al. Stent placement after iliac angioplasty: Comparison of hemodynamic and angiographic criteria. Radiology (1996)
\(^2\) May et al. Critical arterial stenosis. Surgery (1963)
Physical Model

Patient-specific physiological data 

Physics

I. Conservation of mass 
II. Conservation of momentum 
III. Energy loss due to turbulence

Prediction

Patient-specific pressure drop


DETECT-PAD Study

Aim = Validation
Comparison of the predicted pressure drop (model-based) with in-vivo measurements (at rest and during reactive hyperemia)

N = 30

Aniography
- PTA if hyperemic pressure gradient > 10 mmHg
- Selective stenting (dissection, residual stenosis)

DETECT-PAD Protocol

Standard of care
- Treadmill test
- Duplex Ultrasound
- CE-MRA
- Blood pressure

Non-invasive additional measurements
- MR-Flow

Additional during DSA/PTA
- Pressure measurements (XT ComboWire, Volcano Inc.)
- IVUS (Vision PV .018, Volcano Inc.)

Inclusion criteria

- Symptomatic, chronic atherosclerotic lesions of the common iliac artery and/ or external iliac artery
- Single or multiple equivocal (50-75%) stenoses (US)
- Rutherford class 1-6

Patient #1: Clinic

Treadmill test
- Right 0.93 → 0.58
- Left 1.04 → 0.80

Rutherford 3 right limb

DUS / MRA:
- 50-70% stenosis right external iliac artery
- >75% stenosis superficial femoral artery
Patient #1: Model validation (predicted pressure)

Rest
- Proximal (P1) : 97.4 mmHg
- Distal (P2) : 96.4 mmHg
- Gradient (P1-P2): 1.0 mmHg

Hyperemia
- Proximal (P1) : 95.7 mmHg
- Distal (P2) : 92.5 mmHg
- Gradient (P1-P2): 3.2 mmHg

Patient #1: Angiography (in-vivo pressure)

Rest
- Proximal (1) : 92.4 mmHg
- Distal (5) : 91.2 mmHg
- Gradient (1-5): 1.2 mmHg

Hyperemia
- Proximal (1) : 89.4 mmHg
- Distal (5) : 81.6 mmHg
- Gradient (1-5): 7.8 mmHg

Results (rest) 12/30 patients

Results (hyperemia) 12/30 patients

Conclusions
- Pressure drop ≠ lumen area reduction
- The current model first to predict pressure drop in PAD based on non-invasive imaging
- Predictive value for yes/no treatment 92% (12/30 patients)
- Improvements:
  - Inflow and outflow conditions
  - Refinement of clinical input data