Perfusion Imaging of the Foot in CLI-Patients: Prognostic Value of Pharmacologic Interventions
Preliminary results of an ongoing study

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Disclosure

Speaker name: Peter Huppert, M.D.

I have the following potential conflicts of interest to report:

☐ Consulting
☐ Employment in industry
☐ Stockholder of a healthcare company
☐ Owner of a healthcare company
☒ Other(s)
☒ scientific support by Siemens
Evaluation of tissue oxygenation and perfusion in CLI patients

- Tissue Imaging techniques
  - Near infrared imaging¹
  - CT perfusion imaging²
  - Angio perfusion imaging³

- Oxygen and Perfusion Measurement
  - tcPO2 measurement⁴
  - Laser speckle contrast imaging⁵
  - Near-infrared spectroscopy⁶
  - Indocyanine green fluorescence imaging⁷

1 Boezeman RP et al. 2016 Eur J Vasc Endovasc Surg 52;650-6
2 Hur S et al. 2016 Radiology 279;195-206
3 Reekers JA et al. 2016 Cardiovasc Intervent Radiol 39;183-89
4 Benitez E et al. 2014 Semin Vasc Surg 27;3-15
5 Katsui S et al. 2017 Lasers Surg Med 49;645-51
6 Arnold FJ 2018 Wounds 30;E89-92
7 Patel HM et al. 2018 Ann Vasc Surg 51;86-94
Potential value of peripheral blood volume imaging in CLI patients

- To evaluate rise of perfusion after intervention
- To show regional changes of perfusion after intervention
- To guide endpoint of intervention in multivessel disease
- To detect irreversible damage to microcirculation
- To add prognostic value in terms of wound healing
Pilot study of peripheral blood volume imaging with pharmacological and catheter-based interventions

1. 2D /3D imaging for arterial perfusion / tissue blood volume measurements at foot established
2. Standardisation of procedure and data acquisition
3. Testing feasibility of peripheral blood volume imaging at baseline and after interventions
4. Development of rules for comparable measurements
5. Starting prospective evaluation
2D + 3D Imaging of peripheral perfusion

2-D dynamic arterial perfusion
syngo iFlow® (Siemens)

3-D blood volume imaging
syngo PBV® (Siemens)

- Time-contrast intensity curves of target arteries
- Time to peak
- Area under the curve

- Voxel based analysis of blood volume / tissue volume
- Colour coding
- Analysis of Max/Min and mean +/- SD within ROI (cc blood volume/1000 cc tissue volume)
**Study protocol / Methods**

<table>
<thead>
<tr>
<th>1st run</th>
<th>2nd run</th>
<th>3rd run</th>
</tr>
</thead>
<tbody>
<tr>
<td>baseline</td>
<td>post pharmaco-intervention (i.a. 50 mg Papaverin-Hydrochloride)</td>
<td>post catheter-intervention</td>
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**3D blood volume imaging (syngo PBV®)**
### Study protocol / Methods

**3D blood volume imaging (syngo PBV®)**

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**Target lesion**
Protocol of PBV run

Contrast injection protocol:
- 15 cc, 3cc/sec, 300 mg iodin/cc, catheter tip (end hole) at PII
- delay= TTP measured by *syngo* iFlow with ROI at target artery

- Flat panel DSA
- Rotational angiography 270 dg.
- Time 5 sec

No inflow lesion at femoropopliteal artery
# Results

## Patients

<table>
<thead>
<tr>
<th>Condition</th>
<th>Count</th>
</tr>
</thead>
<tbody>
<tr>
<td>CLI (Rutherford 5)</td>
<td>20/20</td>
</tr>
<tr>
<td>Diabetes mellitus</td>
<td>15/20</td>
</tr>
</tbody>
</table>

## Target lesions

<table>
<thead>
<tr>
<th>Lesion</th>
<th>Count</th>
</tr>
</thead>
<tbody>
<tr>
<td>Forefoot</td>
<td>12/20</td>
</tr>
<tr>
<td>Rearfoot</td>
<td>8/20</td>
</tr>
</tbody>
</table>

## Image quality

<table>
<thead>
<tr>
<th>Condition</th>
<th>Count</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sufficient</td>
<td>38/50</td>
</tr>
<tr>
<td>Insufficient (motion artifacts)</td>
<td>12/50</td>
</tr>
</tbody>
</table>
**Impact of interventions on peripheral blood volume**

<table>
<thead>
<tr>
<th>intervention</th>
<th>impact</th>
<th>Target region</th>
<th>Non-target region</th>
</tr>
</thead>
<tbody>
<tr>
<td>pharmacon</td>
<td>increase</td>
<td>6/9*</td>
<td>4/9</td>
</tr>
<tr>
<td></td>
<td>no increase</td>
<td>3/9</td>
<td>5/9</td>
</tr>
<tr>
<td>catheter</td>
<td>increase</td>
<td>12/14*</td>
<td>6/14</td>
</tr>
<tr>
<td></td>
<td>no increase</td>
<td>2/14</td>
<td>8/14</td>
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* procedures without motion artifacts
Impact of interventions on peripheral blood volume

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* procedures without motion artifacts

<table>
<thead>
<tr>
<th>Post pharmacon</th>
<th>Increase 6</th>
<th>no increase 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Post intervention</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Increase</td>
<td>6</td>
<td>1</td>
</tr>
<tr>
<td>no increase</td>
<td>0</td>
<td>2</td>
</tr>
</tbody>
</table>
Lessons learned

• Only 3 of 5 patients are fit for this protocol (renal insufficiency, pts. compliance).

• Fixation of foot and lower leg is mandatory.

• To compare images of consecutive runs matching of anatomical regions is necessary and needs computer based assistance.
On the learning curve

- Not comparable
- Difficult to compare
- Comparable

Baseline vs. post papaverine
Prediction of Revascularization Benefit

native run

post stimulation run (Papaverin i.a.)

post intervention run

PBV: 60 cc/1.000 cc

PBV: 120 cc/1.000 cc

PBV: 145 cc/1.000 cc

Imaging protocol
• 5 sec run time / 270 degr.
• syngo iFlow® 13 sec TTP of target artery
• PBV run delay 13 sec

Contrast injection
• Volume 15 cc
• Flow 3 cc/sec
• Catheter position Pop.II
Prediction of no revascularization benefit

77 years old man
Diabetes
Rutherford 5 at heel
Prediction of no revascularization benefit

77 years old man
Diabetes
Rutherford 5 at heel
Prediction of no revascularization benefit

77 years old man
Diabetes
Rutherford 5 at heel

Baseline

post catheter intervention
Prediction of no revascularization benefit

77 years old man
Diabetes
Rutherford 5 at heel

Baseline
post catheter intervention
Prediction of no revascularization benefit

77 years old man
Diabetes
Rutherford 5 at heel

Baseline

Post pharmacon intervention

Post catheter intervention
Conclusions

• Syngo iFlow® and syngo PBV® are useful tools of peripheral perfusion imaging during angio and interventions.

• Protocol and measurements need detailed standardization.

• Limitations and challenges:
  - 25% of procedures are non-diagnostic due to motion artefacts
  - additional contrast and radiation exposure is necessary
  - anatomical matching mandatory for comparison

• Correlation of PBV Parameters to wound healing will be finished during next 6 months
Thank You for Attention!
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