Can perfusion angiography judge foot perfusion and predict wound healing in patients with CLI: from the REPEAT trial

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Disclosures

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Current techniques like ABI, toe pressures, TcPO2, DSA are indicative for macrovascularization

In diabetic patients pressure measurements are unreliable

Perfusion of the foot is dependent on the status of the microcirculation

2D perfusion angiography (2DPA)

2D perfusion (Philips Healthcare, Best, The Netherlands):
Obtained by post-processing software after standardized DSA (popliteal artery, 9 cc contrast, speed 3 cc/sec)

Comparison of post- and pre-intervention images

Time density curve

1. Time of arrival (TOA)
2. Peak density (PD)
3. Time to peak (TTP)
4. Wash-in rate (WIR)
5. Full width at half maximum (FWHM)
6. Area under the curve (AUC)
7. Mean transit time (MTT)
Pros and cons of 2DPA

- Operator can choose area of interest
- No additional contrast and radiation
- 2D visualization of 3D anatomy
- No robust clinical validation performed (in CLI)

Clinical evaluation and standardization of perfusion angiography is mandatory before introduction in daily practice

REPEAT study

1. PA reproducibility
2. Intra- and inter-observer variability
3. Develop a vessel extraction method

Patient characteristics

- ✔️ Non-healing ulcers or gangrene
- ✔️ Below-the-knee endovascular treatment
- ✗ Severe renal failure (eGFR < 0.30 mL/1.73 m²)
- ✗ Scheduled for major amputation

Image acquisition

- Perfusion protocol
  - Minimization of patient movement
  - Constant kV and mAs
  - Equal-contrast parameters
Analyses

ROI of complete image

Statistics

- Normalized root mean square error
  - NRMSE ≤ 0.10
  - T-test
    - $p > 0.05$

Results

11 patients included
64% NRMSE < 0.10

Unreproducible
Reproducible

Results

4 patients with NRMSE > 0.10
- In one patient caused by major movement

Results

4 patients with NRMSE > 0.10
- In two patients probably caused by adjustment of acquisition settings

Results

- 4 patients with NRMSE > 0.10
  - In two patients probably caused by adjustment of acquisition settings

Frame selection

- 3 out of 4 NRMSE ≤ 0.10
  - NRMSE$_{frame1}$ = 0.00
  - NRMSE$_{frame2}$ = 0.07
  - NRMSE$_{frame3}$ = 0.16
- In total 10 out of 11 (91%) NRMSE ≤ 0.10
Observer variability

- Intra-observer variability
  - One observer
  - Five repeated measurements
- Inter-observer variability
  - Two observers

Region of interest

- Complete foot with exclusion of digits

Intra-observer variability

Inter-observer variability

Results: foot ROI

Conclusion

Foot ROI except digits (Reekers) preferred

But...

contains major arteries
Vessel extraction

Region growing

Results

Conclusion

- 2D perfusion imaging may determine microcirculation in CLI patients during revascularization, but only if:
  - No movement of the foot/leg
  - Frame selection
  - Standardized protocol of DSA
  - Foot ROI except digits (Reekers method)
  - Further development of vessel extraction method