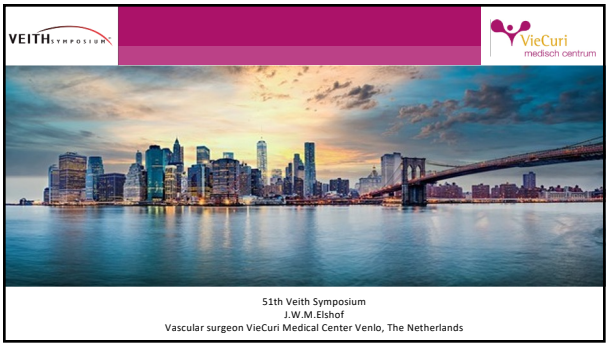
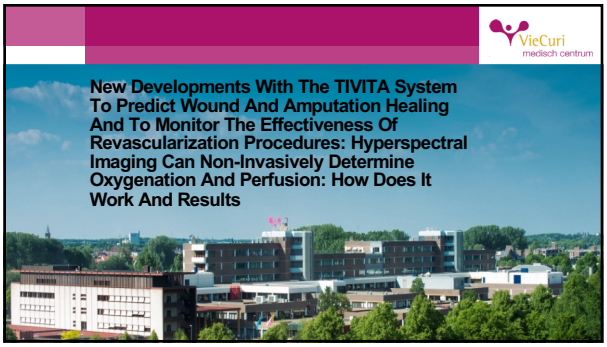


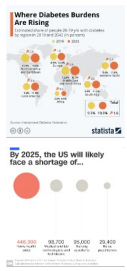
51th Veith Symposium
J.W.M.Elshof
Vascular surgeon VieCuri Medical Center Venlo, The Netherlands

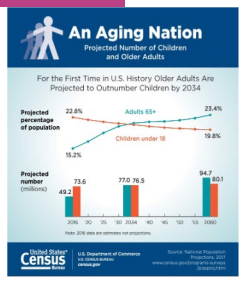


Financial disclosures

- None

Problems emerging





In short

What we do today, will no longer be possible in the future, because

- In developing countries **complex wounds prevalence will continue to grow** and reach 0,2% of total population (WHO, 2023)
- The Global Strategy on Human Resources for Health: Workforce 2030 highlighted a projected health workforce (HWF) **shortage of 18 million health workers by 2030**. (2023)
- Despite growth of healthcare expenditure of 0,7% worldwide, **all budgets and hospital treatment periods are under pressure**

Prediction of wound healing

Wound measurements

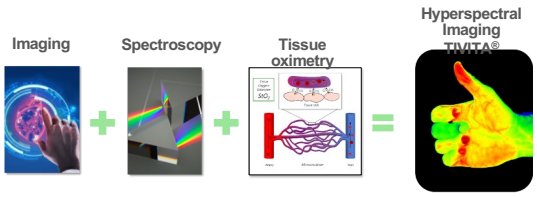
Parameter	Existing golden standard	Problems with golden standard?
Oxygen measurements	TCP0₂	Time consuming (takes 1h, 3 to 5 sensors) Non reliable values in patients with oedema
Perfusion measurements	Laser Doppler measurement (LDI)	Time consuming for only 1 parameter Difficult to use on pediatric burn patients No exact point measurements
Oedema measurement	Punch/press measurement	No objective measurements No values
Pulsation measurement	Duplex Doppler	No objective measurements or values
Toe perfusion pressure	Toe pressure measurement	what if there is no toe? Need for staff

Challenge: how to predict healing?

All available investigations still not very reliable to predict healing and time and staff consuming:

Need for non-invasive, fast, reliable measurements.

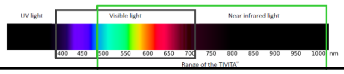
Hyperspectral imaging: basic principle



Hyperspectral imaging: TIVITA Visualise the invisible

Advantages TIVITA

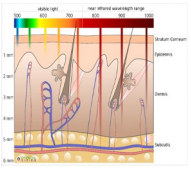
- Painless and non-invasive
- Easy to use
- Reproducable
- Fast (24h) assessment of effect of therapy
- Quick
- Usable on Bed-side and outpatient clinic
- Local measurement in wound site
- Multiple variables in one investigation



TIVITA® 2.0: what do we measure?

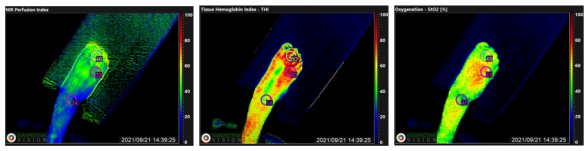
Live-Image

- Tissue oxygen saturation (StO₂ [%])
- Tissue-Hemoglobin-Index (THI)
- NIR-Perfusion-Index (NIR)
- Tissue-Water-Index (TWI)
- Tissue-Lipid-Index (TLI)



Every measurement generates a data cube of 30 mln values

TIVITA versus toe pressure measurements



Hypothesis

- Comparable reliability
- predictor of wound healing
- Early signalling of deterioration

Resulting in reduced risk of tissue loss

Study design

Prospective observational study

1e consultation
Inclusion with HSI and usual diagnostics (Toe pressure,EAI,Duplex,CTA,Angio)

2 weekly follow-up
untill wound healing, amputation, death or lost-to-follow-up

Intermittent admission for intervention: new toe pressure and HSI.
Restart follow-up

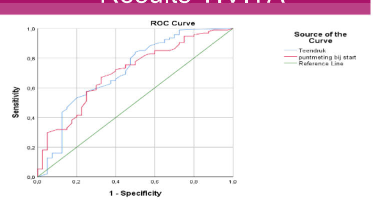
Patient Characteristics

Baseline characteristics	All patients (N=137)	Patients with healed ulcers after 12 weeks (n=95, 69%)	Patients with no healing within 12 weeks (n=42, 31%)	P – value (95% CI)
Age	75.9 (SD 10.4)	75.6 (SD 9.4)	76 (SD 10.8)	0.83
Male Female	80 (58.4%) 57 (41.6%)	52 (54.7%) 43 (45.3%)	28 (66.7%) 14 (33.3%)	0.19
Body mass index (1) ondergewicht (2) normaal (3) overgewicht (4) obesitas	(1) 10 (7.3%) (2) 56 (40.9 %) (3) 37 (27.0%) (4) 27 (19.7%)	(1) 6 (6.3%) (2) 34 (35.8%) (3) 30 (31.6%) (4) 18 (18.9%)	(1) 4 (9.5%) (2) 22 (52.4%) (3) 7 (16.7%) (4) 9 (21.4%)	0.093
Smoker (0) never smoked (1) current smoker (2) former smoker	(0) 58 (42.3%) (1) 31 (22.6%) (2) 48 (35.0%)	(0) 46 (48.4%) (1) 17 (17.9%) (2) 32 (33.7%)	(0) 12 (28.6%) (1) 14 (33.3%) (2) 16 (38.1%)	0.051
Diabetes (0) No diabetes (1) Diabetes	(0) 80 (58.4%) (1) 57 (41.6%)	(0) 55 (57.9%) (1) 40 (42.1%)	(0) 25 (59.5%) (1) 17 (40.5%)	0.86
Kidney failure (0) eGFR >50 (1) eGFR >30 <50 (2)eGFR <30/ dialysis	(0) 78 (56.9%) (1) 34 (24.8%) (2) 24 (17.5%)	(0) 57 (60.0%) (1) 22 (23.2%) (2) 15 (15.8%)	(0) 21 (50%) (1) 12 (28.6%) (2) 9 (21.4%)	0.50
Cardiac disease (0) No cardiac disease (1) Heart failure, heart arrhythmia etc.	(0) 58 (42.3%) (1) 79 (57.7%)	(0) 46 (48.4%) (1) 49 (51.6%)	(0) 12 (28.6%) (1) 30 (71.4%)	0.030
COPD (0) No COPD (1) COPD	(0) 117 (85.4%) (1) 20 (14.6%)	(0) 82 (86.3%) (1) 13 (13.7%)	(0) 35 (83.3%) (1) 7 (16.7%)	0.65
Combined venous and arterial ulcer (0) Not combined (1) Combined ulcer	(0)120 (87.6%) (1) 14 (10.2%)	(0) 79 (83.2%) (1) 13 (13.7%)	(0) 41 (97.6 %) (1) 1 (2.4%)	0.094
Location of the wound (0) dig 1 (1) dig 2-5 (2) hiel (3) dorsum (4) plantair (5) enkel (6) pre-tibiaal	(0) 33 (24.1%) (1) 43 (31.4%) (2) 15 (10.9%) (3) 8 (5.8%) (4) 7 (5.1%) (5) 11 (8.0%) (6) 20 (14.6%)	(0) 23 (24.2%) (1) 23 (24.2%) (2) 9 (9.5%) (3) 8 (8.4%) (4) 6 (6.3%) (5) 9 (9.5%) (6) 17 (17.9%)	(0) 10 (23.8%) (1) 20 (47.6%) (2) 6 (14.3%) (3) 0 (0%) (4) 1 (2.4%) (5) 2 (4.8%) (6) 3 (7.1%)	0.039
Wound area surface	2.77 cm2 (SD 6.3)	2.97 cm2 (SD 7.2)	2.29 cm2 (SD 3.5)	0.57

Results

- 137 patients included
- Average time of wound healing for the whole group was 12.7 weeks (standard deviation of 13.6 weeks).
- 69.3% achieved wound healing (N=95).
- Amputation rate was 19%
- 13% of the patients died before wound healing was achieved.

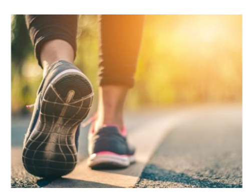
Results TIVITA



- The ROC analysis indicated an optimal cut-off point for the toe pressure of 29.5 mmHg. The optimal cut-off point for the NIR is 35% and is associated with a sensitivity of 90% and a specificity of 18%.

Take home: TIVITA

- Comparable reliability on prediction of wound healing
- Less manpower needed
- Very quick measurements
- More research needed



Future

- More research needed:
  - Observer variability
  - Usage of multiple parameters
  - Pre /per and postoperative measurements
- Hand held TIVITA: planned for 2025
- Artificial Intelligence