Novel diagnostic procedure

Early detection of microcirculatory perfusion changes with a high resolution, real time laser doppler imaging camera—frostbite case study

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A 41-year-old male presented with severe frostbite that was monitored clinically and with a new laser Doppler imaging (LDI) camera that records arbitrary microcirculatory perfusion units (1–256 arbitrary perfusion units (APU's)). LDI monitoring detected perfusion differences in hand and foot not seen visually. On day 4–5 after injury, LDI showed that while fingers did not experience any significant perfusion change (average of 31 ± 25 APU's on day 5), the patient's left big toe did (from 17 ± 29 APU's day 4 to 103 ± 55 APU's day 5). These changes in regional perfusion were not detectable by visual examination. On day 53 postinjury, all fingers with reduced perfusion by LDI were amputated, while the toe could be salvaged. This case clearly demonstrates that insufficient microcirculatory perfusion can be identified using LDI in ways which visual examination alone does not permit, allowing prognosis of clinical outcomes. Such information may also be used to develop improved treatment approaches.

BACKGROUND

Assessment of injury-induced microcirculation perfusion is challenging with clinical examination alone. We wanted to see whether a novel real-time laser Doppler imaging (LDI) camera could allow us to quickly and easily identify critically injured zones and focus our attention where special care was needed.

CASE PRESENTATION

In March 2011, a 41-year-old non-smoking male patient presented to our hospital with severe frostbite injuries affecting both hands and feet after 3 days of exposure to subzero temperatures while climbing the Matterhorn.

After debridement of blisters performed on day 3, frostbite wounds were monitored both clinically and by LDI from day 4 to 5. Clinically, the patient presented with a fixed red staining and reduced sensation on all fingers. All fingers were comparable with respect to colour, temperature and sensitivity testing, except for the fifth finger of the right hand (not shown), which presented with slightly darker coloured areas. At the time of admission, the patient did not report any relevant pain and 1 week of 4 g paracetamol treatment was prescribed.

INVESTIGATIONS

LDI was performed with a new microcirculation-imaging camera (EasyLDI; Aimago SA, Lausanne, Switzerland), which provides real-time LDI over a 7×7 cm area with 150 μ m resolution, while simultaneously providing a white light picture of the corresponding region. Tissue perfusion is expressed as a discrete measure of arbitrary microcirculatory perfusion units (APU's) ranging from 1 to 256.¹

DIFFERENTIAL DIAGNOSIS

Initial LDI assessment performed at day 4 showed reduced perfusion of the left-hand-middle-finger (22 ± 18 APU's) (figure 1B), bilateral-pinky-fingers (15 ± 19 and 44 ± 33 APU's; not shown), bilateral big toes (25 ± 18 and 17 ± 29 APU's) (figure 1F) and left second-toe (30 ± 24 APU's; not shown). These values were markedly lower than the average perfusion measurement in uninjured tissue of fingers on both hands and feet (134 ± 61 APU's). During our 2-day LDI monitoring on day 4 and 5 after injury, the patient's left big toe showed a significant improvement in microcirculation, increasing from 17 ± 29 APU's on day 4 to 103 ± 55 APU's on day 5, while the majority of the analysed fingers did not experience any significant perfusion change (average of 31 ± 25 APU's at day 5, figure 1E–H). These changes in regional perfusion were not detectable by visual examination alone, as depicted by the white light pictures in figure 1A,C,E,G.

TREATMENT

To optimise tissue perfusion, thromboembolic prophylaxis with low molecular weight heparin (clexane 40 mg) and acetylsalicylic acid (aspirin cardio 100 mg) were started at the time of hospitalisation and continued for the whole treatment time. After normalisation of creatine kinase levels, the patient was discharged from the hospital and monitored on an outpatient basis.

OUTCOME AND FOLLOW-UP

On day 6 after injury, the patient returned to his home country where a 'wait and see' approach and clinical follow-up was applied. Demarcation of necrotic tissue areas

Figure 1 (A–D) show the evolution of the wounded fingers of the left hand and (E–H) the big toe of the left foot after 24 h of observation on day 4–5 after injury. Mean $\pm$ SD of LDI perfusion values (APUs) in the indicated regions of interest were: image B = 22 ± 18 , D = 35 ± 24 , F = 17 ± 29 and H = 103 ± 55 . Areas with low perfusion values (35 ± 24 APUs at day 5; images (A–D), finger 3) had to be amputated later, while left-hand-finger two (127 ± 58 APUs at day 5) and four (152 ± 64 APUs at day 5) and the left big toe (103 ± 55 APUs at day 5; images E–H) could be salvaged. Note that visual inspection under white light did not detect differences in the middle finger compared to other fingers, which instead became readily apparent by LDI.

was awaited and on day 53 postinjury all fingers which had shown reduced perfusion by LDI had to be amputated, while the left big toe could be salvaged (figure 1E–H).

DISCUSSION

Delimitation of cold injuries usually takes 1 to 3 months from the time of exposure.² Our case study clearly demonstrates that insufficient microcirculatory perfusion following frostbite can be identified in the first week after injury using LDI technology, thus reducing uncertainties concerning amputation. So far, it has been very difficult to make this type of evaluation, because of case rarity, the long follow-up required and because the only reliable exam available is bone scintigraphy, which unfortunately is an invasive procedure.³ As there are currently no clear management guidelines for the treatment of this severe pathology, monitoring with real-time LDI should be considered and could as well be used to assess the efficacy of conservative treatment modalities, such as hyperbaric oxygen therapy.⁴ Moreover, the identification of critically perfused tissue areas was possible in about 1/10 of the time required by clinical assessment.

Learning points

- Changes in regional perfusion are not easily detectable by visual examination alone.
- A new LDI microcirculation-imaging camera allowed the identification of critically perfused tissue areas in about 1/10 of the time required by clinical assessment, providing both LDI images and APU readings.

Competing interests None.

Patient consent Obtained.

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