burns 35 (2009) 824–831

available at www.sciencedirect.com

journal homepage: www.elsevier.com/locate/burns

Laser Doppler imaging in a paediatric burns population

Julie Mill [a,], Leila Cuttle [a], Damien G. Harkin [b], Olena Kravchuk [c], Roy M. Kimble [a]*

[a] Royal Children's Hospital Burns Research Group, University of Queensland, Department of Paediatrics and Child Health, Royal Children's Hospital, Herston Rd, Herston, Queensland 4029, Australia

[b] School of Life Sciences and Institute of Health and Biomedical Innovation, Queensland University of Technology, Kelvin Grove, Queensland 4059, Australia

[c] School of Land, Crop and Food Science, University of Queensland, St Lucia, Queensland 4072, Australia

ARTICLE INFO

Article history:
Accepted 26 November 2008

Keywords:
Laser Doppler
Paediatric
24 h
Fast scan
Grafting
Scar management
Re-epithelialisation

ABSTRACT

Objective: Laser Doppler imaging (LDI) was compared to wound outcomes in children's burns, to determine if the technology could be used to predict these outcomes.

Methods: Forty-eight patients with a total of 85 burns were included in the study. Patient median age was 4 years 10 months and scans were taken 0–186 h post-burn using the fast, low-resolution setting on the Moor LDI2 laser Doppler imager. Wounds were managed by standard practice, without taking into account the scan results. Time until complete re-epithelialisation and whether or not grafting and scar management were required were recorded for each wound. If wounds were treated with Silvazine™ or Acticoat™ prior to the scan, this was also recorded.

Results: The predominant colour of the scan was found to be significantly related to the re-epithelialisation, grafting and scar management outcomes and could be used to predict those outcomes. The prior use of Acticoat™ did not affect the scan relationship to outcomes, however, the use of Silvazine™ did complicate the relationship for light blue and green scanned partial thickness wounds. Scans taken within the 24-h window after-burn also appeared to be accurate predictors of wound outcome.

Conclusion: Laser Doppler imaging is accurate and effective in a paediatric population with a low-resolution fast-scan.

1. Introduction

Traditional ways for assessing acute burns and subsequent scarring rely largely on qualitative methods such as total burn surface area calculation via the Lund and Browder chart estimation [1] and the Vancouver General Hospital Scar Scale [2]. While such techniques have been useful, they are unable to guide us on the clinical status of a burn when decisions about most appropriate treatments are being made.

Laser Doppler technology originally existed as flowmetry. Reports at that time found that laser Doppler flowmetry could be used as a clinical predictor tool with burns displaying the lowest perfusion values on days 0–3 requiring skin grafting or taking longer than 21 days to re-epithelialise [3,4]. However, as a small probe was required to be in contact with the burn in order to take the measurements, this technique was considered painful and too localised and now laser Doppler imaging (LDI) which can scan the whole burn area in a non-contact manner is more popular.

LDI produces a colour-coded image of skin blood perfusion. A low-intensity red laser light beam penetrates the full dermis and is reflected by both moving red blood cells and the static

* *Corresponding author*. Tel.: +61 7 3636 9067; fax: +61 7 3365 5455.
E-mail address: rchburns@somc.uq.edu.au (J. Mill).
0305-4179/$36.00
doi:10.1016/j.burns.2008.11.016

tissue. The instrument then assigns perfusion units (PU) to quantify the movement of blood cells flowing through the vessels of the skin and the perfusion units are translated into colours which are transposed on a greyscale digital image of the scanned area. This provides a valuable indicator of burn depth and thus severity.

Histological biopsy assessment has long been considered to be the gold standard of burn depth assessment. LDI has been shown to correlate well with histopathological markers of wound depth [5–8], however, this has not been validated in a paediatric population. Also, biopsies may be inaccurate in the first few days as the burn wound progresses and more tissue dies, or recovers. The optimum time that laser Doppler scanning should be performed post-burn is still a controversial topic. Laser Doppler is widely reported to give accurate results when performed between 48 and 72 h [7,9]. Holland et al. 2002 reported that scans at 24 h may be inaccurate as burned areas which initially appear deep can later improve. This was based on scans shown in Niazi's landmark paper in 1993 [5]. However, another study showed that laser Doppler flowmetry performed within 24 h post-burn gave similar flux values to scans taken three days after-burn [10], indicating that perhaps scans within the 24-h window may still give accurate readings. This is a theory supported by others [11] who have also done serial measurements using LDI.

For this study, we were interested to see if LDI might provide a reliable indicator (via colour of scan) of burn depth and therefore outcome when used as early as 0–24 h and continuing up to 120 h after-burn. We also sought to determine if a standard resolution (fast) laser Doppler scan for the paediatric population was accurate. The effect of the prior application of nanocrystalline silver dressing Acticoat^{TM} (Smith and Nephew, Hull, UK) and Silvazine^{TM} cream (1% silver sulphadiazine with 0.2% chlorhexidine digluconate, Smith and Nephew, Clayton, Australia) to the scan was also examined.

2. Materials and methods

2.1. *Patients*

The human research ethics committee of the Royal Children's Hospital (RCH) approved the study and all patients had consent obtained prior any procedures. Subjects were children who presented to the Stuart Pegg Paediatric Burns Centre, whose parents consented or the patient assented to the study. Patients were recruited at any time from 0 to 190 h after burn injury. Both outpatients and inpatients were enrolled in the study.

2.2. *Laser Doppler scanning*

The scanning was done using the MoorLDI-2 laser Doppler imager (Moor Instruments Limited, Devon, UK), with a laser wavelength of 633 nm (visible red), scan range (distance from the wounds) of 35–80 cm, fast scan resolution of 256 $\times$ 64 pix-pixels, and a scan duration of 80 s. The scanner head was aimed slightly off perpendicular to the skin, to prevent reflection and non-valid areas, as recommended by the product manual (p54-55), rather than directly perpendicular to the skin as suggested by others [12]. Software used was v1.5. Using the standard colour palette setting XE, the amount of blood flow (expressed as perfusion units in the range 0–1000) was translated into specific colours: dark blue (<125 PU), light blue (125–250 PU), green (250–440 PU), yellow (440–628 PU), pink (628–812.5 PU), and red (812.5–1000 PU).

LDI was performed with a green drape placed under the patient, using the standard (fast) scan. The laser Doppler scan was performed either in the designated laser Doppler room, burns clinic bathroom or operating theatre. All rooms are maintained at $\leq$25–31° C. Patients wore the standard goggles supplied by Moor during the scan (if age-appropriate), and the door was closed during scanning. For patients who were non-compliant with the goggles (toddlers and babies), a green drape was clipped to the scanner head and the scanner head was lowered into position so that child was unable to see the scanner red point light, thus shielding their eyes completely during the scan. Each body part that was injured was scanned separately and in some cases lateral and medial surfaces were scanned for circumferential burns, as suggested by others [9]. Patients were scanned each time they returned to the outpatients department, if this fell within the first 200 h.

Use of digital photography to document the wounds was also utilised as an adjunct to the laser scan, as the colour photograph representation on a laser Doppler image is traditionally poor quality compared to a digital photograph [9]. A digital photograph was taken at 3.0 megapixels with a Fujifilm E510 Finepix 5.2 Megapixel camera with the flash on, using the normal automatic setting.

2.3. *Patient management*

Patients were given standard pain relief used in the burns outpatient department, most commonly oxycodone and paracetomol (acetaminophen) orally and for inpatients most commonly intravenous morphine. Patients who showed signs of uncontrolled pain during dressing down procedures and who would benefit from immediate redressing were not scanned and a digital image only was taken. Age-appropriate toys were used for distraction to enable to child to relax and keep still for the scan.

If patients presented out of hours, they were clinically assessed by the burns registrar without the use of laser Doppler, a digital photograph was taken and dressings were applied after discussion with the burns consultant. Routine dressing care for the RCH Stuart Pegg Paediatric Burns Centre is to gently cleanse the wound area with 0.1% chlorhexidine digluconate mixed in warm water, removing any creams, or dead skin that has lifted.

Silvazine^{TM} cream was the mainstay of treatment for the RCH Burns Centre until November 2001. Daily cleaning was required due to the necessity to reapply the cream. The advent of nanocrystalline silver dressings such as Acticoat^{TM} has changed the face of burns treatment in our centre. Dressings are applied and left intact for up to 4 days for Acticoat^{TM} and 7 days for Acticoat7^{TM} [13,14]. The centre also pricks blisters and expresses the fluid, leaving the blister skin intact until it