Annals of Plastic and Reconstructive Surgery

Research Article
Published: 05 Mar, 2018

Optimization of Laser Doppler Image (LDI) Acquisition for Burn Depth Assessment

*Ahmad Z**

Department of Plastic and Reconstructive Surgery, University of Exeter, Salisbury General Hospital, Wiltshire, UK

Abstract

Laser Doppler Imaging (LDI) is being increasingly used for assessment of mixed depth or intermediate thickness burns. This modality has a learning curve and the technique is operator and patient dependent. The authors present their experience of using LDI for adult and paediatric burn assessment in two regional centres over the last 5 years and suggest technical guidance on how to optimize and maximize data capture which may guide and enable clinicians in making decisions regarding burns wound management.

Keywords: Laser Doppler flowmetry; Diagnosis; Investigations; Burns

Introduction

Accurate assessment of burn depth is crucial in the management of burn wounds as well as in planning surgical burn excision, in order to minimize scarring, optimize aesthetic appearance and maximize functional outcome [1]. Clearly if burns are not managed promptly and accurately the wounds can progress which may significantly affect overall patient outcome. Figure 1 shows the accepted theoretical model as proposed by Jackson [2].

Detailed history and examination have comprised the mainstay in establishing the overall management of the burn injury. Adjuncts such as Laser Doppler Imaging (LDI), thermography and tissue biopsy amongst others have been well-described [3]. Each of these methods have their benefits and drawbacks as well as their proponents and critics. The authors feel that this practical guide based on 10 years clinical experience from the senior author from his own practice may add much-needed hands-on guidance in the burns literature which is sparse compared to the more readily-available theory behind LDI.

Background

Described in 1962 the Doppler effect and its principles have been applied to medicine and medical technology, which is widely used to date. The first description of its use was in the field of haemodynamics as a research tool to quantify blood flow in human tissue [5]; currently it is being used in otology measuring tympanic membranes as well as in chronic pain management [6].

Stern first employed the LDI in monitoring the cutaneous microcirculation in 1975, and the use of LDI was first applied in the management of adult burns in 1993 [6,7]. Further reports confirmed the accuracy of LDI and demonstrated the value of the technique as an objective tool for the measurement of burn wound healing potential [8,9]. LDI thus far is the only to be approved by the Food and Drug Administration [10].

The LDI device measures the blood flow using a red diode laser through the superficial dermis. It is reflected by the circulating erythrocytes within the burn wound [11]. This beam is sequentially passed over the burn and the computer software generates a colour palette identifying areas with high to low perfusion of the wound (Figures 2) [12]. A colour photograph is also simultaneously taken which allows for clinical correlation between the burn and the LDI colour map.

Indications

The clinician must decide whether it is appropriate to use LDI in the first instance. Indications for its use include assessment of indeterminate or mixed-depth burns, usually scalds, or burns where the healing potential may be hitherto unknown. If indeed LDI is indicated the optimum time period to perform the scan is between day 3 and day 5 [10]. Some authors argue that the scan is most accurate on day 3 post-burn injury, with high sensitivity and specificity on day 3 >90% [11,12].

OPEN ACCESS

Correspondence:
Ahmad Z, Department of Plastic and Reconstructive Surgery, University of Exeter, Salisbury General Hospital, Wiltshire, UK,
E-mail: zeeshan.ahmad@doctors.org.uk

Received Date: *14 Jan 2018*
Accepted Date: *25 Feb 2018*
Published Date: *05 Mar 2018*

Citation:
Ahmad Z. Optimization of Laser Doppler Image (LDI) Acquisition for Burn Depth Assessment. Ann Plast Reconstr Surg. 2018; 2(2): 1014.

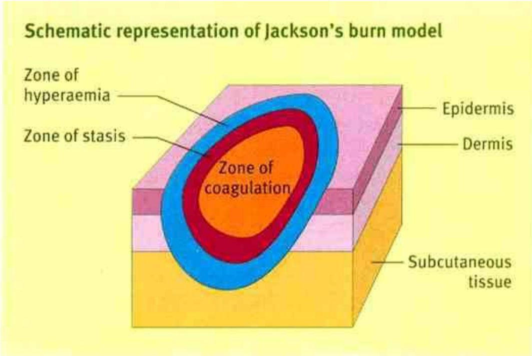

Figure 1: Jackson's burn wound model.

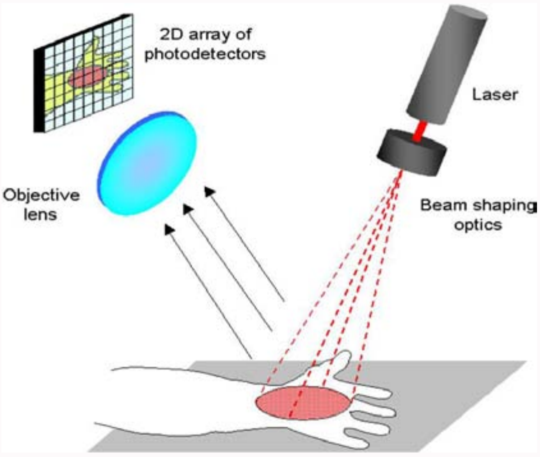

Figure 2: The Laser Doppler flowmetry principles and components.

Technical Factors

The scanner component of the LDI takes approximately 30 minutes to warm up and therefore is not available instantly. The device needs to be calibrated prior to each use. This calibration is performed in a dark room using a custom-made calibration instrument provided by the manufacturer.

In our institution we use Moor LDI systems (Moor Ltd. Axminster, Devon, UK). The manufacturer recommends Moor LDI-B2/B1 (Figure 3) for larger wounds and the Moor LS - for smaller wounds and for use in children where a faster scan is beneficial.

Machine Positioning

The machine should be positioned as close to a plug socket to avoid tension on the cord such that it pulls out mid-scan. This can minimize hazard risk to staff who may be in the vicinity who may be aiding with dressings, performing assessments or administering medications or when other adults or children aside from the patient maybe nearby (this is more commonly seen in the paediatric setting in the authors' experience).

The operator should position the scan head unit perpendicular to the long axis of the limb or along the long axis of a trunk wound. It should be tilted 15º forwards from the vertical to minimize reflection artifact from the burn wound.

The distance from the laser diode to the burn is should ideally be 70 cm. This distance according to the manufacturer's recommendations produces the optimal optics thereby delivering the best quality and accurate scans [9]. In our institution a tape measure is attached to the LDI machines in order optimize the quality of image acquisition.

Patient Factors

Safety

LDI consists of a class A laser which may cause retinal damage and therefore patient and operator safety are crucial [13].

Patient Positioning

An appropriately counseled and consented patient is crucial in facilitating the acquisition of the scan. All movement should be avoided, which may be challenge in the paediatric population. Careful explanation and positioning of the patient will help to avoid movement artifact; this is commonly seen in scanning hands and feet and understandably in children. The patient should be appropriately positioned and comfortable enough to maintain the position for the length of the scan. If the patient cannot ambulate or cannot be transferred to the LDI machine, the LDI machine can be moved to the patient. This maybe cumbersome however may well be easier in the in terms of logistics.

The patient should be adequately hydrated and the temperature should be closely regulated as variations in the ambient temperature can alter cutaneous vasomotor response. This will influence the images obtained from the scans. However, burns patients should not be allowed to become hypothermic because of an investigation.

Wound Preparation

The wound should be cleaned and debrided (under analgesia if required) by the bedside by removing loose epidermis and wound exudates, leaving a clean and dry wound prior to the scan. Any topical creams or ointments e.g. sulfadiazine should also be wiped clear of the wounds. These steps minimize reflection and interference laser artifact.

Interpretation of Results

Users must remain mindful of certain situations when interpreting the images obtained from the study. Potential artifacts exist particularly at edges of curved or beveled surfaces. Furthermore, in darker skin types (Fitzpatrick IV-V) the images of burns can be more difficult to assess as the unburned skin may not register on the scan. Scans around digits as well as tattoos also provide a degree of artifact and therefore must be borne in mind when interpreting the result. Further patients with peripheral vascular disease or smokers should have their images interpreted with care.

Scans performed under general anaesthesia (in children) can lead to underestimation of burn depth due to peripheral vasodilatation of the dermal plexus.

Moreover, the skin in some areas of the body as well as some patients can be variable.

The volar forearm skin is thinner than the dorsal skin, as is the skin on the dorsum of the hand compared to its glabrous counterpart. The eyelid skin in the thinnest in the human body, whereas the forehead nearby is much thicker. Children and the elderly have different skin compositions, however both of their skins are thinner compared to healthy adults.

The images should be interpreted as a whole bearing in mind the

Figure 3: The moor laser Doppler imaging device (Moor Instruments Ltd, Axminster, Devon, UK).

peripheral tissues. The mean flux of the different areas of the wound can be calculated using the manufacturer's software. This can be compared with the overall healing potential of the wound.

Clearly when performing LDI in practice not all circumstances can be controlled rigorously particularly when there are clinical variables, inter-operator variability as well as 'human factor'. Some authors argue that the scan is most accurate on day 3 post-burn injury, with high sensitivity and specificity on day 3 >90%, whilst others question the utility of LDI in burns assessment [11]. LDI is an adjunct and not a prescriptive tool and therefore ultimately the decision to operate or not to operate rests with the clinician.

Conclusion

The authors feel that this 'hands-on' practical guide in the use of the LDI is point summary is a useful guide for all of those undertaking use of LDI in the assessment and subsequent management of burns, ranging from junior staff to experienced consultants. As the interpretation and subsequent decision-making is operator-dependent it is crucial to ensure that the users try their best to achieve some sort of acceptable or optimal standard of imaging.

Acknowledgement

The authors would like to thank Senior Sister Clare Thomas, Lead for Paediatric Burns and Burns Centre Staff at Birmingham Children's Hospital and Senior Sister Elizabeth Shale, Lead for Adult Burns and Burns Centre staff at Queen Elizabeth Hospital Birmingham. The authors would also like to thank Moor Instruments Ltd, Axminster, and Devon, UK for their guidance and support.

References

1. Janzekovic Z. A new concept in the early excision and immediate grafting of burns. J Trauma. 1970;10(12):1103-8.
2. Jackson D. The diagnosis of depth of burn. Br J Surg. 1953;40(164):588-96.
3. Sharma VP, O'Boyle CP, Jeffery SL. Man or machine? The clinimetric properties of laser Doppler imaging in burn depth assessment. J Burn Care Res. 2011;32(1):143-9.
4. Park YS, Choi YH, Lee HS, Moon DJ, Kim SG, Lee JH, et al. The impact of laser Doppler imaging on the early decision-making process for surgical intervention in adults with indeterminate burns. Burns. 2013;39(4):655-61.
5. Sainsbury DC. Critical evaluation of the clinimetrics of laser Doppler imaging in burn assessment. J Wound Care. 2008;17(5):193-4.
6. Feinstein AR. An additional basic science for clinical medicine. The development of clinimetrics. Ann Intern Med. 1983;99(6):843-8.
7. Stern M. In vivo evaluation of microcirculation by coherent light scattering. Nature. 1975;254:56-8.
8. Niazi Z, Essex T, Papini R, Scott D, Mclean N, Black M. New laser Doppler scanner, a valuable adjunct in burn depth assessment. Burns. 1993;19(6):485-9.
9. Hoeksema H, Van de Sijpe K, Tondu T, Hamdi M, Van Landuyt K, Blondeel P, et al. Accuracy of early burn depth assessment by laser Doppler imaging on different days post burn. Burns. 2008;35(1):36-45.
10. Moor Instruments. 2009.
11. Jeng JC, Bridgeman A, Shivnan L, Thornton PM, Alam H, Clarke TJ, et al. Laser Doppler imaging determines need for excision and grafting in advance of clinical judgment: a prospective blinded trial. Burns. 2003;29(7):665-70.
12. Cho JK, Moon DJ, Kim SG, Lee HG, Chung SP, Yoon CJ. Relationship between healing time and mean perfusion units of laser Doppler imaging (LDI) in pediatric burns. Burns. 2009;35(6):818-23.