Laser Doppler Imaging: a clinimetric tool for determining burn depth?

The accurate measurement of burn depth has challenged clinicians, as the correct diagnosis is important for the prompt management to optimise scarring and functional outcome [1]. Jackson’s burn wound model initially described the three zones of a burn [2] – the zone of coagulation (permanent cell necrosis), stasis (potentially reversible damage) and hyperemia (reversible damage). These zones can progress in either direction depending on the promptness of management. Clinically burns are often classified as superficial epidermal, superficial dermal, deep dermal and full thickness [3]. Superficial epidermal burns heal within seven days leaving no scars, superficial dermal burns are painful, deep dermal burns are insensate and full thickness burns are leathery white and insensate [4].

This article reviews the clinimetrics of laser Doppler imaging (LDI) in assessing burn depth.

TRADITIONAL ASSESSMENT OF BURN DEPTH

Traditionally, clinicians used clinical judgement by taking a complete history looking at mode of injury, length of contact of heat with skin, age of patient and initial first aid administered [5]. Examination includes calculation of total surface body area affected and inspection of the burn, looking at colour, pain sensation and capillary refill [3,4]. Histological diagnosis by biopsy is the gold standard for the determination of burn depth [6,7]. However it does not assess the whole burn, is invasive therefore causes pain and scarring and is affected by sampling variation as biopsies can miss the deepest part of the burn [8].

The ideal tool to measure burn depth should be sensitive (positive for proportion of population with burn), specific (negative for proportion of population with no burn), reliable (produce the same results repeatedly), valid (measure what it claims to measure), reproducible (can be replicated by different observers), cost-effective, non-invasive and acceptable to the patient and clinician (practically and ethically) [3,9].

BASIC PRINCIPLES OF LASER DOPPLER IMAGING (LDI)

LDI measures the extent of superficial dermal microvascular blood flow [9-11]. Disruption of this blood flow can correlate with extent of injury, with deep dermal/full thickness burns showing significant reduction in dermal blood flow [9,12], it can therefore assess burn depth in patients.

The importance of correct assessment is paramount as superficial epidermal and dermal burns can be managed conservatively with dressings [4], whereas deep dermal and full thickness burn require surgical intervention in order to heal.
quicker and with fewer complications [13,14]. Thanks to to the validity of the LDI as an assessment tool, correct diagnosis reduces mortality, cost and unnecessary surgical interventions [15-17]. LDI uses a red diode laser, which is reflected by circulating erythrocytes and immobile tissue, therefore displaying the 'Doppler Shift Effect' according to which light reflected from an object that is moving is relative to the light source undergoes a frequency shift [18]. A transducer, which derives values for dermal perfusion, detects the reflected light and these values are used to produce a colour map of the wound [12,19].

Michieles et al. [12] reported that superficial burns show high rates of perfusion, whereas deeper burns show low rates of perfusion due to damaged blood vessels. The colour maps are red/yellow in areas of high perfusion (e.g. superficial epidermal and superficial dermal) and green/blue in areas of moderate-low perfusion (deep dermal) and blue in areas of low perfusion (full thickness) [12,19]. These maps can be compared to clinical photographs and examination of the patient in order to allow accurate measurement of burn depth, as they are not sufficient for assessment [1,3,4].

**PROS OF LDI**
- LDI sensitivity ranges from 90-100% and specificity from 92-97% [1,4,20,21].
- LDI can be used to assess responsiveness of treatment by observing the healing of the wound [17].
- LDI is well tolerated by both adults and some paediatric patients due to its non-invasive nature [17].
- LDI can assess a large area without any contact with burn surface, therefore reducing cross infection and leaving no scarring [17].
- Scanning time is <2 minutes with an experienced scanner and a co-operative patient [22].
- Overall costs are reduced as inpatient stay is 2 days shorter, rates of infection is lower and therefore there is increased bed availability [17].

**CONS OF LDI**
- Surrounding hyperemia and debris can skew the results of the LDI [17].
- Burns have been shown to evolve over 48-72 hours, therefore the scanning window has been suggested to be at its most optimal point at 48hours [2,4].
- Scanning after 72 hours has not shown any significant changes [17].
- Changes in the angle that the probe is held at can affect LDI reliability [1]. Studies have shown angles between 15-30 [22] or at 90 degrees [20] to be most accurate.
- Movement adversely affects reliability of LDI, especially in the paediatric population [1,23]. Sedation or general anaesthetic may be considered, however the risks need to be weighed against the benefits.
- Dressings such as Acticort can produce silver particle residues which can also affect LDI readings [20].
- LDI units cost > Eur 42 000 [19].

**THE FUTURE**
LDI is a very sensitive and specific tool to measure burn depth, easy to use, reliable and acceptable to the patient due to its quick and non-invasive nature. It remains a widely accepted tool to assess burn depth, with an ever-increasing body of evidence as discussed below to support its use. It is the only diagnostic modality that has regulatory approval from the United States Food and Drug Administration [22]. With respect to LDI, improvements in validity, cost and reproducibility could improve this clinometric tool, as it is difficult to satisfy the entire evaluation criterion all the time. Close collaboration between clinicians, statisticians, epidemiologists and psychologists is necessary in order to develop clinimetrics to develop both clinical practice and clinical research.

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**REFERENCES**