Cost-Effectiveness of Laser Doppler Imaging in Burn Care in The Netherlands: A Randomized Controlled Trial

M. Jenda Hop, M.D., Ph.D.
Carlijn M. Stekelenburg, M.D.
Jakob Hiddingh, M.Sc.
Hedwig C. Kuipers, M.D.
Esther Middelkoop, Ph.D.
Marianne K. Nieuwenhuis, Ph.D.
Suzanne Polinder, Ph.D.
Margriet E. van Baar, Ph.D.
For the LDI Study Group

Background: In patients with burns, an early accurate diagnosis of burn depth facilitates optimal treatment. Laser Doppler imaging combined with clinical assessment leads to an accurate estimate of burn depth. However, the actual effects of the introduction of laser Doppler imaging on therapeutic decisions, clinical outcomes, and costs are unknown.

Methods: A randomized controlled trial was conducted in the Dutch burn centers, including 202 patients with burns of indeterminate depth. In the standard care group, estimation of burn depth was based on clinical assessment only; in the laser Doppler imaging group, clinical assessment and laser Doppler imaging were combined. Primary outcome was time to wound healing. Furthermore, therapeutic decisions and cost-effectiveness were analyzed.

Results: Mean time to wound healing was 14.3 days (95 percent CI, 12.8 to 15.9 days) in the laser Doppler imaging group and 15.5 days (95 percent CI, 13.9 to 17.2 days) in the standard care group ($p = 0.258$). On the day of randomization, clinicians decided significantly more often on operative or nonoperative treatment in the laser Doppler imaging group ($p < 0.001$), instead of postponing their treatment choice. Analyses in a subgroup of admitted patients requiring surgery showed a significant earlier decision for surgery and a shorter wound healing time in the laser Doppler imaging group. Mean total costs per patient were comparable in both groups.

Conclusions: Laser Doppler imaging improved therapeutic decisions. It resulted in a shorter wound healing time in the subgroup of admitted patients requiring surgery and has the potential for cost savings of €875 per scanned patient. (Plast. Reconstr. Surg. 137: 166e, 2016.)

Disclosure: The authors declare that they have no financial interests to disclose.
traditionally considered expensive care, there is a growing interest in costs and cost control.\textsuperscript{6-9} To provide cost-effective burn care, there is a need for an accurate and timely method of burn depth estimation.

Laser Doppler imaging is the only technique that has been shown to accurately predict healing time with a large weight of evidence.\textsuperscript{10} Laser Doppler imaging should be used in combination with standard clinical assessment,\textsuperscript{11} as a so-called add-on test.\textsuperscript{12} In the past decade, several prospective studies on the diagnostic accuracy of laser Doppler imaging have demonstrated an accuracy varying between 95 and 100 percent.\textsuperscript{2,3,10-13} Timing of laser Doppler imaging is important: only scanning between 48 hours and 5 days results in a high accuracy (>95 percent).\textsuperscript{10,11,13-16} The literature on the accuracy of laser Doppler imaging in burn depth assessment is convincing; however, the therapeutic impact remains less clear. To our knowledge, only one retrospective cohort study\textsuperscript{4} and one prospective nonrandomized study\textsuperscript{5} investigated the therapeutic impact of the introduction of laser Doppler imaging. Petrie et al.\textsuperscript{4} reported a lower rate of operative interventions (6.8 percent before and 2.2 percent after introduction of laser Doppler imaging; \(p = 0.029\)) in a pediatric burn population and a reduced length of hospital stay for surgically treated patients (15.1 days before and 9.8 days after; no \(p\) value), in a retrospective study design. The overall length of stay was 3.4 days before and 2.1 days after the introduction of the laser Doppler imaging. Kim et al.\textsuperscript{5} studied the impact of laser Doppler imaging on surgically treated pediatric patients with burns. The mean time to decision for surgery was shorter, 8.9 days in the laser Doppler imaging group compared with 11.6 days in the clinical assessment group (\(p = 0.01\)). No studies reported on health-related quality of life of patients after the introduction of laser Doppler imaging.

The British National Institute for Health and Care Excellence recently published guidance on laser Doppler imaging for the assessment of burns.\textsuperscript{17} They concluded that there was good clinical evidence that laser Doppler imaging increases the accuracy of predicting burn wound healing and can be used to facilitate treatment plans. With laser Doppler imaging results, the decision of whether surgery was needed could be made earlier, resulting in a shorter hospital stay; it reduced the size of areas that were operated on or avoided surgery completely in some patients who otherwise might have had to undergo operative treatment. According to the British National Institute for Health and Care Excellence, the average cost saving was £1248 (€1504) per patient scanned, when using the MoorLDI-B1 (Moor Instruments, Inc., Wilmington, Del.) in addition to clinical evaluation. This was based on a cost model, assuming a 17 percent reduction in the number of skin graft operations and a 2-day reduction of hospital stay. The methods and results of the cost estimations, however, were incompletely described. For instance, the source of the numbers of reduction of surgery and hospital days remains unclear. Furthermore, it is unclear to what degree these cost estimations apply to other health care settings (e.g., The Netherlands).

To summarize, current research gives indications on the diagnostic and therapeutic impact of laser Doppler imaging in burn care. However, randomized cost-effectiveness studies in both pediatric and adult patients with burns are lacking.

Therefore, it is still unclear whether laser Doppler imaging actually influences diagnostic and therapeutic decisions, patient outcomes, and costs, and as a consequence adds to the quality of care. The aim of the present study was to analyze the effectiveness and cost-effectiveness of laser Doppler imaging in burn care.

**PATIENTS AND METHODS**

**Study Design, Participants, and Randomization**

A multicenter, randomized, controlled trial was conducted in all three burn centers in The Netherlands from December of 2011 to March of 2013. The study protocol was approved by the Medical Research Ethics Committee of Rotterdam (NL37844.101.11) and registered at ClinicalTrials.gov (NCT01489540).

Inclusion criteria were burns of indeterminate depth, admission or outpatient treatment, and presentation within 5 days after burn. Patients were excluded in case of presence of evident full-thickness wounds (besides intermediate wounds), topical treatment/dressings that impaired scanning, periorbital facial burns, no informed consent, and/or a total body surface area burned greater than 20 percent. In randomization, stratification was performed for the three different centers and for burn size: total body surface area burned less than or equal to 10 percent or greater than 10 percent. The allocation sequence was concealed by using sequentially numbered, opaque sealed envelopes. The full trial protocol has been published elsewhere.\textsuperscript{18}

**Intervention**

Patients were assigned randomly to (1) clinical assessment plus laser Doppler imaging (laser
Doppler imaging group) or (2) clinical assessment alone (standard care group), on the day of the scan, by a research physician/nurse. A laser Doppler imaging scan was obtained of all wounds (a wound was defined as an area bounded by nonburned skin) of indeterminate depth by a trained (2 months before the start of the trial) research physician/nurse, between 48 hours and 5 days after burn. Laser Doppler imaging results were revealed to the treating clinician in the laser Doppler imaging group and remained blinded in the standard care group. The laser Doppler imaging results were presented as a healing potential (<14 days, between 14 and 21 days, or >21 days), with a validated color code for image interpretation.10 Clinicians then decided on the preferred treatment, based on both the laser Doppler imaging and their clinical expertise (laser Doppler imaging group) or their clinical expertise alone (standard care group).

Outcomes

Primary Outcome Measure

The primary outcome measure was time to wound healing (>95 percent reepithelialization) from the day of randomization onward. Reepithelialization of all separate wounds within one patient was assessed in a bedside procedure by an experienced burn specialist, not blinded to randomization group.19

Secondary Outcomes Measures

Secondary outcomes measures included the following:

Diagnostic decisions of burn clinicians in the laser Doppler imaging group, before and after laser Doppler imaging: Sensitivity and specificity of the laser Doppler imaging were calculated compared to the respective reference test [time to wound healing (in conservative patients) or biopsy (in surgical patients)].18

Therapeutic decisions of burn clinicians: Including surgery/no surgery/postponement decision, time to surgical decision, time to surgery, and length of hospital stay.

Quality of life: Assessed at baseline and after 3 months with a questionnaire. For patients aged 0 to 4 years, the Infant and Toddler Quality of Life Questionnaire–47 (11 dimensions; range, 0 to 100) was used. For patients aged 5 years and older, the EuroQol-6D (range, 0.0 to 1.0) was used.20–22

Scar quality: Assessed after 3 months with the Cutometer Skin Elasticity Meter 575 (Courage and Khazaka Electronic GmbH, Cologne, Germany),23 the DermaSpectrometer (vascularity and pigmentation) (Cortex Technology, Hadsund, Denmark),24 and the Patient and Observer Scar Assessment Scale (POSAS).25,26

Economic evaluation: Performed from a societal perspective in accordance with the Dutch guidelines for economic evaluation studies.27

Direct health care costs, direct non–health care costs, and indirect non–health care costs from randomization until 3 months after burn were included. Costs of laser Doppler imaging included costs of initial investment, investments during use and maintenance, personnel costs, and overhead and housing. A bottom-up approach was applied (following the microcosting method of Gold et al.28). Cost prices were inventoried in the financial department of one burn center. In addition, charges as a proxy of real costs27 were used with data from patient questionnaires. The costs applied to the financial year 2012.

Statistical Analysis

Power calculation was based on a reduction of 5.3 days in length of stay in patients undergoing surgery after the introduction of laser Doppler imaging.1 The mean time to wound healing in surgically treated patients admitted to the Dutch burn centers (42.5 percent of all admitted patients) was 19.0 days, before the start of the trial.18 Thus, an overall reduction of 2.25 days (42.5 percent × 5.3 days) could be expected (SD, 5 days). An α level of 0.05 and a β level of 0.20 (power, 0.80) resulted in a calculated sample size of 95 per group. With a 5 percent dropout rate, a total sample size of 200 was required.

Data were analyzed according to the intention-to-treat principle. Differences in time to wound healing, surgical decision, and surgery in both groups were analyzed with mixed model analysis (three levels: burn center, patient, wound). Differences in therapeutic decision were analyzed with multinomial logistic multilevel regression. Quality of life, scar quality, and length of stay were analyzed using univariate linear regression, with a correction for burn center and also for baseline measures in quality of life.

Diagnostic accuracy was assessed by calculating sensitivity and specificity of the laser Doppler imaging compared with the reference standard (wound healing time in nonoperative wounds and biopsies in operative treated wounds). Differences in mean costs were analyzed with nonparametric
techniques (bootstrapping, 1000 times). Effects of laser Doppler imaging in admitted patients (therefore excluding outpatients) were analyzed separately in a subanalysis. Data analysis was performed using SPSS PASW Statistics Version 18.0 (SPSS, Inc., Chicago, Ill.) and Stata (StataCorp, College Station, Texas).

RESULTS

Flowchart, Patient, and Injury Characteristics

In Figure 1, the trial’s flowchart is presented. A total of 202 patients were included, 106 in the laser Doppler imaging group and 96 in the standard care group, of which baseline characteristics are shown in Table 1.

Wound Healing Time

Mean time from injury to randomization was 3.4 days in the laser Doppler imaging group and 3.5 days in the standard care group. Mean time to wound healing from randomization was 14.3 days (95 percent CI, 12.8 to 15.9 days) in wounds in the laser Doppler imaging group and 15.5 days (95 percent CI, 13.9 to 17.2 days) in the standard care group (p = 0.258) (Table 2).

A nonsignificant shorter time to wound healing was found in the operatively treated wounds, with 16.5 days (95 percent CI, 14.0 to 18.9 days) in the laser Doppler imaging group (74 wounds) versus 19.2 days (95 percent CI, 16.8 to 21.5 days) in the standard care group (63 wounds) (p = 0.099). As expected, mean time to wound healing in the nonoperatively treated wounds was equal in both diagnostic groups: 12.5 days (95 percent CI, 10.4 to 14.5 days) in the laser Doppler imaging group (108 wounds) and 12.4 days (95 percent CI, 10.3 to 14.5 days) (p = 0.953) in the standard care group (85 wounds). The subanalysis for admitted patients revealed a significantly shorter time to wound healing in operatively treated wounds, 16.0 days (95 percent CI, 13.5 to 18.5 days) in the laser Doppler imaging group versus 19.9 days (95 percent CI, 17.5 to 22.3 days) in the standard care group (p = 0.022).

Diagnostic Decisions

The wound depth according to laser Doppler imaging results was comparable in both diagnostic groups: 24.7 percent versus 25.2 percent had a predicted healing potential of less than 14 days, and 47.3 percent versus 51.7 percent had a predicted healing potential of more than 21 days. Accuracy was good, with a sensitivity of 93.5 percent (95 percent CI, 86.2 to 96.9 percent) and a specificity of 88.6 percent (95 percent CI, 70.6 to 85.9 percent).

Therapeutic Decisions

On the day of the laser Doppler imaging scan, clinicians decided significantly more often on operative or nonoperative treatment (20.4 and 44.1 percent, respectively) in the laser Doppler imaging group (p < 0.001), instead of postponing their treatment decision (35.5 percent), which occurred more often in the standard care group (82.1 percent) (Fig. 2). Reasons for postponement of treatment choice in the laser Doppler imaging group were as follows: different predicted healing potentials within one wound (65.6 percent) and a predicted healing potential of 14 to 21 days (23.0 percent), doubt on the laser Doppler imaging prediction (6.6 percent), and wound too small for surgery (4.9 percent).

Reasons for postponement in the standard care group were indeterminate burn depth (89.2 percent) or unclear (burn) size for surgery (10.8 percent). The mean time to decision for surgical treatment was 4.6 days (95 percent CI, 3.0 to 6.1 days) after randomization in wounds in the laser Doppler imaging group, compared with 6.3 days (95 percent CI, 4.8 to 7.6 days) in wounds in the standard care group (p = 0.096). The time to actual surgery was 8.6 days (95 percent CI, 7.1 to 10.1 days) after randomization in the laser Doppler imaging group versus 9.7 days (95 percent CI, 8.3 to 11.1 days) in the control group (p = 0.276) (Table 3).

In a subanalysis for the admitted patients only, time to the surgical decision was significantly shorter in the laser Doppler imaging group: 4.1 days (95 percent CI, 2.5 to 5.7 days) in the laser Doppler imaging group and 6.5 days (95 percent CI, 5.0 to 8.1 days) in the standard care group (p = 0.029). Time to actual surgery did not differ significantly, 8.5 days (95 percent CI, 7.0 to 10.1 days) in the laser Doppler imaging group and 9.9 days (95 percent CI, 8.5 to 11.4 days) (p = 0.170) in the standard care group. Mean length of stay was 9.6 days (95 percent CI, 7.5 to 11.7 days) in the laser Doppler imaging group and 10.2 days (95 percent CI, 7.9 to 12.4 days) in the standard care group (p = 0.696). Unnecessary surgery (i.e., surgery performed in wounds with a predicted healing potential of less than 14 days) was observed in only one of 38 wounds in the standard care group (surgery was performed 5 days after randomization).
Quality of Life and Scar Quality at 3-Month Follow-Up

Scar quality 3 months after burn was comparable between the laser Doppler imaging and the standard care groups (Table 4). In addition, quality of life 3 months after burn was also comparable between both randomization groups (data not shown).

Costs

The mean price of laser Doppler imaging scan(s) per patient was €151 (Table 5). Mean total costs per patient were comparable in both groups: €20,202 (95 percent CI, €17,341 to €23,063) in the laser Doppler imaging group and €20,504 (95 percent CI, €17,614 to €23,394) in the standard care group (p = 0.870). Costs of specific parts of health care use and patient costs were also similar (Table 6).

In subanalysis, mean total costs for admitted patients were €22,854 (95 percent CI €19,664 to €26,044) in the laser Doppler imaging group and €23,816 (95 percent CI, €20,661 to €26,973) in the standard care group (p = 0.627). In outpatients, mean total costs were, respectively, €8056 (95 percent CI, €5551 to €10,562) in the laser Doppler imaging group and €7080 (95 percent CI, €4910 to €9250) in the standard care group (p = 0.538).

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**Fig. 1.** Flow of patients through the trial. TBSA, total body surface area; LDI, laser Doppler imaging; p.b., after burn.
This is the first randomized controlled study that analyzed the effects and costs of laser Doppler imaging as an additional test in the diagnosis of burn depth. It proved to provide guidance for therapeutic decisions, for both nonoperative and operative treated patients from the day of the laser Doppler imaging scan onward, which is valuable for both patients and professionals. On the day of the laser Doppler imaging scan, a definitive treatment choice (operative versus nonoperative) could be made significantly more often in patients in the laser Doppler imaging group ($p < 0.001$). Although we hypothesized that a significantly shorter time to wound healing in the laser Doppler imaging group was possible by earlier surgery for deep burns, overall, no significant differences in time to wound healing were found. However, in the subgroup of admitted patients that required surgery, a significantly earlier decision for surgery and a shorter wound healing time (16.0 versus 19.9 days; $p = 0.029$) were seen. No differences in total costs were found between treatment groups. The introduction of laser Doppler imaging enabled an accurate burn depth diagnosis and early determination of therapy, against costs of €151 per scanned patient.

We conducted a pragmatic randomized controlled trial with broad inclusion criteria to mirror the use of laser Doppler imaging in our daily practice. We observed differences in the use of laser Doppler imaging in the clinical and outpatient settings. In the clinical setting, the majority of patients had an indication for laser Doppler imaging, in contrast to the outpatient setting, in which laser Doppler imaging was not frequently indicated. Furthermore, effectiveness of laser Doppler imaging was predominantly seen in admitted patients, probably partly because of logistic reasons, such as more frequent wound inspection.$^{11}$ An important finding of this trial was the major reduction in the “postponement of decision,” which is likely to improve patient and physician satisfaction and offers the possibility of performing surgery earlier and decreasing length of stay. We observed a significant reduction of 2.4 days in time to operative decision in admitted patients in the laser Doppler imaging

| Table 1. Patient and Injury Characteristics |
|--------------------------------------------|
| LDI Group | SC Group |
|-----------------|-----------------|
| No. | 106 | 96 |
| Male-to-female ratio, % | 62.3:37.7 | 69.8:30.2 |
| Mean age at the time of injury, yr | 33.6 | 32.0 |
| SD | 0.74 | 0.89 |
| Cause, % | 23.3 | 22.5 |
| Fire/flame | 48.1 | 44.8 |
| Scald | 30.2 | 30.2 |
| Others | 21.7 | 25.0 |
| Mean % TBSA burned | 5.6 | 5.3 |
| Range | 0.5-20.0 | 0.2-18.0 |
| SD | 4.3 | 4.2 |
| Body location burned, %* | |
| Head/face | 4.8 | 3.3 |
| Trunk | 13.4 | 16.6 |
| Arm | 31.2 | 32.5 |
| Hand | 21.0 | 26.5 |
| Legs | 22.0 | 17.9 |
| Feet | 7.5 | 3.3 |
| Total no. of wounds | 186 | 151 |
| Mean no. of included wounds per patient | 1.8 | 1.6 |
| % of patients with: | |
| 1 wound | 47.2 | 60.4 |
| 2 wounds | 36.8 | 25.0 |
| 3 wounds | 11.3 | 11.5 |
| 4 wounds | 2.8 | 3.0 |
| 5 wounds | 1.9 | 0.0 |
| Admitted vs. outpatient treatment, %† | 76.4/23.6 | 76.0/24.0 |
| LDI, laser Doppler imaging; SC, standard care; TBSA, total body surface area. *More locations per patient are possible. †On the day of randomization. |

| Table 2. Time to Wound Healing, on Wound Level from Randomization Onward* |
|-----------------------------------------------|
| LDI Group | SC Group |
|-----------------|-----------------|
| No. (%) | Mean Time to Wound Healing$^\dagger$ (95% CI) | No. (%) | Mean Time to Wound Healing$^\dagger$ (95% CI) |
| Wounds of all patients | | | |
| All wounds‡ | 182 | 14.3 (12.8-15.9) | 148 | 15.5 (13.9-17.2) |
| Operative treated wounds | 74 (40.7) | 16.5 (14.0-18.9) | 65 (42.6) | 19.2 (16.8-21.5) |
| Nonoperative treated wounds | 108 (59.3) | 12.5 (10.4-14.5) | 85 (57.4) | 12.4 (10.3-14.5) |
| Wounds of admitted patients | | | |
| All wounds | 154 | 14.0 (12.2-15.8) | 122 | 16.0 (14.1-17.9) |
| Operative treated wounds | 68 (44.2) | 16.0 (13.5-18.5) | 56 (45.9) | 19.9 (17.5-22.3) |
| Nonoperative treated wounds | 86 (55.8) | 12.1 (9.7-14.4) | 66 (54.1) | 12.0 (9.4-14.6) |
| LDI, laser Doppler imaging; SC, standard care. *Adjustment for burn center and patient level by multilevel analysis. †Days. ‡Wound healing time missing in seven wounds. |

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group, similar to Kim et al., who observed a 1.7-day reduction. We were not able to reproduce the results of Petrie et al., who presented a large reduction of length of stay (5.3 days) in operatively treated patients using laser Doppler imaging, in a before-and-after cohort study.

Fig. 2. (Above) Therapeutic decisions in the laser Doppler imaging (LDI) group. *Significantly different from standard care group (p < 0.001). (Below) Therapeutic decisions in the standard care (SC) group. HP, healing potential.
Possible reasons for these “less than expected” results were the learning curve in the study, scarce operating room time in our burn centers, and the inclusion of a relatively high number of outpatients.

To measure the real cost consequences of the introduction of a new diagnostic intervention for burn injuries, all costs involved should be calculated. Because no overall clinical effects were observed, we refrained from a cost-effectiveness analysis and focused on comparison of cost on overall equally effective strategies. In our study, the cost of laser Doppler imaging per patient was €151 (including equipment, personnel, and overhead costs), which seems a reasonable price for improving our burn diagnosis and treatment prognosis. A reduction of 1 hospital day in surgically treated patients already negates the extra costs of the laser Doppler imaging scans. Unfortunately, we were not able to detect such a cost reduction. Because we did detect a significantly earlier surgical decision, the potential for earlier surgery and cost reduction is certainly present.

Next to the introduction of laser Doppler imaging, hospital logistics also need to be adapted to enable a reduction in hospital stay. With only 1 surgery day per week available (as in one of the participating burn centers) and scarce operating room time, it is difficult to operate earlier on patients. Of course, in large organizations such as hospitals, logistics changes are complex and take time. If time to surgery can be reduced by 2.4 days, similar to the time to decision for surgery in our study, cost savings of €2124 per surgery patient can be reached, or €875 per scanned patient (this latter price also includes operatively treated patients).

To our knowledge, the only other article that discussed the costs and savings of laser Doppler imaging was the British National Institute for Health and Care Excellence guidance.17

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### Table 3. Time to Surgical Decisions and Time to Actual Surgery, on Wound Level from Randomization Onward*

|                      | LDI Group |           | SC Group |           | p   |
|----------------------|-----------|-----------|----------|-----------|-----|
|                      | No. Mean (95% CI) | No. Mean (95% CI) |           |          |
| Wounds of all patients† | 73 4.6 (3.0–6.1) | 63 6.3 (4.8–7.8) | 0.096 |
| Time to decision surgical treatment, days‡ | 74 8.6 (7.1–10.1) | 64 9.7 (8.3–11.1) | 0.276 |
| Wounds of admitted patients† | 67 4.1 (2.5–5.7) | 56 6.5 (5.0–8.1) | 0.029 |
| Time to decision surgical treatment, days‡ | 68 8.5 (7.0–10.1) | 57 9.9 (8.5–11.4) | 0.170 |

LDI, laser Doppler imaging; SD, standard care.

*Adjustment for burn center and patient level by multilevel analysis.
†One outlier was removed from the LDI group (1-year-old boy with complicated wound healing because of wound infection, time to decision for surgical treatment was 52 days, which is more than 4 SD above the mean, total body surface area operated on was 0.3%).
‡Two values are missing (one in the laser Doppler imaging group and one in the standard care group).

### Table 4. Scar Quality 3 Months after Burn

|                      | LDI Group |               | SC Group |               | p   |
|----------------------|-----------|---------------|----------|---------------|-----|
|                      | No. Mean (95% CI) | No. Mean (95% CI) |           |               |     |
| Scar elasticity (ratio Uf)* | 81 0.71 (0.62–0.80) | 70 0.72 (0.62–0.82) | 0.868 |
| Scar color† | 97 | 8.1 (6.1–10.1) | 82 | 7.5 (5.3–9.8) | 0.726 |
| Erythema | 7.6 (6.2–9.1) | 7.2 (5.5–8.8) | 0.671 |
| Melanin | Subjective scar scale (POSAS)‡ | 97 4.2 (3.8–4.6) | 77 4.1 (3.6–4.7) | 0.910 |
| Patient total score | 98 3.2 (2.9–3.6) | 80 3.3 (2.9–3.6) | 0.903 |

LDI, laser Doppler imaging; SC, standard care; POSAS, Patient and Observer Scar Assessment Scale.

*Scar elasticity: ratio scar/control of maximal skin extension (Uf).
†Scar-control.
‡The mean total score is calculated by adding the scores of the separate items of the POSAS and dividing this by the number of items.

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### Table 5. Full Cost of Laser Doppler Imaging Use per Patient

|                      | € (2012) |
|----------------------|---------|
| LDI device* | 73      |
| Personnel costs† | 33      |
| Overhead and housing (41.9%) | 45      |
| Total costs per patient | 151     |

LDI, laser Doppler imaging.

*Based on initial investment of equipment (€57,590), investments during use and maintenance (€2338), number of years of use (10 yr), and number of procedures per year (n = 131).
†Based on 30 min of scan time by a burn care nurse, and 10 min of interpretation time.
Their estimated average cost saving was £1248 (€1504) per patient scanned. This estimation was based on the assumption of a 17 percent reduction in the number of skin graft operations and a 2-day reduction in length of stay. In our treatment policy of delayed surgery (>10 days) in indeterminate burns, unnecessary surgery was not a preexisting problem. In our centers, cost savings can be reached by earlier surgery and a subsequently shorter length of stay. However, in centers where early excision and grafting (within 1 week after burn) is daily practice, the potential cost savings can be reached by avoiding unnecessary surgery. Thus, laser Doppler imaging can be of added value in both early and delayed excision.

The main limitation of this study is that a learning curve can be expected when a new diagnostic instrument is introduced. The laser Doppler imaging was already introduced 2 months before the start of the trial, but this was probably not long enough to eliminate a learning curve in interpretation of results. We suppose that the effects of laser Doppler imaging would be larger when this trial would be repeated in our centers in the near future.

Although laser Doppler imaging is a desirable additional test in burn depth diagnosis, the assessment of burn depth and subsequent treatment choices remains difficult in some cases. We observed that treatment choice was often postponed in wounds with "mixed" laser Doppler imaging predictions. Earlier studies indicate that wounds that do not heal within 21 days have a higher risk of scar hypertrophy. In contrast, a recent study suggests that the risk for hypertrophic scarring in small burns (<5 percent total body surface area), and also those that heal after 21 days, is low. The best treatment for wounds with a mixed healing potential of 14 to 21 days and more than 21 days remains to be determined. To reach an optimal scar quality, should we wait for spontaneous healing of parts of these mixed wounds and perform late surgery on the remaining parts (like in our trial), or should we operate early? This would be a good subject for further study.

### CONCLUSIONS

The introduction of laser Doppler imaging in burn care improved therapeutic decisions from the day of the laser Doppler imaging scan, between 2 and 5 days after burn. No overall significant differences in time to wound healing or costs could be shown, but time to wound healing was improved in the subgroup of admitted patients

### Table 6. Mean Costs of Health Care Use, Work Absence, and Travel Costs (€, 2012) per Patient

| Cost Category                     | LDI Group (n = 106) | SC Group (n = 96) | Difference in Costs, p (95% CI) |
|-----------------------------------|---------------------|------------------|---------------------------------|
| Hospital days (including readmittance)* | 8895               | 9481             | 0.881 (−2538 to 5244)          |
| ICU days                          | 565                 | 216              |                                |
| Day care                          | 435                 |                  |                                |
| Total burn center stay            | 9895               | 10,105           | 0.068 (−480 to −117)           |
| LDI†                              | 151                 | 0                |                                |
| Other diagnostic procedures‡      | 385                 | 276              |                                |
| Total diagnostic procedures       | 536                 | 276              |                                |
| Surgical treatment                | 1138                | 1054             |                                |
| Wound care§                       | 660                 | 605              |                                |
| Blood products (erythrocytes)     | 39                  | 13               |                                |
| Scar care (pressure garments/ silicons splints) | 322     | 310              |                                |
| Total treatment                   | 2160                | 1982             | 0.621 (−918 to 527)            |
| Total clinical consultations      | 168                 | 176              | 0.883 (−86 to 107)             |
| Total outpatient burn care        | 530                 | 537              | 0.885 (−91 to 115)             |
| Total costs specialized burn care | 13,288              | 13,076           | 0.894 (−4034 to 5434)          |
| Total other health care costs     | 374                 | 575              | 0.461 (−281 to 51)             |
| (outside hospital)                |                     |                  |                                |
| Work absence (of patient/partner/ parents) | 6297             | 6459             |                                |
| Travel costs                      | 243                 | 394              |                                |
| Total patient costs               | 6539                | 6854             | 0.706 (−1294 to 967)           |
| Total per patient (95% CI)        | 20,202 (17,341 to 23,063) | 20,504 (17,614 to 23,394) | 0.870 (−3384 to 4279)          |

LDI, laser Doppler imaging; SC, standard care; ICU, intensive care unit.
*Hospital day including personnel costs, accommodation, equipment, overhead, housing, food, laundry, and medication.
†Costs of LDI, including costs of initial investment, investments during use and maintenance, personnel costs, and overhead and housing.
‡Among others, radiography, computed tomographic scan, and bronchoscopy.
§Wound care costs consist of material costs only, in both inpatient and outpatient settings.
requiring surgery. Further optimization of acute care in our burn centers, including logistics, can lead to potential cost savings of €875 per scanned patient.

Margriet E. van Baar, Ph.D.
Burn Centre
Maastad Hospital
P.O. Box 9100
Rotterdam AC 3007, The Netherlands
baarm@maastadziekenhuis.nl

ACKNOWLEDGMENTS
This study was supported by grants from the Nuts Ohra Foundation (grant no. 1002-030) and the Dutch Burns Foundation (grant no. 11.102). We would like to thank the patients and their families for their contribution and participation in our study.

APPENDIX
The LDI Study Group
The LDI study group consists of Gerard I. J. M. Beerthuizen, Bouke K. Boekema, Roelf S. Breederveld, Jan Dokter, Helma W. C. Hofland, Irma M. M. H. Oen, Ursula Penninga-Puister, Sonja M. Scholten-Jaegers, Fenike R. H. Tempelman, Nicole Trommel, Wit E. Tuinebreijer, Cornelis H. van der Vlies, Jos F. Voelmaans, and Martijn B. A. van der Wal.

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