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Improving burn care efficiency

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Summary

In this thesis we searched for methods to optimise efficiency in burn care. Therefore, both healthcare and non-healthcare costs of burn care were studied in detail, and important cost items and predictors for high costs were identified. Furthermore, the effectiveness and cost-effectiveness of upcoming diagnostics and treatment options in burn care were evaluated. In this summary the main findings of the thesis will be presented.

Part I. Overview of burn care costs

In Part I of the thesis we aimed to identify both healthcare and non-healthcare costs of burn care and to find important cost items and predictors for high costs. Therefore we conducted a systematic review, a retrospective and a prospective cohort study. We demonstrated that burn care is associated with high costs. Both healthcare costs, especially hospital stay, and non-healthcare costs, like work absence, are substantial in the short- and long-term.

In the systematic literature review on burn care costs (**Chapter 2**) we presented that burn care was in general more expensive than other injuries. The mean total healthcare cost per burn patient in high-income countries was €56,010. Significant cost categories in the cost review were hospital stay, followed by surgery. Also productivity loss and informal care seemed to be major cost categories, but were presented by one author only (in two articles of Sanchez et al.). In our prospective cohort study on burn care costs within 3 months post-burn (**Chapter 3**), conducted in a Dutch burn centre, mean costs per patient were €26,540 per patient, varying from €740 to €235,560, in a population with a mean burn size of 8% total body surface area. The major cost categories found in our literature review could be confirmed in the prospective cohort study; burn centre days and ICU days were the most important burn care cost categories, followed by work absence and surgical interventions.

Burn centre stay accounted for 81% of the total specialised burn care costs, mainly caused by high burn centre day prices. In burn care, no clear costs prices for burn centre days were described until this thesis. In our prospective study, we calculated burn centre day prices in detail, with the help of annual accounts, which consisted of personnel, material, equipment, nutrition, medication, housing and overhead. We found that the costs of a non-ICU burn centre day were €948 and of a ICU burn centre day €2,966. We recommend using these day prices for future economic evaluations in high-income countries. In non-healthcare costs, work absence represented the main cost category. The mean costs per patient of work absence were even substantially higher than of surgery (€5,255 versus €1,298). Patient and injury characteristics associated with high costs were a higher age, flame burns and a higher %TBSA burned (max. 80%).

Our retrospective study on reconstructive surgery after burn injuries (**Chapter 4**) showed that one out of eight patients needs reconstructive surgery after a burn injury. Mean number of reconstructive procedures per patient was 3.6 (range 1-25). Frequently reconstructed locations were hands and head/neck. The most important indication was scar contracture and the most applied technique was release plus random flaps/ skin grafting. Reconstructive surgery represents a significant cost category in burn care, with a mean of €8342 (range 928-70,067) per patient that undergoes reconstructive surgery in the first decade post burn.

With the cost insights gained in the first part of this thesis, a baseline was established for the design of new cost-effectiveness studies in Dutch burn care, which are highly desirable because burn care is expensive care and there is an on-going need for improvement of burn diagnostics and treatment. We also recommend to further extend our insight in burn care costs in future, by designing cost studies in and outside burn centres with a long follow-up time (e.g. 5 years).

Part II. Improving burn care efficiency: diagnostics and costs

In Part II of this thesis different applications of the diagnostic instrument LDI were described: 1) LDI as an add-on test in burn depth diagnosis, and 2) LDI + clinical assessment as a gold standard to investigate the validity of photographic assessment of burn depth. In our RCT on the cost-effectiveness of LDI (**Chapter 5&6**) we showed that laser Doppler imaging is effective in Dutch burn care by improving therapeutic decision making, as early as 2-5 days post-burn: on the day of randomisation clinicians decided significantly more often on operative or non-operative treatment in the LDI group ($p < 0.001$) instead of postponing their treatment choice. In a subgroup of admitted patients requiring surgery, an earlier decision for surgery and a shorter wound healing time in the LDI group (16.0 versus 19.9 days, $p = 0.022$) was found. In our study we were able to show significant improvements in burn care treatment, however, we were not able to present differences in costs between the LDI and control group. We expect that therapeutic decision-making can even further improve when clinicians will have fully incorporated the LDI in daily practice, and this will eventually lead to cost savings by earlier surgery and a subsequent decreased length of stay (LOS), with the potential to save € 875 per patient. All three centres that participated in this study bought the LDI afterwards and use it regularly, which can be considered as a great result of our study.

In this thesis we also investigated the validity and reliability of telemedicine (by using photographs judged by experts) as an instrument to improve burn size and depth diagnosis (**Chapter 7**). With our study, we were able to give a more nuanced view on the diagnostic abilities of the most simple and least costly form of telemedicine. Photographs can be used accurately by burn experts to assess burn size, but not burn depth. This is in contrast to several previous studies. Because photographic assessment showed to have limitations, the search for an ideal form of telemedicine continues. In the Netherlands, recently 'Teleburn' was introduced: a smartphone with direct connection to burn experts, used in trauma helicopters and several emergency departments. This live interactive video method gives the opportunity of an extensive anamnesis and testing of capillary refill and sensibility. At this point, we do not have insight in the effectiveness of Teleburn yet, but we recommend to research its' effectiveness and cost-effectiveness.

Part III. Improving burn care efficiency: therapeutics and costs

Part III of this thesis showed that the optimal timing of burn surgery still is not clear and that in burn surgery dermal substitutes can be used effectively without significant impact on total costs.

Early excision and grafting vs. delayed excision and grafting; it remains a hot topic in burn care. An important finding of our Cochrane review (**Chapter 8**) was a very basic one: the definition of early excision and grafting in literature is still unclear. Unclear definitions complicate the debate on early vs. delayed excision. It is possible that treatment preferences are more alike than realised. Current performers of delayed excision and grafting probably hardly ever wait until natural separation of eschar, while performers of early excision and grafting do not operate all burns within 24 hours. In severe, clearly full thickness burns, probably a similar timing of surgery, within the first days post burn, is applied.

Outcome measures of the studies included in our review differed widely, preventing us of pooling data. All together: no clear recommendations were derived from this review. There was insufficient data to support any definite conclusions on the effects of early excision and grafting on scar quality.

Does earlier excision and grafting lead to an improved scar quality and functional outcome as described in Engrav et al. and Maslaukas et al.? This probably depends on the depth of burn wounds in which early excision and grafting is performed. In full thickness wounds, most burn experts agree that early excision and grafting is preferred to decrease mortality and

morbidity, as proposed by Dr. Zora Janzekovic in the 1970s. In partial thickness wounds, however, it is more difficult to determine which wounds will benefit most from early excision and grafting. With the help of LDI, we are better equipped to assess burn depth, and choose which wounds should be treated surgically. We strongly recommend to all burn specialists to publish their experience with early vs. delayed grafting or even conduct a randomised controlled trial on this topic and use the LDI as an gold standard for burn depth assessment.

In our search for an improvement of burn care efficiency, we elaborated on optimal burn depth diagnosis, the optimal selection of burn wounds requiring surgery, and the optimal timing of surgery in this thesis. Another possible way to improve healing quality is optimisation of surgical techniques. In this thesis we performed a cost-effectiveness analysis on the use of dermal substitutes and skin grafts under topical negative pressure (**Chapter 9**). Because of subtle differences in clinical effectiveness (scar elasticity), a cost-minimisation analysis was performed: total costs between intervention groups did not differ significantly, and the intervention costs contributed only to a small part (7%) of total burn care costs (€2912 in the intervention group and €1703 in the control group: split skin graft alone). Thus, the assumption that the use of dermal substitutes leads to cost raises could not be confirmed. In the implementation of dermal substitutes in burn care clinical effectiveness should therefore be decisive instead of costs. The effectiveness, in the form of improved scar quality, of dermal substitutes was not clearly shown in the trial described in this thesis, but was demonstrated before in both acute and reconstructive burn wounds. Therefore, we believe that dermal substitutes should get a role in daily practice of specific acute burns (for example in functional areas) and reconstructive wounds.

Conclusion

To improve burn care efficiency both evaluation of effects and costs of interventions are required. In burn diagnostics and treatment on-going advancements are achieved, but economic evaluation studies remain scarce. In this thesis we were able to extend our cost insights of patients with burns and to produce usable reference prices for future cost studies. Furthermore, we evaluated several upcoming and promising diagnostics and therapeutics in burn care and were able to assess their cost-effectiveness, which is inevitable to introduce new interventions in the current economic climate with limited budgets and increasing expenditures. Therefore, we recommend to always consider the inclusion of cost-effectiveness analyses in future intervention studies in burn care.