Think global, act local: Burn care in a resource-limited setting

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Think global, act local:

Burn care in a resource-limited setting

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In this manuscript you will see several personal photographs in between chapters. These photographs depict the work performed at Haydom Lutheran Hospital. I would like to thank all colleagues and patients for their collaboration during the research.

Colleagues and patients have provided consent for the use and distribution of the photographs in this manuscript.


LUTHERAN

Chapter 1

Introduction & background information

Introduction

The burden of burn injuries remains a major global health issue.[1,2] Worldwide, millions of people suffer from burns and burn-related disabilities and deformities. Every year over 8 million people require medical attention due to burns. Burns cause an estimated loss of 8.5 million disability-adjusted life years (DALYs) each year due to premature death and disability.[3] Five per cent of all injury-related deaths are caused by burns, which amounts to an estimated 120,000 deaths annually.[4] Non-fatal burns are a leading cause of disability, which cause long-term physical and psychological problems.[5,6]

There are large differences in burn care worldwide.[1] In high-income countries (HICs) major progress has been made in acute burn care over the past decades. With advancements made in the prevention of burns and treatments of wounds, the incidence of burns has decreased and the survival rate of patients has increased. The current mortality reported by HICs is 1.5%.[7] This is in stark contrast to low- and middle-income countries (LMICs). In these countries the burden of burn incidence, mortality and morbidity remains high.[1,8,9] The vast majority of all burns globally occur in LMICs. This is because people use open fires in daily life, for example for cooking, heating and agriculture. The incidence of burns in these countries is estimated to be 1.3 per 100,000 people, compared to 0.14 per 100,000 people in HICs.[8,10] The few existing studies from LMICs show that poor populations are most at risk of sustaining burns, and that the majority of patients are children.[1,2,9,11,12] The higher morbidity and mortality is a consequence of the fact that geographically isolated and economically disadvantaged populations have limited access to safe and timely burn care.[2] Due to this lack of care, 95% of all fatal fire-related cases of mortality due to burns occurs in LMICs. Studies have estimated that the risk of child mortality due to burns is currently over seven times higher in LMICs compared to HICs.[4,8]

Patients who survive severe burns may face long-term complications of burns. The most debilitating complications are burn scar contractures.[13–15] In a contracture the (burned) skin is replaced by excessive scar tissue. In general scars have the tendency to contract over time and can be insufficiently extensible. When such a scar is located over a joint, it can limit the range of motion (ROM) of the joint. This is defined as 'burn scar contracture'.[5,14,16,17]

The significance of burn scar contractures is that they impair joint function in the performance of daily activities, and that they may consequently cause disability or lower the quality of life (QoL).[6,18–21] Furthermore, contractures can be painful, disfiguring and can cause stigma.[5,15,17] Scar contractures develop more frequently in patients with deep partial and full-thickness burns, in burns over a large TBSA (total body surface area), in flame burns and in wounds that require skin graft surgery. Joints of the upper extremities are more at risk of developing contractures compared to joints of the lower extremities.[5,14,22]

Several treatments are available to reduce the development of scar contractures, such as optimized wound healing, splinting, positioning, and physiotherapy.[23–26] Even when these treatments are available, contractures still frequently develop and their prevalence varies worldwide between 38% and 54% on discharge from hospital.[5,14,22,27] Also in high-income countries (HICs), contractures are frequently observed in severely burned patients, and burn scar contracture release surgery is frequently indicated.[14] In Dutch burn centers, for example, 20.9% of joints with burns develop a contracture, and in 13.3% of joints burn scar reconstruction is performed in the form of contracture release surgery.[5,22]

In resource-limited settings there is a lack of access to burn care, as illustrated in the 'patient journey' described in a separate section of the introduction. The literature defines three types of delays which can theoretically impair access to surgical care.[28] The first delay is in seeking care. Patients may delay seeking care due to health illiteracy, lack of trust in medical care, or concern about healthcare costs. The second delay is in reaching care, as hospitals are few and patients' travel is limited. The lack of referral infrastructure between hospitals may also lead to delays. The third delay is in receiving care. This can be due to shortages of staff. Burn care can be provided by trained medical doctors or associate clinicians (i.e. physician assistants, see background information on healthcare workers). However, not all hospitals may have adequately trained health workers who can provide the appropriate burn care in a timely fashion. Other delays may occur due to a lack of surgical equipment and supplies. The limitations of infection prevention or the lack of safe anesthesia can cause delays in the provision of safe care.[28,29]

There is a lack of experience with reconstructive surgery in resource-limited settings. Currently, international non-governmental organizations (NGOs) organize short-term surgical missions to bridge this gap in surgical care. During

these missions, reconstructive plastic surgeons from high-income countries work on a voluntary basis and provide specialized surgical care for those in need in resource-limited settings. They frequently provide complex reconstruction of burn scar contractures, i.e. contracture release surgery. These missions are organized for a set period, from a few days up to several weeks.[30–32] In the United States alone, over 400 unique organizations have been identified that provide surgical care in LMICs, which spend approximately $250 million per year on missions.[33]

It should be noted that prevention is an important strategy to reduce the incidence of burn injuries in resource-limited settings. Several organizations have established burn prevention programs in resource-limited settings. However, it is beyond the scope of this thesis to assess effective methods of burn prevention. The studies focus on burn care and include diagnosis and treatment of burn wounds, and the reconstruction of burn scar contractures. These aspects are features of secondary and tertiary prevention.

Aims and outline of the thesis

The studies described in this thesis aim to evaluate the current state of burn care in resource-limited settings, and to provide new insight in three domains that can guide future developments, namely short-term reconstructive surgical missions (Part I), acute burn care (Part II) and burn scar contracture release surgery (Part III).

Part I: short-term reconstructive surgical missions

Tanzania has only one plastic surgeon, and there are no plastic surgeons at Haydom Lutheran Hospital. To provide specialized surgical care for burn patients, Haydon Lutheran Hospital organizes short-term surgical missions in collaboration with Doctors of the World Netherlands (a Dutch Non-Governmental Organization). The facilitators are volunteer plastic surgeons from Global Surgery Amsterdam (a foundation that aims to improve access to surgical care in resource-limited settings). The main goals of these missions are to provide contracture release surgery and to train Tanzanian healthcare workers in the basics of surgical care with the emphasis on burn care. The healthcare workers are predominantly medical doctors, although general surgeons and nurses are involved to a lesser extent.

While these missions carry out valuable work, they also raise interesting questions among the team members. What is the long-term impact of these short-term surgical missions on patients, doctors, and the hospital? Can they carry out long-term follow-up? Can these missions sustainably train local healthcare workers? From the existing literature it became clear that, although surgical missions are common worldwide, they are also increasingly coming under fire in the global health literature for their lack of outcomes, follow-up and effectiveness.[31,34,35] It is still not known whether reconstructive surgery that is performed during short-term missions is safe and effective.

There are several reviews that elaborate on the evidence of medical missions in general. All types of missions are included in the reviews, such as obstetrics and gynecology, club foot surgery and ophthalmology surgery missions.[31,36,37] These reviews provide valuable insights into medical missions in general. However, owing to the diversity of medical and surgical missions, they do not specifically provide insight into the outcome of short-term reconstructive surgical missions.

Therefore the aim of the study in Chapter 2 is to systematically review the current available evidence on the impact of short-term reconstructive surgical missions. In this review four key aspects of missions are addressed: i) basic characteristics of missions, (ii) patient safety, (iii) health gains for individual patients, and (iv) the sustainability of missions.

Part II: Acute burn care in resource-limited settings

The burden of burn injuries is disproportionally high in resource-limited settings. Patients are burdened by severe wounds; however, treatment is not readily accessible. This leads to preventable mortality and morbidity. To provide the best effective treatment, several practice guidelines are available which provide valuable recommendations for the treatment of burn wounds in resource-limited settings.[38–40] However, these guidelines and other literature sources also point out that the evidence of the outcomes of treatment in resource-limited settings is scarce and of limited quality.[1,41]

To guide future improvements of burn care in resource-limited settings, insight into current treatment and its outcomes is of vital importance and urgently

needed. The aim of the prospective study in Chapter 3 is to evaluate the outcomes of burn care provided in a resource-limited setting in a low-income country up to three months after injury. Complications, surgical procedures, wound closure, disability and quality of life were assessed.

Scar contractures are commonly observed after severe burns. They often impair joint function, can cause disability and disfigurement and can bring about a variety of functional and social consequences. Knowledge of the scale of the problem of burn scar contractures and the impact that contractures can have on functionality and quality of life helps to evaluate the current state of burn care, set international benchmarks and direct future developments.[27]

Until now such knowledge has been limited.[6,14,27,42,43] A systematic review of the prevalence of contractures reveals that the prevalence is inconsistently reported due to the different definitions of contractures and the timing of measurements.[17,27] The prevalence of contractures in resource-limited settings is still unknown.[5,27] Moreover, very few studies have been performed worldwide on the impact of contractures on the functionality of joints, or the disability and QoL of patients.[19,20,44] The scarcity of studies of resource-limited settings on scar contractures is even more relevant, as burn scar contractures can be more severe and disabling in these settings.[1,2,8,11,38]

The aim of our prospective study in Chapter 4 is to assess the development of burn scar contractures up to one year post-injury in resource-limited settings. The impact of the contractures is evaluated using the function of joints, disability and QoL as primary and validated outcome measures.

Access to healthcare is the result of a complex interaction between patients and healthcare providers. It has been defined as “the opportunity to reach and obtain appropriate healthcare services in situations of perceived need for care”.[12] Alkire et al. studied the access to surgery on the basis of four criteria: timeliness, safety, affordability and surgical capacity.[13] Based on their models, about 5.8 billion people lack access to surgical care.

Based on our previous work at Haydom Lutheran Hospital in Tanzania, we found that accessibility to burn care can be compromised. The study in Chapter 3 already described the safety of burn care. Apart from safety, the medical literature

provides little information on the other barriers that burn victims face. The few studies available show that socioeconomically disadvantaged people lack access to timely burn care or that health illiteracy can cause delays in the provision of burn care.[14–16] However, these studies do not report which barriers are crucial and should receive priority.

Insight into the existing barriers of access to burn care in resource-limited settings is important to improve safe and timely burn care. The aim of the study in Chapter 5 is thus to identify existing barriers to burn care in a resource-limited setting. Three domains of access are evaluated: the timeliness of care, the surgical capacity of the surrounding health facilities, and the affordability of treatment for patients with burn wounds and contractures.

Part III: Burn scar contracture release surgery in low-income countries

Despite the available treatments, burns still commonly occur worldwide. The prevalence of contractures is unknown in resource-limited settings, and neither is it known how often contracture release surgeries are performed. However, given that the incidence of burns appears high, that access to safe burn care can be limited and that the consequences of contracture can be severe in these settings, one can assume that there are a large number of burn victims who suffer from contractures and therefore the need for reconstructive interventions is evident.[1,8,45]

The principle of contracture release surgery is to release or excise the scar and to cover the defect that remains after releasing the scar, with the aim of increasing the range of motion of the affected joint. Many surgical techniques are described in the literature.[46] If adjacent tissue is available, local transposition flaps are recommended.[47–49] There is a wide variety of local flaps, including interposition, five-flap or z-plasty flaps. They provide healthy tissue, thereby adding pliability and extensibility, which can further aid in increasing the range of motion of joints.[47,50,51] If enough adjacent tissue is not available for a local flap, skin grafts are mostly used, preferably full-thickness grafts (FTGs), as they re-contract less than split skin grafts (SSGs).[51–53]

At present there is a lack of evidence globally of the effectiveness of contracture release surgery.[38,46,54] A systematic review points out that existing studies on

this topic vary in methodology. They apply different outcome measures or have statistical shortcomings. This makes comparisons between studies impossible.[54] Currently there are no studies that have assessed the effectiveness of contracture release surgery performed during short-term surgical missions.[55]

To improve our understanding of this matter, the study described in Chapter 6 aims to evaluate the effectiveness of contracture release surgery during surgical training missions in a resource-limited setting, with a follow-up of up to one year postoperatively and using range of motion (ROM) as a validated outcome measure.

While contracture release surgery is frequently performed worldwide, current knowledge of functional recovery is still limited. The few studies available provide limited information about the effectiveness of contracture release surgery.[48,54] Although the relevance of burn scar contractures is that they impair joint function and that they may cause disability or reduce QoL, none of the previous studies assessed whether or to what extent function is regained after surgery. Only a few studies assessed disability or QoL after contracture release surgery.[54,56]

To determine the recovery of joint function, Oosterwijk et al. recently proposed the use of functional ROM.[6,57] Functional ROM is a function-based cut-off value, defined as the range of motion required to perform daily activities.[57] To evaluate the impact of contracture release surgery performed in a resource-limited setting, the change in functional ROM, disability and QoL is assessed up to one-year postoperatively in Chapter 7.

The findings of the studies presented are discussed in Chapter 8 and the future perspectives of burn care in the world are outlined. Chapter 9 presents a summary of this thesis.

Background: About the Haydom Lutheran Hospital

The Haydom Lutheran Hospital is a 250-bed regional referral hospital. It serves a catchment area that inhabits over two million people, who are spread out over the large territory of the Manyara district in Tanzania. Undoubtedly the hospital occupies a unique location, as it is set remotely in a rural part of Tanzania. The famous national parks of Serengeti, Ngorongoro and Lake Manyara are in the surrounding area, and the nearest urbanized area is Arusha, which is a five-hour drive away. Haydom is also the only area where the four main ethno-linguistic groups of the continent meet, namely the *Bantu, Khoisans, Nilotics and Cushitic groups*.

Figure 1. Haydom Lutheran Hospital

The hospital has changed dramatically in recent years. Haydom was founded by a Norwegian surgeon and missionary in 1955, and for a long period the hospital was under Norwegian administration. Over the past ten years the administration and medical care have been gradually transferred to Tanzanians and the hospital

is now fully managed by Tanzanians. In 2010 the Tanzanian authorities declared the hospital a referral and teaching hospital, where currently over ten Tanzanian specialists provide medical care and supervise the training of young medical doctors and nurses. Haydom provides primary and secondary care, including essential surgical care. It has elementary laboratory facilities and a physiotherapy team.

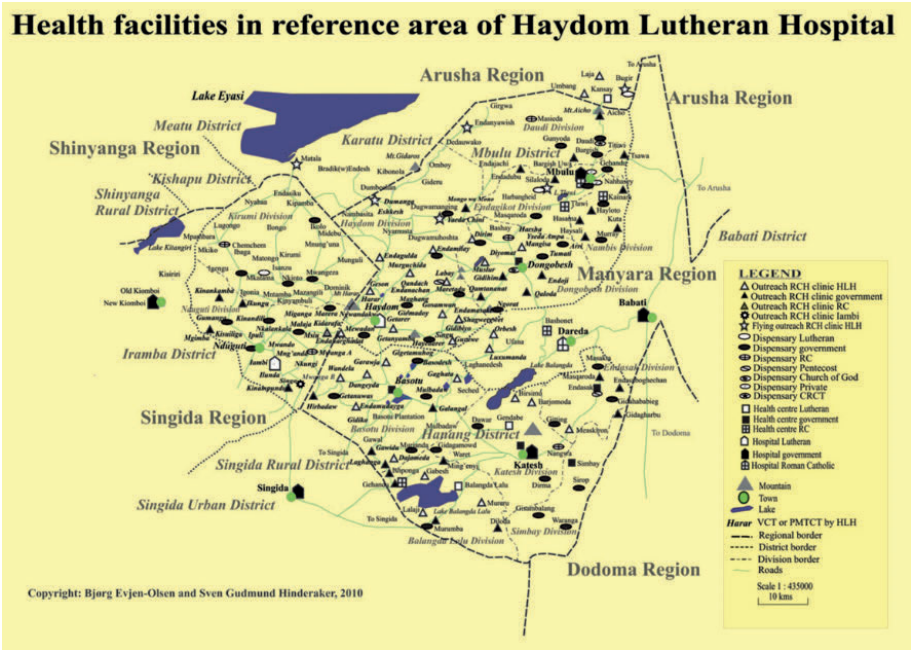

Figure 2. Health facilities in the catchment area of Haydom Lutheran Hospital

Background: About the burn care workforce

The burn care workforce is the network of personnel who collaborate in the delivery of burn care. In resource-limited settings this includes, but is not limited to, all associate clinicians and medical doctors who diagnose, manage and treat burn patients. Surgical care of burns can be provided by these clinicians and medical doctors. If available, fully trained pediatric and surgical specialists can provide and supervise burn care. The workforce includes nurses, who are essential in providing patient care and wound care. Physiotherapists are essential for the recovery of patients. Dieticians and rehabilitation and occupational therapists are generally not available in resource-limited settings. More complex reconstructions of burn scar contractures are performed by (reconstructive) plastic surgeons. At Haydom Lutheran Hospital they are performed by volunteer plastic surgeons during sustainable training partnerships.

Figure 3. The surgical theatre staff including management, anesthesiology-associates, theatre nurses, nurse students, and sterilization staff.

Associate clinicians are health workers who are trained to diagnose and treat basic medical and surgical conditions, but are not physicians. 'Associate clinician' is a protected professional title. In the Netherlands they are referred to as physician assistants and in Tanzania as clinical officers.

Overall a limited number of healthcare workers are available, and the numbers and shortages of staff may vary between different levels of care, regions and countries.

Background: About burns

The severity of a burn depends on the extent of the body surface area that is burned and the depth of the burn. The extent of a burn is expressed as the percentage of the total body surface area (%TBSA) burned. The extent can be estimated by the Rule of Nines for adults and the Modified Lund-Browder chart for children. The palm of the hand, including the fingers, is equivalent to 1% of the body surface area.

The depth of a burn can be classified as: superficial, superficial partial-thickness, deep dermal partial-thickness and full-thickness, as proposed by Shakespeare.[58] Superficial burns are not included when determining the extent of a burn wound, and they heal spontaneously without treatment. In partial-thickness burns the dermis is damaged. This type of burn can further be classified into superficial partial-thickness and deep partial-thickness burns. Superficial partial-thickness burns heal spontaneously without scars because rapid reepithelialization is possible through the keratinocytes from the basal layer of the epidermis, which are present in hair follicles and sweat glands extending deep into the dermal tissue. Deep partial-thickness burns involve the dermis and will not heal spontaneously within two to three weeks. In full-thickness burns, all layers of the skin are involved and the damage may even penetrate the layers below the skin, including the subcutis or fascia.

Secondary deepening of a burn wound can occur in the first two days and can be prevented by cooling immediately after the injury, proper fluid resuscitation, adequate burn wound treatment, elevating affected limbs and optimizing the hemodynamics of the patient.

The primary goals of the treatment are to achieve wound closure, provide pain management, prevent infection and minimize scar formation. Burn wound size, depth and location are the main factors determining the treatment plan. Delayed wound healing may promote scar formation. The longer the treatment delay, the more scar tissue may develops that can cause a burn scar contracture.

A fully conservative treatment is indicated for superficial epidermal burns and superficial partial thickness burns. Surgical treatment is indicated for deep dermal partial thickness and full thickness burns. In mixed deep dermal partial-thickness burns conservative treatment is advisable in the first two weeks post-injury. The timing of surgery for burns is dependent on the burn wound size, depth and location, and also on the general condition of the patient and the available resources.

Background: Patient journey of Anna

Anna is a young eight-year-old girl. She lives with her father, mother and three siblings in a small village. Anna is from the Datoga tribe, a large tribe that lives in the Manyara district. She speaks Iraqw and Swahili. Her family work as peasants, growing maize and kale on their own land, and they are the proud owners of livestock: they have three goats, some chickens and even a cow. Anna goes to the local primary school and is a good student. After school she helps her mother with the housework.

One normal afternoon, Anna is playing in front of the house near the open fire, where her mother cooks uji (a kind of porridge) every day. As she chases her younger brother around, she comes too close to the fire, and her clothes are suddenly set on fire. She starts to run and screams in panic. A neighbor sees what is happening and rushes to her. He pushes her to the ground, and with his kitenge, a large cloth, he manages to smother the flames of her burning clothes. Her mother arrives and quickly starts to take off her burned clothes and pours some water from her jerrycan over Anna. Anna's mother is shocked at the size of the burn.

A friend comes to help. She tells them about a traditional remedy consisting of ashes and eggs. When dry it forms a thick crust, preventing the wound from becoming contaminated. They apply the medication, and the friend takes her and her mother to a nearby hospital on the back of his motorcycle.

At the hospital, the medical doctor on call observes that Anna has sustained a severe burn and prescribes antibiotics, oral rehydration solution (ORS) and intravenous fluid therapy. The mother stays with her child and takes care of her. The doctor notices that, despite the treatment, Anna has weakened by the third day. She calls her supervisor and together they decide that she needs to be referred to the regional referral hospital in Haydom. The family agrees, although the mother has to spend the last of her money. It is arranged for the ambulance to pick her up the next day early in the morning.

The ambulance arrives in Haydom and Anna is brought in. Now day four post-burn, she has become seriously weakened. The intern on call, Dr Mtui, takes her vital signs and does a physical examination, estimating that one-third of her body

is burnt. He notices that Anna is dehydrated, lethargic, swollen all over and has a fever. Although she is in pain, she no longer has the energy to cry. He prescribes antibiotics, does laboratory tests and tries to insert an intravenous line. Then he calls me, the second doctor on call that day.

When I arrive, Anna's mother is terrified and looks anxiously at me. She tells me it is day four post-burn, that Anna has received a lot of fluids, but she is not improving and has started to swell all over. She asks me if she will survive. I check the lab results. They show me that she has acute kidney failure and anemia, and that her white bloods cell count is greatly elevated, indicating sepsis. I tell the mother that the condition is serious, but that we are going to give her the best treatment we have available. Together with the intern we conclude that the wound needs direct surgical cleaning, to which the mother hesitantly agrees.

In the following days, Dr Mtui and I are happy to observe that our patient is improving. Both her mother and father are now at the hospital, taking care of her and providing food. The swelling reduces, and she is able to take in food again. We encourage her to eat the local 'fortified food', a mixture of milk and peanut butter to supplement her normal food. Her wounds are cleaned daily by the wound care nurse.

At ten days post-injury, Anna's condition has progressed well and she is out of immediate danger. The sepsis has been treated effectively, leaving large but clean wounds. Together with the social worker at the hospital, we discuss with Anna and her family that the time is now right to cover her wounds with skin grafts. A nearby patient helps by proudly showing his skin graft. We inform the family about the hospital policy to pay prior to the surgery. Unfortunately, the father refuses. He fears the costs and does not see how a surgical procedure can heal such a big wound. They even consider leaving the hospital to find treatment elsewhere. We all leave the room and give the family some time to think things over. I have to admit that I feel disappointed and frustrated. Why can't we just help this patient?

The next day the social worker comes back to me. She tells me that she was able to convince the father, with the help of one of the hospital workers who has close relatives living in the same village as Anna. The father is already travelling back to the village to sell his cow and to talk with the village headman. If the village headman supports the treatment, they can come to a payment arrangement and

pay in installments.

Four weeks after the burn injury, the father returns and pays the hospital bills. We can now go to theatre for the first skin graft procedure. Dr Mtui and another intern assist with the procedure. After four days we are curious to see what we will find when we remove the dressing. The procedure was successful: almost a 100% take. The father is delighted that new skin has started to grow.

Then suddenly a few days later, I am called during the night by an intern doctor. Anna is struggling again, she has pronounced diarrhea and is severely dehydrated. She can't take any fluids or food. We struggle to keep her hydrated, administer antibiotics and apply all available treatments. The day after, however, she becomes even weaker and keeps losing fluids despite our regimens. We are running out of options, and we are not sure she will survive.

But Anna is a fighter, and so are her parents. They keep faith, also in our treatment, and continue to care for their daughter. The diarrhea slowly stops, and Anna can eat and drink and starts to recover.

Two weeks later after the arrival of blood for a transfusion, we can finally perform the second skin graft. A third follows. The wounds heal well, although contractures in both armpits start to develop. Anna is recovering and is receiving physiotherapy to mobilize her joints. She can now manage to walk around the ward and plays with the other children. Dr Mtui discharges Anna after five months in hospital.

The parents promise us that they will return for follow-up, when plastic surgeons from Doctors of the World visit the hospital to relieve Anna's contractures. The parents thank us for our help. I thank them for their cooperation and wish them well.

Figure 4. Traditional Datoga-tribe settlement

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PART I

RECONSTRUCTIVE SURGICAL MISSIONS

Chapter 2

Impact of short-term reconstructive surgical missions: a systematic review

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Abstract

Introduction

Short-term missions providing patients in low-income countries with reconstructive surgery are often criticised because evidence of their value is lacking. This study aims to assess the effectiveness of short-term reconstructive surgical missions in low- and middle-income countries.

Methods

A systematic review was conducted according to PRISMA guidelines. We searched five medical databases from inception up to 2 July 2018. Original studies of short-term reconstructive surgical missions were included, which reported data on patient safety measurements, health gains of individual patients and sustainability. Data were combined to generate overall outcomes, including overall complication rates. PROSPERO registration: CRD42018099285.

Results

Of 1662 identified studies, 41 met full inclusion criteria, which included 48,546 patients. The overall study quality according to Oxford CEBM and GRADE was low. Ten studies reported a minimum of six months follow-up, showing a follow-up rate of 56.0% and a complication rate of 22.3%. Twelve studies that did not report on duration or follow-up rate, reported a complication rate of 1.2%. Fifteen out of 20 studies (75%) that reported on follow-up, also reported on sustainable characteristics.

Conclusions

Evidence on the patient outcomes of reconstructive surgical missions is scarce and of limited quality. Higher complication rates were reported in studies which explicitly mentioned the duration and rate of follow-up. Studies with a low follow-up quality, might be underreporting complication rates and overestimating the positive impact of missions. This review indicates that missions should develop towards sustainable partnerships. These partnerships should provide quality aftercare, perform outcome research and build the surgical capacity of local healthcare systems.

Key questions

What is already known?

- There is rising concern about the accountability, patient safety and sustainability of short-term reconstructive surgical missions; however, data on these parameters are lacking.

What are the new findings?

- Evidence provided by research on surgical outcomes is limited and of low quality, and the safety of missions is likely to be overestimated by studies in which the quality of follow-up is not reported. Our data suggest that engagement in sustainable development of the local healthcare system and the feasibility of conducting high-quality, long-term follow-up go hand-in-hand.

What do the new findings imply?

- We call for implementing longer-term outcome research of future missions.
- One approach that could provide a framework to conduct such research, is to implement diagonal development missions. These missions combine the positive impact of the short-term vertical inputs (e.g. providing surgical services) and long-term horizontal investments (e.g. development of sustainable healthcare systems), with the aim of improving access to, and capacity of, the local surgical healthcare systems in the long-term.

INTRODUCTION

Conditions that are treatable by reconstructive surgery make up a large part of the global burden of surgical disease. Examples are burns (8 .1 million Disability-Adjusted Life Years (DALYs)[1], orofacial clefts (0.23 million DALYs)[1], complex wounds (including trauma-related wounds (unknown DALYs, but estimated to be significant), pressure sores (0.67 million DALYs)[1] or noma (a neglected tropical disease, a roughly estimated 1-10 million DALYs).[2] Short-term reconstructive surgical missions are a well-established, routine method of addressing these conditions and reducing their impact on global health, by providing specialised care in underserved populations.[3] Such missions are commonly short-term, disease-specific, focus on service delivery and have a tendency to work outside the local healthcare system. This is also referred as a "vertical approach to healthcare development".[4]

Despite being a common model, the impact of reconstructive surgical missions is hardly known.[5,6] Medical missions in general are commonly debated in the literature.[7-15] There is rising concern about the limited accountability of missions, with little data reported back to healthcare authorities due to a lack of outcome measurements.[8,9] Quality of care is debated, as missions often have limited capacity to provide ancillary services or follow-up.[16] Furthermore, sustainability is questioned in terms of lasting positive impact on the local healthcare system or its cost-effectiveness. The question is whether short-term surgical missions are the most rational allocation of resources to address local healthcare needs. [4,7,8,12,15] Ultimately, the ethical implications of surgical volunteerism often ignite debate.[17,18]

These concerns are discussed in several reviews of medical missions in low- and middle-income countries (LMICs).[7,9,10,12-15,19] For instance, Martiniuk et al. and Roche et al. argued that global standards are needed for short-term medical missions[7,14] and Sykes et al. show that only 6% of all published studies on medical missions report on empirical data.[10] Only a few studies reviewed surgical missions specifically.[9,12-15,19] Shrime et al. systematically compare three types of charitable platforms for global surgery (short-term missions, self-contained surgical platforms and specialty surgical hospitals run by NGOs). Although they conclude that evidence in the literature is scarce, they state that self-contained temporary platforms and specialised surgical centres appear to provide more effective and cost-effective care than short-term surgical missions, except when no other delivery platform exists.[12]

These reviews provide valuable insights into medical missions in general. However, the diversity of medical and surgical missions is large, which hampers the interpretation of empirical data. This review aims to systematically review evidence on the impact of short-term reconstructive surgical missions specifically, and critically analyse the quality of the available empirical data. In this review four key aspects are addressed: basic characteristics of missions, patient safety, health gains of individuals and sustainability.

METHODS

We conducted a systematic review of the literature following the Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA) guidelines.[20] The study method was registered at PROSPERO (registration CRD42018099285).

Inclusion criteria

All original studies that analysed empirical data of short-term missions pertaining to reconstructive surgical care in LMICs were eligible. Studies lacking analyses of empirical data, reviews, studies of speciality surgical hospitals that provide continuous year-round care, mobile surgical platforms sent from in-country hospitals, studies in conflicts zones, studies not related to LMICs, or studies of patients that were transported to high-income countries (HICs) were excluded. The studies were restricted to English and Dutch language. No restrictions were applied regarding publication dates. Duplicates were excluded.

Search strategy and data sources

PubMed, Embase.com, Clarivate Analytics/Web of Science, and Open Grey were searched up to 1 July 2018; Proquest up to 1 July 2017 (by CR, TH and JK). The last database was no longer available to us after 2017. The following terms - including synonyms - were used as index terms or free-text words: ‘plastic surgery’, ‘reconstructive surgical procedures’, ‘cleft lip’, ‘post-burn contractures’, or ‘noma’ combined with ‘medical missions’, ‘humanitarian’ or ‘charity’. More studies were identified by reviewing the bibliographies of retrieved studies. The full search strategies for all databases can be found in the supplementary material.

Study selection

Studies were screened for eligibility by two independent investigators (TH and CR): in case of disparity a third author was involved (MB). Two investigators independently extracted the data to create tables and figures (TH and CR).

Data on mission characteristics and individual patient-level data were extracted and analysed across four key features:

1. Basic characteristics of the missions, including mission length, number of patients who received surgery, and age and gender distribution.

2. Patient safety by means of complication registration. Data were collected on three indicators: follow-up length, follow-up rate and complication rate. The follow-up rate was calculated by the number of patients who completed follow-up divided by the total number of patients who were included for follow-up. The complication rate was calculated as follows: the number of patients with complications divided by the total number of patients who completed follow-up.

3. Health gains: data on surgical outcomes were collected, e.g. improvement of range of motion (ROM), patient reported outcome measures (PROMs) or DALYs averted per patient. All reported PROMs were recorded, for example on surgical outcomes, complications or the quality of care provided. All types of formats, questionnaires or any other tool describing these outcomes were included.

   DALYs are used to define the overall disease burden over a population and are calculated by "adding the number of years of life lost due to premature mortality to the number of years of healthy life lost related to disability."[21] This means that 1 DALY can be defined as 1 lost year of healthy life.[21] Many limitations of this approach are described in the literature. The biggest challenge is that it is not based on health data from countries, but on complex estimation techniques. DALYs are therefore estimations and many concerns exist about their reliability and uncertainty.[22,23] Despite these challenges, DALY metrics are commonly applied in global surgery studies.[1,21,24]

4. Sustainable characteristics of missions: studies were reviewed for data on long-term partnerships, training objectives and involvement of local staff.

Also data on the cost-effectiveness of missions were collected. Missions were categorised either as stand-alone or consecutive missions to the same hospital, region or country.

Data analysis and synthesis

After a pilot, data were extracted independently and in duplicate using a data extraction sheet (TH and CR). Authors were contacted when data on complication registration were missing. Quantitative data synthesis consisted of compiling total number of patients (e.g. total number of patients who were included, total number of patients with complications) to generate overall outcomes. Table 1 and the appendix provide details of the data extracted from each reference. Due to the heterogeneity of studies in types of surgery, local healthcare settings or available resources, statistical analyses were not feasible. Study quality assessment was performed independently by authors TH and CR according to the Oxford CEBM Level of Evidence classification[25] and the GRADE (Grades of Recommendation, Assessment, Development and Evaluation) system.[26]

RESULTS

The search identified 1662 unique citations. After screening titles and abstracts 1570 studies were excluded because they did not concern short-term reconstructive surgical missions. Ninety-two studies concerned reconstructive surgical missions and were reviewed full-text. Of the full-text studies, 51 were excluded. Studies reviewing specialty hospitals missions were excluded, as this was outside the scope of this review. After full-text analyses, 41 met full inclusion criteria (Figure 1 and Table 1).[27-67]

The studies included predominantly consisted of case series, with 37 studies graded at Oxford CEBM Level IV. The remaining four economic analyses were graded at level IIB. This resulted in a C grade of recommendations for our review, according to CEBM. The overall Grade score was 2.7 (low to moderate quality), meaning that our confidence in the effect estimate is limited (Table 2).[26,68]

Twenty-eight of 41 studies included, pertained to cleft care (78% of the total study population). The number of patients in all studies totalled 48,546, with a mean age of 13.4 years (SD 8.5) (Table 3). The average mission length was 10 days (SD

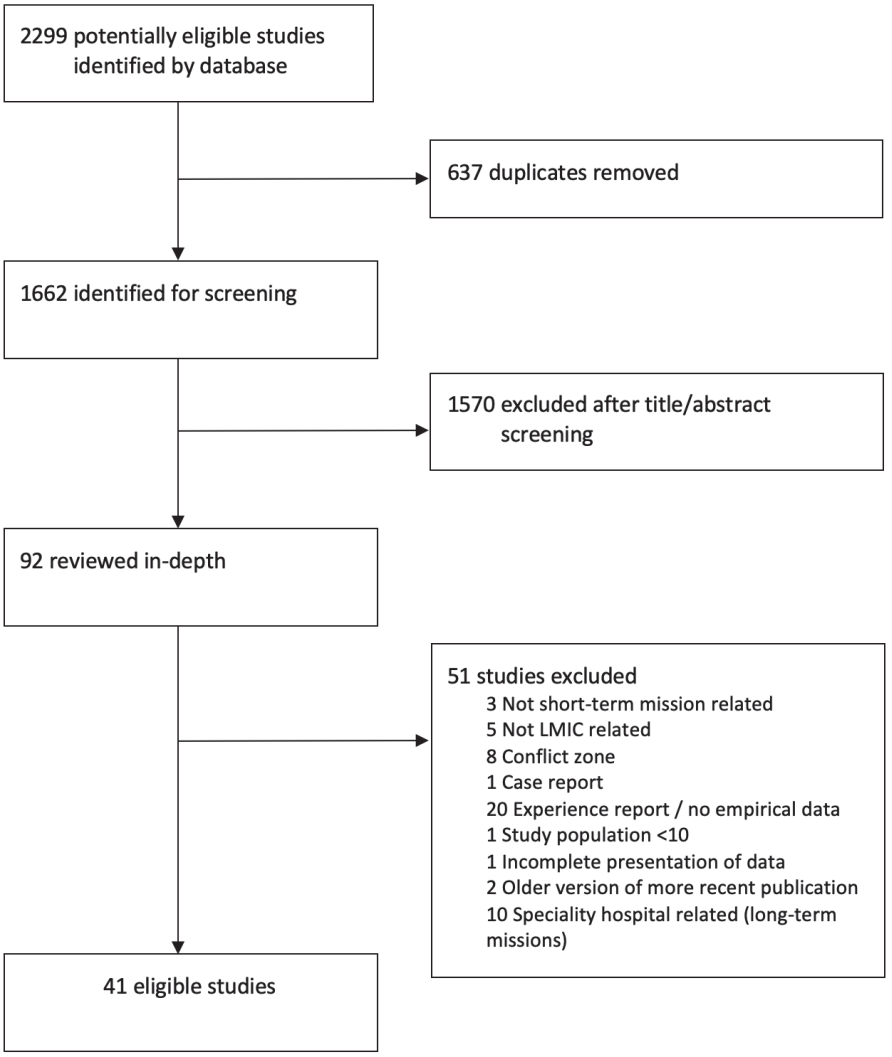

Figure 1. Flow diagram

3.8, range 6-21 days). Organisations were active in Africa, South-East Asia, Eastern Europe, South and Central America. A typical mission team consisted of two or three plastic and/or maxillofacial surgeons, one or two anaesthetists, a mission coordinator, theatre nurse and one or two resident doctors, totalling 8 to 10 individuals for one single mission.[32,33,37,46,47,50,51,54,58] Some teams were considerably larger, up to 40 individuals.[36]

Table 1. Study characteristics.

Authors (year)	Affiliated organisations	Country of mission	Year of mission	Number of patients treated [a]	Length of follow-up [b]	Follow-up rate	Complication rate [c]	Health gains
Clefts								
Aziz et al. (2009)	NA	Bangladesh	2006-2008	146	≤10 days	NA	8/146 (5.5%)	NA
Bello et al. (2018)	CFDF	Nigeria	2011-2017	448	2 months	155/448 (34.6%)	35/155 (34.6%)	NA
Bermudez et al. (2009)	Operation Smile	40 countries	2007	4,086	1 year	812/4,086 (19.9%)	NA	NA
Calis et al. (2016)	Interplast Turkey	Uzbekistan	2009-2014	5 29	NA	NA	1/529 (0.2%)	NA
Daniels et al. (2016)	ReSurge Int.	China	2005-2009	201	1-5 years b	116/201 (57.7%)*	34/96 (35.4%)*	NA
Fayyaz et al. (2015)	Cleft Lip and Palate Association Pakistan	Pakistan	2014	312	3 months	NA	18/312 (5.8%)	NA
Guneren et al. (2015)	Turkish international development agency[a]	Asia, Middle East, Africa	2007-2014	25	NA	NA	NA	NA
Hackenberg et al. (2015)	Operation Smile	India	2006-2012	3,503	NA	NA	NA	Total 21,006 DALYs averted 6.0 DALYs averted per patient
Hughes et al. (2016)	Hands Across the World	Ecuador	2015	27	NA	NA	NA	NA

Authors (year)	Affiliated organisations	Country of mission	Year of mission	Number of patients treated [a]	Length of follow-up [b]	Follow-up rate	Complication rate [c]	Health gains
Hughes et al. (2012)	Hands Across the World	Ecuador	1996-2011	1,142	7 days	1,089/1,142 (97.1%)*	40/1122 (3.6%)*	Total 396 - 1042 DALY averted 3.9 – 10.2 DALY averted per patient
MacIntosh et al. (2013)	Healing the Children	Colombia	1994-2011	2,558	NA	NA	10/2727 (0.4%)†	NA
Madsen et al. (2015)	US military	Dominican Republic	2005-2009	223	30 months	205/223 (91.1%)	13/223 (5.8%)	Speech score improved from 11.4 (6-24) to 5 postoperatively (Borderline = 6)
Magee et al. (2010)	Operation Smile	Kenya, Russia, Nicaragua, Vietnam	2008	303	NA	NA	NA	Total 3099.52 DALYs averted 10.1 DALYs averted per patient
Maine et al. (2012)	ReSurge Int and Rostros Felices	Ecuador	2000-2005	315	>14 days	128/315 (40%)	72/128 (56.3%)	NA
McQueen et al. (2007)	Operation Smile	Jordan, Iraq	2005	71	NA[i]	NA	4/71 (5.6%)	NA
McQueen et al. (2009)	Operation Smile	18 Countries	NA	8,151	NA	NA	67/8151 (0.8%)	NA
Moon et al. (2012)	Smile for Children	Vietnam	2007-2010	303	NA	NA	NA	Total 377 to 458 DALYs averted on average mission

Authors (year)	Affiliated organisations	Country of mission	Year of mission	Number of patients treated [a]	Length of follow-up [b]	Follow-up rate	Complication rate [c]	Health gains
Navarro et al. (2015)	CIRPLAST	Peru	1994-2014	6,108	12 days (range 12 days- 9 years) [c]	5,162/6,108 (84.5%)	377/5162 (7.3%)	NA
Park et al. (2018)	Operation Smile	India	2010-2011	890	7 days	662/890 (74.4%)	101/662 (15.3%)	NA
Rauso et al. (2015)	Emergenza Sorrisi Onlus	Uganda, Gabon	2012-2014	56	NA [i]	NA	2/56 (3.6%)	NA
Rivera et al. (2013)	Operation Smile	Honduras	2007	45	6 months	22/45 (48.9%)	3/22 (13.6%)	NA
Roessingh et al. (2012)	SedoGoho hospital, TdH, CHUV Laus.	Benin and Togo	1993-2008	131 [j]	5.6 - 7.6 years	36/71 (50.7%)*	14/71 (19.7%)*	Speech follow-up: 36 patients. Acceptable 17/36=47.2% Unacceptable 40/71 = 52.8%
Rossell-Perry et al. (2015)	ReSurge International and Smile Train	Peru	2002-2012	257	1-5 years [c]	97/353 (27.5%)†	34/257 (13.2%)*	NA
Sharp et al. (2008)	Operation Smile	Philippines	2003	120	6 months	52/99 (52.5%)*	10/50 (20.0%)*	- Improved speech 52% - Improved eating 25% - Improved social benefits 14% - Improved appearance 6%

Authors (year)	Affiliated organisations	Country of mission	Year of mission	Number of patients treated [a]	Length of follow-up [b]	Follow-up rate	Complication rate [c]	Health gains
Sieg et al. (2004)	NA	Africa, Asia, Central America	NA	14	≥ 1 years	10/14 (71.0%)*	1/10 (100%)*	NA
Uemura et al. (2015)	Duang-Kaew Foundation	Thailand, Vietnam, Myanmar, Laos, Cambodia, China, Sri Lanka, Bhutan and India	1988-2008	6,832	1 month	5,412/6832 (79.2%)	186/5412 (3.4%)	NA
Uetani et al. (2006)	Japanese Cleft Palate Foundation	Vietnam	1993-2003	790	NA	NA	NA	NA
Wes et al. (2017)	Changing Children's Lives Int.	Thailand	2013	56	< 1.5 years	30/56 (53.6%)	0/30 (0%)	Self-reported improvement: Social interactions 83,3%; Confidence 83.3%; School performance 75%
Post-burn contracture								
Borghese et al. (2005)	NA	Cambodia, Bangladesh	2002, 2003	200	NA	NA	14/200 (7.0%)	NA
El Ezzi et al. (2017)	Terre des Hommes	Benin and Togo	2002-2011	50	3.6 years	50/50 (100%)	28/50 (56.0%)	NA
Fuzaylov et al. (2015)	Doctors Collaborating to Help Children	Ukraine	2011-2013	39	NA	NA	1/39 (2.6%)	NA

Authors (year)	Affiliated organisations	Country of mission	Year of mission	Number of patients treated [a]	Length of follow-up [b]	Follow-up rate	Complication rate [c]	Health gains
Kim et al. (2012)	Operation ReStore, Operation Smile and Cents of Relief	India	2010	38	NA	NA	9/60 (15.0%)	NA
Sinha et al. (2016)	Operation ReStore	India	2012	31	84 days	31/39 (79,5%)	9/31 (29.0%)	SF-36 QoL : improvement of 5.8 points WPI: 13.7% mean improvement
Noma								
Bouman et al. (2010)	Facing Africa and Dutch Noma Foundation	Ethiopia, Nigeria	2007, 2008	63	35 days	74/74 (100%)†	47/74 (63.5%)†	Excellent results 36% Satisfactory 23% Mediocre 16% Poor 11% Very poor 14%
Marck et al. (2010)	Facing Africa	Ethiopia	2007, 2008	77	35 days	77/77 (100%)	54/77 (70,1%)	Good results 30.7% Acceptable 34.6% Mediocre 17.9% Poor 7.7% Very poor 9.0%

Authors (year)	Affiliated organisations	Country of mission	Year of mission	Number of patients treated [a]	Length of follow-up [b]	Follow-up rate	Complication rate [c]	Health gains
McGurk et al. (2010)	Project Harar	Ethiopia	2007-2009	95	35 days	89/95 (94%)	57/89 (64.0%)	Simple surgery group: good or acceptable results 90% Complex surgery group: good or acceptable results 40% Overall, poor results 6% Overall, very poor results 6%
Rodgers et al. (2015)	Facing Africa and Dutch Noma Foundation	Ethiopia	2008-2014	34	36 days	NA	17/34 (50.0%)	NA
General reconstructive missions								
Baran et al. (2007)	Physicians for Peace and Interplast	Multiple countries	1985-2004	4736	NA	NA	NA	NA
Figus et al. (2009)	Interplast Italy	Multiple countries	1988-2008	5235	NA	NA	NA	NA
McClenaghan et al. (2013)	Project Harar	Ethiopia	2012	40	21 days	30/30 (100%)	7/30 (23.3%)	NA
Merrel et al. (2007)	Operation Smile	Vietnam	1990-2004	266	NA	NA	6/266 (2.3%)	NA

Notes: When data wer not available, NA was denoted. Authors were contacted when data were missing for follow-up. Of note, in several studies (indicated with an *) the follow-up rate or complications rate were calculated over different sub-groups, therefore columns may not add up or correlate. a. When available, this review reports the number of patients who received surgery, when not available the number of procedures was used, when not available the number of diagnosis was used; b. When studies reported a range of FU intervals, the shortest length of FU was used for calculations; c. When the total number of patients who completed follow-up was not available, the total number of patients included was used (in line with the cited articles). † the complications rate cited was calculated over the total number of procedures; NA not available.

Table 2. Quality assessment results. Information listed per condition. Quality assessment of included studies was performed using the GRADE system[26, 68] and Oxford CEBM Level of Evidence.

Type of missions	Number of studies included	Oxford CEBM Level of Evidence	Average GRADE score
Cleft care mission	28 studies	24 Level IV studies 4 Level IIB	2.6 (quality: low - moderate)
Post-burn contractures mission	5 studies	5 Level IV studies	3.4 (quality: moderate)
Noma mission	4 studies	4 Level IV studies	4.3 (quality: high)
General reconstructive surgery mission	4 studies	4 Level IV studies	1.3 (quality: very low- low)
Overall quality and level of recommendation	41 studies	37/41 Level IV studies 4/41 Level IIB studies Level C recommendations	2,7 (Quality: low – moderate)

Regarding patient safety, nine studies (22%) did not report on complications. Twelve studies (29%) only reported a complication rate without reporting on follow-up length or rate. The overall complication rate in these twelve studies was 1.2%. Ten studies (24%) reported a follow-up length shorter than 180 days, with a mean follow-up rate of 81.3% and a complication rate of 7.1%. Ten studies (24%) provided a follow-up length longer than 180 days, reporting a mean follow-up rate of 56.0% and a 22.3% complication rate (Table 3). Mortality after cleft surgery was reported in three studies, totalling 3 out of 14,551 patients included in these studies.[16,28,64] For general reconstructive surgical missions - not specified for a single disease - one single study reported one death[54] and no mortality was reported in contracture and noma missions.

Twelve studies (29%) reported on health gains of the mission, reporting heterogeneous methods and outcomes (Table 1). Methods used in cleft studies included photographic assessment of aesthetic outcomes,[30,70] speech evaluation[16,47] or DALYs averted.[41,43,48,55] Three cleft studies evaluated speech functionality post-operatively, either by questionnaires[61] or speech tests.[16,47] Study methods were

clear and showed overall improvements of speech. Four cleft studies reported on DALYs averted by cleft lip and palate repair surgery. DALYs averted per patient were 3.9,[43] 6.0,[41] and 10.1 per patient.[48] In three noma missions, a surgeon-reported outcome scale was used to score aesthetic and functional outcome.[32,50,52] Overall findings showed that high-complex surgery is associated with greater risks of unsatisfactory results. Three studies used PROMs. One contracture study reported improvements in quality of life and disability by using validated questionnaires, and reported overall positive outcomes.[63] Two cleft studies used self-developed questionnaires to assess PROMs, reporting positive results.[61,66] None of the studies reported on patient-reported outcomes on the quality of the care provided.

With regard to the sustainable characteristics of missions, 29 studies reported qualitative data (71%) on sustainability, while none of the studies reported quantitative data. Fifteen out of twenty studies that reported on follow-up and complications also reported on sustainable characteristics such as long-term partnerships or training activities (Table 4). Ten organizations (24%) were engaged in longer-term partnerships, and thirteen missions (32%) returned to the same regions or hospitals. Few data were available on the frequency of missions, although several studies reported conducting yearly missions.[32,35,43,50] Fifteen studies (35%) described teaching objectives as a goal during their missions. Activities mentioned were lectures,[29,37,55] training of local surgeons,[16,35,38,54] healthcare workers[47,55,60] or fellowships in donor countries.[16,54,55] However, none of the studies published empirical data on the effects of training or elaborated on how the training of local healthcare personnel was organised.

Four cost-effectiveness studies were available for short-term cleft missions. Three studies reviewed the effectiveness per DALY averted, reporting $33.94/DALY[48], $56.0/DALY[55] and $ 247.42/DALY[41]. The variation is explained by the differences in study populations, sample sizes, effectiveness measurements and 'costing approaches' used.

Table 3. Overview of overall outcomes on basic characteristics of missions and on patient safety.

	Length of mission			**Total number of patients**			**Gender distribution**			**Age**			
	Total length (days)	Average (days)	# of studies	Number of patients (%)	Average per study	# of studies	Female	Male	# of studies	Mean (years)	# of studies	Median (years)	# of studies
Clefts	168	9	18	37,642 (78%)	1344	28	12,210 (45.8%)	14,435 (54.2%)	18	9.22	12	4.5	3
Post-burn contractures	23	8	3	358 (1%)	72	5	143 (44.8%)	176 (55.2%)	4	27.6	2	4.0	1
Noma	28	14	2	269 (1%)	67	4	102 (58.6%)	72 (41.4%)	3	23.9	1	17.0	1
General reconstructive	57	14	4	10,277 (21%)	2569	4	143 (44.8%)	176 (55.2%)	1	24.0	1	NA	NA
Totals	276		27 (66%)	48,546 (100%)		41 (100%)	12,598 (45.9%)	14,859 (54.1%)	26 (63%)		16 (39%)		5 (12%)
Overall mean or median	10 (+/- SD 3.8)			1184 (SD 2134.4)						13.4 (SD 8.5)		4.5 (Q_{25-75} 2.9-13)	

	Complication rate of studies that did *not* report on follow-up length and rate					**Complication rate of studies with follow-up length < 180 days**					**Complication rate of studies with follow-up length > 180 days**				
	Follow-up %	# comp-lications	# patients reviewed	Compli-cation %	# of studies	Follow-up %	# comp-lications	# patients reviewed	Compli-cation %	# of studies	Follow-up %	# complications	# patients reviewed	Compli-cation %	# of studies
Clefts	NA	111	11,992	0.9%	7	81.0%	739	12,513	5.9%	6	54.3%	181	887	20.4%	9
Post-burn contractures	NA	24	383	6.3%	3	77.4%	9	31	29.0%	1	100.0%	28	50	56.0%	1
Noma	NA	17	34	50.0%	1	97.6%	158	240	65.8%	3	NA	NA	NA	NA	0
General reconstructive	NA	6	266	2.3%	1	100%	7	30	23.3%	1	NA	NA	NA	NA	0
Totals		158	12,675		12 (29%)		878	12,659		10 (24%)		209	937		10 (24%)
Overall rate	NA			1.25%		81.3%			7.1%		56.0%			22.3%	

Notes: Figures add up in columns, may not add up between rows.

Table 4. Sustainable characteristics of short-term missions.

Authors (year)	Years	# and frequency	Long-term relationship				Teaching objective				Advancement of local staff			Quality follow-up and sustainable characteristics [b]
			Consec-utive missions to the same country	Consecutive missions to the same region/city	Consecutive missions with (part of the) same team	Partnership	Training local staff	Lectures / workshops / education	Advice on logistics within healthcare system	Encouraging medical independence of local staff	Participation of local staff in surgical care and pre-op and/or post-op care	Fellowship abroad	Providing medical supplies	Studies that reported both on follow-up details and sustainable characteristics
Aziz et al. (2009)	2006-2008	3 (annual)	✓		✓	✓	✓				✓			
Bello et al. (2018)	2011-2017	17	✓	✓			✓				✓			●
Baran et al. (2007)			✓	✓	✓		✓	✓		✓	✓	✓	✓	
Bermudez et al. (2009)	2007					✓					✓			
Borghese et al. (2005)	2002-2003		✓											
Bouman et al. (2010)	2007-2008	4 (biannual)	✓											●
Calis et al. (2016)	2009-2014	6 (annual)	✓	✓	✓						✓		✓	
Daniels et al. (2016)			✓		✓									✓
El Ezzi et al. (2017)	2002-2011	9 (biannual)	✓	✓	✓	✓	✓		✓		✓	✓	✓	✓
Fayyaz et al. (2015)	2004-present	130	✓	✓	✓						✓		✓	
Figus et al. (2009)	1988-present	47	✓				✓	✓		✓	✓			
Fuzaylov et al. (2015)	2011-2013	3 (annual)	✓	✓		✓	✓	✓			✓		✓	
Guneren et al. (2015)	2007-2014	27			✓						✓		✓	
Hughes et al. (2012)	1996-2011	16 (annual)	✓			✓								●
MacIntosh et al. (2013)	1993-present	(biannual)	✓				✓				✓			
Madsen et al. (2015)	2005-2009	(annual)	✓	✓				✓			✓			✓
Maine et al. (2012)	2000-2005					✓								✓
Marck et al. (2010)	2007-2008	2 (annual)	✓	✓	✓									●
McClenaghan et al. (2013)	2012		✓	✓										●
McQueen et al. (2007)	2005							✓			✓			
Merrel et al. (2007)	1990-2004	11	✓	✓			✓	✓				✓		
Moon et al. (2012)	2007-2010	4 (annual)	✓				✓	✓		✓	✓		✓	
Navarro et al. (2015)	1994-2014	141 (10 annually)	✓											●
Park et al. (2018)	2010-2011	2	✓	✓		✓	✓		✓	✓	✓			●
Rivera et al. (2013)	2007	1									✓			✓
Roessingh et al. (2012)	1993-2008	(annual)				✓	✓	✓	✓			✓	✓	✓
Rossell-Perry et al. (2015)	2002-2012		✓	✓	✓	✓	✓							✓
Uemura et al. (2015)	1988-2008	458	✓						✓		✓			●
Uetani et al. (2006)	1993-2003		✓	✓			✓				✓		✓	
			reported by 23 studies	reported by 13 studies	reported by 9 studies	reported by 9 studies	re ported by 13 studies	reported by 8 studies	reported by 4 studies	reported by 4 studies	reported by 18 studies	reported by 4 studies	reported by 9 studies	Reported by 15 studies (75%) of all 20 studies that reported on follow-up details

Notes: In order to determine whether or not missions were sustainable, the data were collected and allocated to three groups, i.e. building long-term relationships, teaching objectives during the mission and the advancement of local staff. Each sustainability group is divided into different subsets. A checkmark means the study describes the concomitant form of sustainable health care. a: part of part of the operation smile international program (OSI); b: added to this table were studies that reported both on sustainable characteristics and on quality of follow-up (including length and rate of follow-up and complication rate); Eight studies with follow-up shorter than 180 days (● marks), 7 studies with follow-up longer than 180 day (✓ marks). Five studies reported on quality of follow-up, but did not report on sustainable characteristics.

DISCUSSION

Several systematic reviews about short-term medical missions are available.[7,9,10,12-15] This is the first systematic review that specifically assesses the quality of available data on short-term reconstructive surgical missions.

Although all the studies included in our review reported a positive impact of surgical missions, the level of evidence remains low. It seems that follow-up of treated patients is a challenge. Although a majority of studies provide data on complication rates, the varying quality of this outcome measure makes it difficult to draw any conclusions. The results showed that reported complication rates were considerably higher when the quality and length of follow-up increased. This suggests that without data on quality of follow-up, there is a high risk of reporting bias, due to underreporting of complications. This also means that without comprehensive information on follow-up, the safety of missions is likely to be overestimated.

Furthermore, studies used different control groups to benchmark their respective findings with regard to complication rates. Three of cleft care studies included, compared complications between mission patients and patients who underwent similar procedures in a HIC. Results showed substantially higher complication rates in mission patients.[34,49,60] One study showed that fistula risk was 15.6 times that for a U.S. cohort.[34] Maine et al.[49] state that complication rates were 20 times higher in the mission cohort compared to a U.S. cohort, independently of whether the surgery was performed by Ecuadorian or American surgeons. It should be mentioned that comparisons of complication rates between HICs and LMICs cannot be made without taking into consideration that HICs have more resources at their disposal to limit complications. Therefore we would suggest developing benchmark complication rates of LMICs, which can be used to assess the outcomes of short-term missions.

Some authors argue that longer-term specialty surgical hospitals may be provide more effective care than short-term missions.[9,12,39] Specialty hospitals provide continuous care all year round in a LMIC. The cleft care centre of Operation Smile in India,[39] or Smile Train's model are examples of this approach.[70-79]

Both organisations report lower complication rates than those reported in short-term missions. The centre of Operation Smile reports a short-term complication

rate of 4.0% (cleft lip repair) and 15.8% (cleft palate repair), which is lower than the rates of their counterpart short-term missions.[39] Smile Train studies report lower rates, between 0.88% and 3%.[71,72,74,79] However, they note that there might be a risk of underreporting or selection bias due to a dependence of Smile Train surgeons on payment-per-patient (risking fewer referrals when higher complication rates are reported) and a limited capacity of surgeons to treat complex cases.[71,72,74,79] Furthermore, with only one Smile Train study reporting on follow-up lengths,[74] these complication rates should be interpreted with caution. To be able to compare the strengths and weaknesses of different approaches of providing surgical care in a LMIC, there is a need for more high quality studies.[12,39] Apart from registrations of complications, such studies should assess long-term outcome using validated outcome measures and PROMs. Specialty hospitals, which provide services all year round, could provide good conditions for longer-term outcome research.

Several studies in this review consistently report on follow-up, thereby showing that substantial efforts are being made to improve the data output of missions.[16,34,35,49-51,61,63] Ten studies reported significant follow-up lengths of more than six months and high numbers of patients returning for follow-up were sh own.[16,34,35,47,49,58,60-62,66] The majority of these missions were engaged in long-term partnerships. This included training of local healthcare personnel, which was likely to improve the feasibility of organising follow-up. Several strategies were implemented to ensure the quality of follow-up. Some missions deployed medical students to assess palate fistulas,[34] or sent a speech pathologist in-country to review outcomes.[61] Others trained local surgeons on follow-up and revision surgery.[54] The relatively high number of complications seen in noma missions could be partly explained by a stringent follow-up, done by an independent researcher who consistently reported on follow-up. All the studies mentioned above provide examples of how to ensure patient safety during and after missions.[50,69]

Although some studies reported on health gains, with several studies reporting positive functional outcomes,[16,47,61,63,66] the methods and evidence are heterogeneous and results are too limited to draw conclusions. The role of PROMs are effective in reconstructive surgery to assess the quality and outcomes of health care.[80,81] Only few of the studies included reported successfully on outcomes using PROMs[61,63,66] and none assessed the quality of care experienced by patients. Patient experience of outcomes and quality is important.[82] Future

studies should include PROMS on surgical outcomes and quality of care. Only a few studies report on the sustainable characteristics of missions. Data on this topic are usually qualitative and highly variable. It is noteworthy that reporting on sustainability and higher quality of patient follow-up often go hand-in-hand. This suggests that more sustainable missions may be better able to follow their patients for a longer period. However, as empirical evidence on sustainability is still non-existent, there is an urgent need for further studies.[12]

Limitations

This systematic review has several limitations. Literature on short-term reconstructive missions is scarce and of limited quality, thereby limiting the strength of this review.[25] As the majority of studies are cleft studies, the conclusions and recommendations of this review may not be fully applicable to other types of reconstructive surgical missions.

The studies included represent just a small proportion of the many reconstructive surgical missions conducted worldwide. This may introduce a potential bias. It likely that the small proportion likely does not fully represent the actual effect of all reconstructive surgical missions. In our view, this emphasises the need to incorporate standard monitoring and evaluations into missions.

Furthermore, this review addresses only short-term missions and does not attempt to make a direct comparison with long-term surgical platforms such as specialty hospitals. It is often argued that specialty hospitals are safer and have a more positive effect on local healthcare systems.[12,77-79,83,84] Comparative studies of short-term missions and specialty hospitals can identify strengths and weaknesses of each approach. However, a definitive comparison between missions and specialty hospitals seems to be premature at present given the lack of comparative studies.[12,39]

Concerns regarding the use of DALY metrics are applicable to the studies included in this review. It is argued that surgical conditions are underestimated in the global burden of disease studies.[1] Attempts to estimate the surgical burden across all disease conditions have been challenging.[85,86] In a recent study it was argued that the current DALY approach is inadequate to quantify the burden of paediatric surgical conditions.[87]

Recommendations

There are opportunities for NGOs to develop short-term missions towards more sustainable partnerships. In the past, missions have been a 'vertical' approach to healthcare development.[4] Such missions have limitations, for example in building local capacity of surgical services. The results of this study indicate that longer-term follow-up is frequently lacking, with complications being potentially missed. To address these shortcomings, the 'diagonal development' approach has been proposed.[4] It combines the short-term vertical inputs of missions with longer-term horizontal benefits, with the ultimate aim of improving access to, and surgical capacity of, the local healthcare system. Such goals may be achieved through long-term development of surgical infrastructure, continued training of the local surgical workforce, or building an academic culture.[4]

One example of such a diagonal approach is to aim for standardised tracking of longer-term outcomes of missions in strong collaboration with local partners. This might yield several advantages. Besides empowering local researchers and building an academic culture, outcomes can be reported back to patients and healthcare authorities. This will enhance the accountability of NGOs[8,9] and allow for evaluations of the quality of care provided.

Another example of long-term investments in the local surgical capacity, is strengthening of the training activities of surgical NGOs. Such activities should be integrated into existing national or regional training activities. The training should be adapted to local settings, needs-driven and should focus on bilateral knowledge exchange.[4]

CONCLUSION

This review shows that evidence for the effectiveness of short-term reconstructive surgical missions is both of limited substance and quality. Given the overall lack of evidence, there is an urgent need to incorporate outcomes research in future missions. This should include longer-term complication registration and measurements of health gains among individual patients. The effectiveness of training activities should also be evaluated. One approach to achieve this is to develop short-term missions towards diagonal development missions, which aim to build surgical capacity of local healthcare systems through long-term investments.

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PART II

ACUTE BURN CARE IN RESOURCE-LIMITED SETTINGS


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Chapter 3

Outcomes of acute burn care in a low- and middle-income country setting: a cohort study

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Abstract

Background

There is a paucity of studies on the safety and effectiveness of acute burn care in low-income countries. A cohort study was therefore carried out to determine such outcomes.

Methods

The study was conducted in a rural Tanzanian hospital in 2017-2018. All patients admitted with burns were eligible. Complications were scored during admission as an indication for safety. Survivors of severe burn injuries were evaluated for time of reepithelialization, graft take, disability (WHODAS2.0) and quality of life (EQ5D-3L) up to 3 months post-injury, as an indication of effectiveness.

Results

Patients presented on average at 5 days post-injury (SD 11, median 1, IQR 0-4). Three patients died at admission. The remaining 79 patients were included in the cohort. Their median age was 3 years (IQR 2-9, range 0.5-49), mean TBSA burned 12% (SD10%) and mortality rate 11.4%. No surgery-related mortality or life-threatening complications were observed. Skin grafting was performed on 29 patients at a delayed stage (median 23 days, IQR 15-47). Complications of skin grafts included partial (25% of procedures) and complete graft necrosis (8% of procedures). The mean time to reepithelialization was 52 (SD 42) days post-admission. Disability and quality of life improved from admission to 3 months post-injury ($p<0.001$, $p<0.001$, respectively).

Conclusion

In this resource-limited setting patients presented after a delay and with multiple complications. The mortality during the first two weeks after admission was high. Surgery was found to be safe and effective. A significant improvement in disability and quality of life was observed.

Highlights

- In this resource-limited setting patients presented after a delay with multiple complications and a high mortality risk.
- Delayed skin grafting in survivors of severe burns was found to be safe and effective in this setting.
- Over time the disability lessened and quality of life improved in the majority of cases.
- There is room for improvement of the access to timely and safe burn care in underserved populations.

Introduction

Major advances in acute burn care have been made over the past decades. Optimalization of the prevention, acute management, infection control, and wound closure have substantially decreased the incidence, morbidity and mortality of severe burn injuries.[1] In High-Income Countries (HICs) patients present early after a burn injury, and mortality is reported to be as low as 1.5%.[2–8] Because of the optimalization of burn care in HICs, attention and resources have gradually shifted towards the prevention and treatment of the long-term physical,[9,10] and psychological consequences of burns. Important outcomes currently are scar quality[11–13] functionality[10,14] post-traumatic stress syndrome[15] and health-related Quality of Life (QoL).[16,17]

Such advances in burn care have not been observed in Low and Middle-Income Countries (LMICs),[18–20] although the vast majority of all burn injuries worldwide occur in these countries.[21] Existing studies show that poor populations are predominantly at risk of sustaining burns, and that up to 70% of patients are children.[19,22–24] Populations that are geographically and economically disadvantaged have limited access to safe burn care.[22] Due to this lack of care, the mortality in LMICs is high. Ninety-five percent of all mortality caused by fire-related burns worldwide occurs in LMICs.[25] The risk of child mortality due to burns is currently estimated to be over seven times higher in LMICs than in HICs.[18] Those patients who survive burns, risk developing burn scar contractures. Burn scar contractures may impair joint function, disability-free survival and QoL.[26]

In response to the need for safe and timely burn care worldwide, the International Society for Burn Injuries (ISBI) published practice guidelines tailored to Resource-Limited Settings (RLS) in 2016.[27,28] The current evidence on the safety and effectiveness of burn care in resource-limited settings is scarce and of limited quality, as shown in our recent systematic review on burn care in sub-Saharan Afric.[29] To improve our understanding of burn care, the World Health Organization (WHO) called for efforts to collect data and promoted research on this topic.

To guide future improvements of burn care of underserved populations in LMICs, insight into current treatment and its outcomes is vital. Therefore, this single-center prospective study aimed to evaluate the early outcome of burn care provided in an LMIC setting up to three months after injury.

Methods

Study design and setting

This prospective cohort study was conducted in 2017-2018 at Haydom Lutheran Hospital, a remotely located regional referral center for the two million people living in Manyara province in Tanzania. HLH provides primary and secondary burn care. HLH has a 250-bed capacity, essential laboratory facilities, a physiotherapy team and a surgical theatre with essential surgical equipment, including basic surgical sets, a humbey knife, an electric dermatome (Aesculap® Acculan 3Ti) and an anesthesia machine for mechanical ventilation.

HLH utilizes a cost-sharing model, where patients and the hospital share treatment costs. To be eligible for elective surgery, the patient fee must be paid prior to surgery. HLH attempts to provide financial support for patients who face potential catastrophic expenditure.

Study participants and follow-up

During 2017-2018 all pediatric and adult patients admitted to Haydom Lutheran Hospital with a burn injury were eligible for participation in this study. Written informed consent was obtained from all the patients who were included in the study. For children below the age of 18 years consent was obtained from their caregivers. A subgroup of patients who survived and for whom split-skin grafting was indicated were also eligible to participate in the assessments regarding effectiveness. The wounds that required skin grafting were considered severe burns. In this study severe burns are defined as deep partial-thickness burns and full-thickness burns – the wounds that did not show reepithelialization after 14 days – which involved at least 5% of total body surface area (TBSA). This selection was made to ensure a high follow-up rate in this resource-limited setting. Patients with minor burns with no indication for skin grafting, who had less risk of burn wound complications, were not included in the subgroup as they would be less inclined to go through the time and economic burden of follow-up.

All the patients were assessed from admission to discharge. In addition, the subgroup of patients who required skin grafting were also assessed at 1.5- and 3-months post-injury for disability and QoL. In this subgroup, some of the patients remained admitted, and others were already discharged and assessed

as outpatients. To ensure a high follow-up rate of the outpatients, they were compensated for their traveling expenses and were counseled by telephone and outreach.

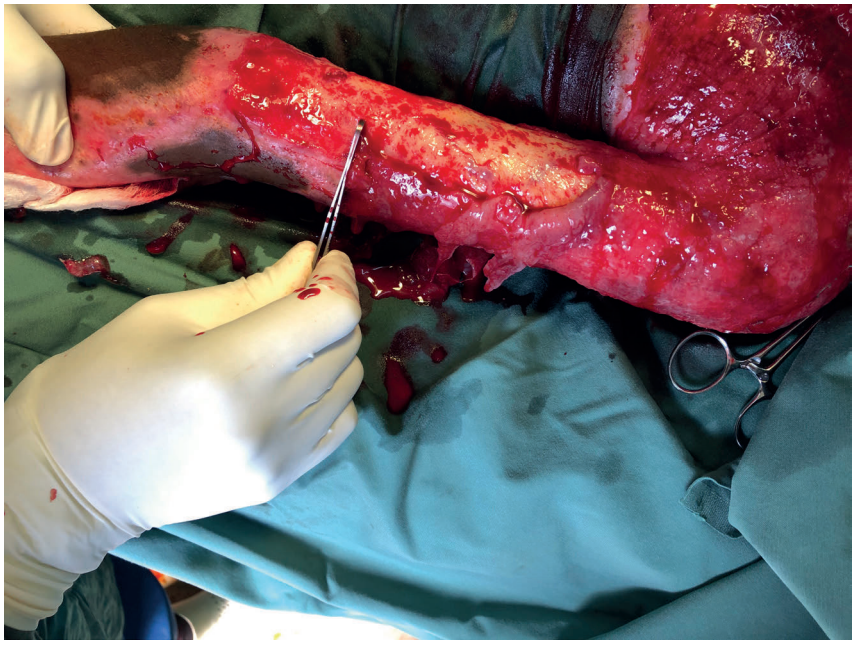
Treatment

Where possible, we tried to provide treatment in accordance with the Emergency Management of Severe Burns and ISBI guidelines for Resource-Limited Settings (RLS).[27] As this study was conducted in a rural and resource-limited setting, it was not possible to achieve a 100% guideline adherence. Guideline adherence was documented and is specified under data collection. Treatment was provided after counseling and agreement of relatives for both adult and pediatric patients.

Initial management was provided at admission. Adults with >15% and children with >10% TBSA burned, presenting within 48 hours post-injury had an indication for fluid resuscitation (Appendix 1). An escharotomy was performed in deep circumferential burns of the extremities if the blood flow to the distal parts was or might be threatened. Antibiotics were available and indicated for infected burn wounds or sepsis. Infected burn wounds were diagnosed clinically (i.e. pus, erythema, edema, fever, sepsis). A limited supply of fortified nutrition and blood transfusions were available, and when available, were provided to cases with malnutrition and anemia. Antithrombotic treatments were not available.

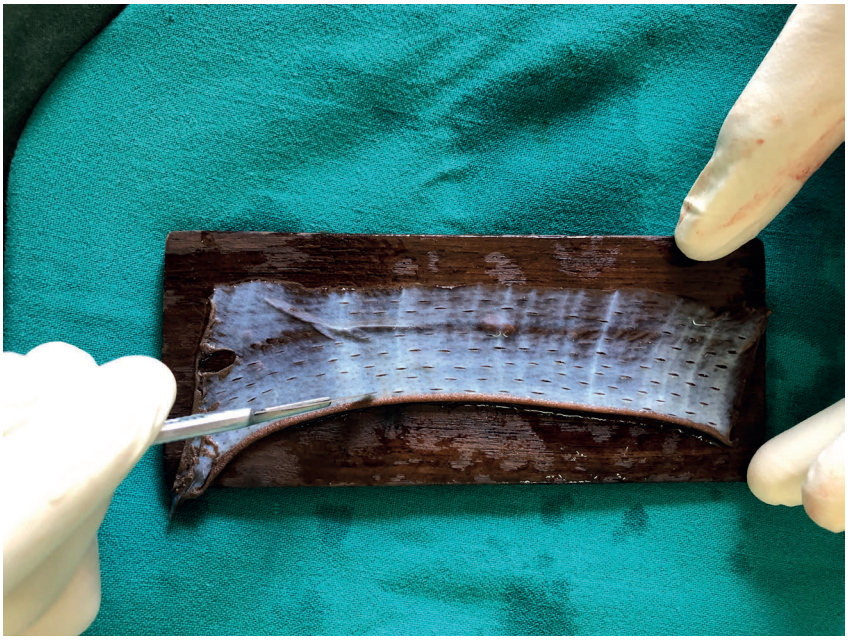
Wound care consisted of daily wound cleansing in lukewarm water with 5% sodium chloride. Silver-sulfadiazine was applied to burn wounds. An occlusive – i.e. closed method – wound dressing was applied, using conventional petroleum jelly gauzes covered by dry gauzes. Anesthesia during wound care was only available to a limited extent and consisted of oral and intramuscular medication. Due to limited anesthesia staff and equipment and the cost of treatment, ketamine anesthesia was only available for children with burns of more than 20% TBSA burned. To limit loss of range of motion, all patients received physiotherapy during admission, which consisted of mobilization and instructions for active and active-assisted range of motion exercises.

All wounds smaller than 1% were treated conservatively. In larger wounds, surgery was performed if no adequate reepithelialization had occurred between 14 and 21 days after admission. Staged delayed grafting was the predominant approach:



1a. Debridement

1b. Harvesting skin with the electrical dermatome



1c. Meshing by hand

1d. Sututing meshed skin graft

Figure 1. Example of delayed skin grafting. Photo release consent was provided by the patient and the caregivers after extensive counseling.

spontaneous eschar separation was awaited to limit the surgical excision of eschar. (Figure 1) This allowed stabilization of patients prior to surgery, and limited the necessity of blood products. We aimed to debride wounds at day 14, debriding as minimally as possible to obtain a clean wound without eschar, and if possible, to perform immediate subsequent grafting with autologous split-skin. In extensive wounds multiple grafting procedures were performed: during each operation, approximately 5% to 10% of the wound was grafted. An electric dermatome was used to harvest grafts of 0.2 mm thickness, which were meshed by hand in a 1:1.5 ratio. Postoperatively, wounds were dressed with tetracycline and petroleum jelly gauzes, covered by dry gauzes. Splints were used over joints of the extremities to protect the grafts during the first week. Inspection was performed at day 3 to 5, depending on whether there was clinical suspicion of wound infection. After inspection, grafts sites were left open. The donor site was left dressed when wounds were clean until complete reepithelialization had occurred. Finger, toe and below-the-knee amputation was performed in burn patients who had developed dry gangrene after demarcation.

Data collection

At admission, burn characteristics, e.g. etiology, %TBSA burned, burn depth and localization were documented, as well as basic patient characteristics including gender, age, hemoglobin, weight and comorbidity. Comorbidities such as neurological complications (seizures, epilepsy) or diabetes were documented. The type of initial treatment (e.g. administration of fluids and antibiotics), wound care (e.g. method of dressing and topical therapy) and length of stay were documented. Surgical interventions were documented, specifically the type and timing of the intervention. Compliance with guidelines was documented regarding fluid resuscitation and antibiotic administration.

Patient safety

To determine safety, 'timeliness', was documented (defined as the time from burn injury to presentation (i.e. patient delay)) as were complications, including complications of burns and treatment-related complications. Infectious complications concerned wound infection, sepsis, urinary tract infection and pneumonia. Wound infection was diagnosed clinically (see above). Signs of sepsis

were fever <36.5 ºC to >39 ºC, tachycardia (>110 b.p.m.), tachypnoea (>25 breaths/min), thrombocytopenia (<100,000 μl), hyperglycemia in the absence of diabetes, or inability to continue enteral feeding. A patient was considered septic if at least three of the previous criteria were met.30 Multi-organ failure was defined as the presence of a systemic inflammatory response and dysfunction of at least two organs. Urinary tract infection was diagnosed by dipstick, pneumonia was diagnosed clinically in combination with chest x-ray. Cultures were not performed as microbiology resources were only available to a limited extent and costs were high. Non- infectious complications concerned dehydration, diarrhea, severe facial edema, anemia, severe acute malnutrition (weight-for-length below 3 SD), gangrene of digits, and cardiovascular, pulmonary and renal failure (acute renal failure).

Treatment-related complications involved anesthesia and surgery and had to occur within 30 days post-surgery. Examples of surgical complications included hemorrhage, surgical site infections, graft necrosis, donor site morbidity, and pulmonary complications. Partial graft necrosis was a graft taken between 30% to 80%, complete graft necrosis was a graft taken below 30%. Anesthesia-related complications included cardiovascular or mechanical ventilation-related complications.

Burn care was considered safe when no major complications occurred. Major complications were defined according to the Clavien-Dindo Classification.[31,32] Major complications include life-threatening complications, such as single or multi-organ dysfunction (Grade IV), or patient death (Grade V).[31,32]

Effectiveness of treatment

The effectiveness of treatment was assessed in the subgroup of burns survivors who required split skin grafting. This included assessments of the timing of completed reepithelialization, graft take, disability-free survival and QoL. Graft take was assessed in the second week postoperatively.

Disability

Disability was assessed with the validated World Health Organization Disability Assessment Schedule version 2.0 (WHODAS 2.0, 12-item), in the Kiswahili

language.[33,34] The questionnaire consists of 12 questions regarding disability in different domains of daily life, scored on a 5-point Likert scale. A total score is calculated, ranging between 0 and 1, where a higher value represents greater disability. A score lower than 0.25 is classified as 'disability-free survival', according to Shulman et al.[33] This questionnaire has been validated to assess disability in patients aged 18 years of age and older.[35,36] For patients under 18 years of age, parents were asked to fill in the questionnaire by proxy.[37]

Quality of Life

Patient QoL was assessed using the EuroQoL-5D-3L questionnaire (EQ-5D-3L), which is interculturally validated for this purpose [38–40]. The questionnaire consists of five questions, scored on a 3-point Likert scale. A total score is calculated, ranging between 0 and 1, where a higher score represents a higher QoL. The questionnaire is available for adults and pediatric patients aged between 8 and 18 year of age (the EQ-5D-Y).[41–43] Parents were asked to fill in the questionnaire for patients younger than 8 years of age.[44]

Data analysis

Descriptive data analysis was performed to describe the outcomes. Continuous data were presented as the mean with standard deviation (SD), non-continuous variables as the median with interquartile range (IQR), and categorical data as percentages (n, [%]). Kaplan-Meijer curves were analyzed and created using GraphPad Prism 8.3.1 (GraphPad Software, San Diego, CA, USA). The statistical differences in mean disability and mean QoL at admission and at follow-up were calculated and analyzed with t-tests using IBM SPSS Statistics version 22.0 (IBM Corp., Armonk, NY, USA).

Results

In 2017-2018, 82 patients with burn injuries were admitted at Haydom Lutheran Hospital. Three patients died within 12 hours after admission and did not provide informed consent. All the remaining 79 patients provided informed consent. Of all the patients included, 45 had severe burns. Of those patients, 36 survived and were analyzed in a subgroup.

Patient and burn wound characteristics

The median age of all patients was 3 years (IQR 2-9, range 0.5-49 years). The vast majority of patients included were children aged below 14 years (62/79, 78%) (Table 1). Males and females were evenly affected. The mean BMI of adult patients was 17.6 kg/m^2 (STD 2.8). One pediatric patient presented with malnutrition with a weight-for-length below 3 SD. Epilepsy (16%) and mental retardation (11%) were the most prevalent comorbidities. The most common cause of burn injury was scalds (58%). The mean TBSA burned was 12% (STD 10). Of all the patients, 63% suffered from deep dermal or subdermal burns. The patient and wound characteristics of subgroups are presented in Table 1.

In all patients, the median patient delay was 1 day post-injury, and the mean delay was 5 days (IQR 0-4, STD 11, range 0-58). In the subgroup of severe burn survivors, the median patient delay was 3 days, and the mean delay was 7 days (IQR 0-7, STD 12, range 0-47).

Treatment

Guideline adherence was limited regarding fluid and antibiotic administration. Fluid administration at admission was indicated in 44% of all the cases. Compliance with the ISBI guidelines was achieved in 78% of these. All patients (100%) received antibiotics at admission, whereas only 25% of the wounds were classified as infected at admission. Almost all the patients (97.5%) received occlusive wound dressing, which was according to the local protocol.

In total, 36 patients were eligible for the subgroup of patients with severe burns which required skin grafting. Escharotomy was performed in four patients. Seven patients refused autologous skin grafting due to fear of costs, lack of trust in the healthcare providers, or health illiteracy. Skin grafting was thus performed in 29 patients (81%). The vast majority of grafting was performed at a delayed stage (90%), i.e. >10 days post-injury (median 23 days post-injury, IQR 15-47) (Figure 2). In 9 patients, several grafting procedures were necessary (ranging from 2-4 procedures), totaling 41 procedures. Amputation was performed in five cases, including fingers, toes and below-the-knee amputation.

Table 1. Patient and burn wound characteristics

Variable	All patients	Deaths	Severe burn survivors
Patient characteristics			
N	79	9	36
Male/female, n	43/36	2/7	19/17
Median age, years	3 (IQR 2-9)	4 (IQR 3-11.3)	5.0 (IQR 2-22)
Mean age, years	9 (STD 13)	10 (STD 14)	13 (STD 16)
Weight-for-length, n	Known in 59 patients	Known in 6 patients	Known in 24 patients
> 0 SD	18 (31%)	0	6 (25%)
0 to -1 SD	21 (36%)	3	11 (46%)
-1 to -2 SD	15 (25%)	3	4 (17%)
-3 to -2 SD	4 (7%)	0	3 (13%)
>-3 SD	1 (2%)	0	0 (0%)
Mean BMI, kg/m²	17.6 (STD 2.8)	14.5 (N=2)	18.5 (STD 2.6)
Comorbidity, n (%)			
Epilepsy	13 (16%)	1 (11%)	9 (25%)
Mental retardation	9 (11%)	2 (22%)	5 (14%)
Diabetes	1 (1%)	1 (11%)	0 (0%)
HIV	1 (1%)	0 (0%)	1 (2%)
Heart failure	1 (1%)	0 (0%)	0 (0%)
Median Hb, g/dL	11.5 (IQR 10.1-13.7)	11.2 (IQR 8.8-12.5)	11.4 (IQR 9.9-14.4)
Burn wound characteristics			
Etiology, n (%)			
Scalds	46 (58%)	4 (44%)	11 (31%)
Fire	32 (38%)	4 (44%)	23 (64%)
Contact	3 (4%)	1 (11%)	2 (5%)
%TBSA			
Mean %TBSA	12 (STD 10)	21 (STD 17)	14 (STD 10)
Median %TBSA	10 (IQR 5-16)	20 (10-28)	10 (IQR 7-17)
Mean %TBSA full thickness	13 (STD 8)	22 (STD 20)	10 (STD 9)
Median %TBSA full thickness	8 (IQR 5-16)	20 (IQR 6-32)	8 (IQR 5-12)
Deepest burn depth, n (%)			
Superficial partial-thickness	29 (37%)	2 (22%)	0 (0%)
Deep partial-thickness	13 (16%)	1 (11%)	5 (14%)
Full-thickness	29 (37%)	4 (44%)	25 (69%)
Full-thickness and vital structures below	8 (10%)	2 (22%)	6 (17%)
Body part affected, n (%)			
Head/neck	20 (25%)	3 (33%)	9 (25%)
Trunk	41 (52%)	7 (78%)	17 (47%)
Buttocks	20 (25%)	2 (22%)	8 (22%)
Genitalia	7 (9%)	1 (11%)	3 (8%)
Upper extremity	38 (48%)	6 (67%)	20 (56%)
Lower extremity	42 (53%)	6 (67%)	21 (58%)
Time to wound closure, days			
Mean (STD, range)	25 (STD 33, range 0-203)	N/A	52 (STD 41, range 6-203)
Median (IQR)	10 (IQR 6 -29)	N/A	45 (IQR 25-60)

Patient safety

Patient safety was considered unsatisfactory in the first two weeks after admission, based on the Clavien-Dindo classification. Patients presented with life-threatening complications on admission and the mortality rate was high in the first two weeks after admission.

Clearly, many complications in the first two weeks related to the situation at admission. In all patients, 87 burn wound-related complications were observed on admission. Major complications (i.e. grade IV complications) included sepsis (11%), severe acute malnutrition (6%), and acute kidney failure (6%). The most common minor complications present on admission were dehydration (35%) and burn wound infection (25%). The complications of the subgroups are presented in Table 2.

Of all patients included, 9 died during admission, comprising a total in-hospital mortality of 11.4% (n=9/79). The majority of deaths occurred within the first two weeks post-admission. In the subgroup of patients who died, the median time from admission until death was 10 days (IQR 2-17), ranging from 0 to 73 days. Two patients died within 24 hours after admission (2/9=22%), three between 1 and 4 days (3/9=33%), and three between 4 and 14 days (3/9=33%) and one between 14 and 73 days (1/9=11%) (Table 2 and Figure 3). Shock due to sepsis (44%) or hypovolemia (22%) were the most common causes of death. In the subgroup of patients who died (n=9), the mean patient delay was significantly longer (14 vs. 5 days, p = 0.0377) compared to the total study population (n=79). Likewise, the mean TBSA% burned (21% vs. 12%, p = 0.0262) was higher. Deep burns were more prevalent in the group of the patients who died (77% having deep burns vs. 63%, p = 0.408); however, there was no significant difference compared to the total study population (n=79).

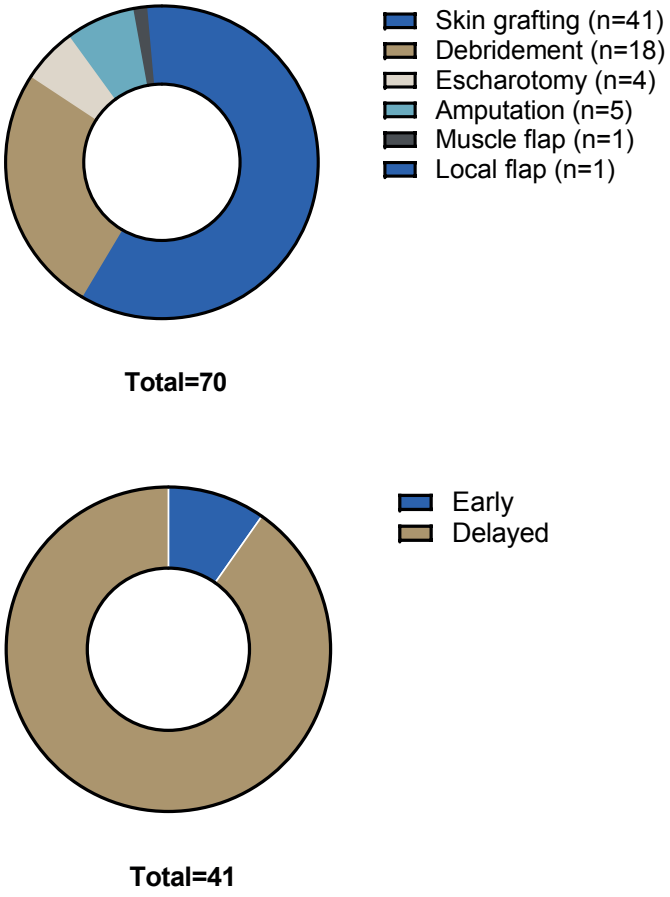


Figure 2. Surgical interventions performed in patients with severe burns and timing of grafting procedures.

Table 2. Patient safety: complications and mortality

Variable	All patients	Deaths	Severe burn survivors
Complications of burns			
Delay, days			
Mean (STD, range)	5 (STD 11, range 0-58)	14 (STD 20, range 0-58)	7 (STD 12, range 0-47)
Median (IQR)	1 (IQR 0-4)	3 (IQR 1-23)	3 (IQR 0-7)
Minor complications at admission, n (%)			
Dehydration	28 (35%)	3 (33%)	25 (69%)
Burn wound infection	20 (25%)	2 (22%)	16 (44%)
Anemia	8 (10%)	1 (11%)	7 (19%)
Other	9 (11%)	3 (33%)	6 (17%)
Major complications at admission, n (%)			
Sepsis	9 (11%)	2 (22%)	7 (19%)
Severe acute malnutrition	5 (6%)	3 (33%)	1 (3%)
Acute kidney failure	5 (6%)	2 (22%)	3 (8%)
Compartment syndrome	3 (4%)	2 (22%)	1 (6%)
Minor complications during admission, n (%)			
Pneumonia	2 (3%)	1 (11%)	2 (5%)
Anemia	8 (10%)	2 (22%)	6 (17%)
Diarrhoea	7 (9%)	2 (22%)	4 (11%)
Dry gangrene	3 (4%)	0 (0%)	3 (8%)
Decubitus	2 (3%)	0 (0%)	1 (3%)
Facial edema	2 (3%)	1 (11%)	0 (0%)
Dehydration	21 (27%)	3 (33%)	18 (50%)
Other	3 (4%)	0 (0%)	3 (8%)

Variable	All patients	Deaths	Severe burn survivors
Major complications during admission, n (%)			
Severe hypovolemia	2 (3%)	2 (17%)	0 (%)
Sepsis	11 (14%)	4 (44%)	7 (19%)
Acute kidney failure	6 (8%)	1 (8%)	2 (6%)
Severe acute malnutrition	6 (8%)	3 (33%)	1 (3%)
Coma due to progressive epilepsy syndrome	1 (1%)	1 (11%)	0 (%)
Electrolyte imbalance	3 (4%)	2 (22 %)	0 (0%)
Respiratory failure	2 (3%)	1 (11%)	1 (3%)
Death			
Number of deaths, n (%)	9 (11%)*	9 (100%)*	0 (%)
Mean time to death since admission, days	16 (STD 23, range 0 - 73)	16 (STD 23, range 0 - 73)	NA
Median time to death since admission, days	10 (IQR 2 -17)	2 (IQR 2 -17)	NA
Mean time to death since injury, days	29 (STD 36, range 0-111)	29 (STD 36, range 0-111)	NA
Median time to death since injury, days	17 (IQR 4-38)	17 (IQR 4-38)	NA
Death within 24 hours of admission, n (%)	2 (3%)	2 (22%)	NA
Cause of death, n (%)			
MOF due to septic shock	4 (5%)	4 (44%)	0 (0%)
MOF due to distributive shock	2 (3%)	2 (17%)	0 (0%)
MOF with acute kidney failure	1 (1%)	1 (8%)	0 (0%)
Respiratory failure due to tetanus	1 (1%)	1 (8%)	0 (0%)
Sudden Unexpected Death in Epilepsy (SUDEP)	1 (1%)	1 (8%)	0 (0%)

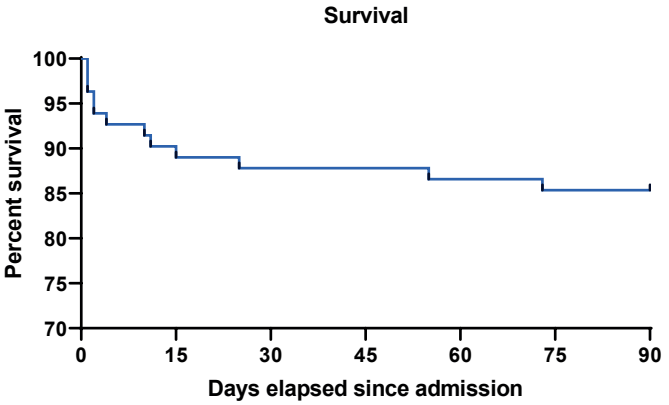


Figure 3. Survival of patients admitted with burns. Days elapsed since admission.

The safety of anesthesia and surgical procedures was satisfactory according to the Clavien-Dindo classification. Seventy procedures were performed, including 41 skin grafts and no surgery-related life-threatening complications and mortality were observed (Table 3). The most predominant complications of skin grafts were partial (22%) and complete necrosis (7%). Two patients died who underwent escharotomy procedures; however, they died of multi-organ failure due to the severity of their burn injuries. One patient died who underwent a below-the-knee amputation; however, she died due to complications of epilepsy, more than 60 days after amputation. None of the patients who died had received debridement or skin grafting.

Effectiveness of treatment

Thirty-six patients with severe burns had clinical indications for split-skin grafting. Seven patients refused surgery and 29 patients underwent skin grafting (see 'treatment'). The mean TBSA% that needed grafting was 10.2% (SD 9), with a mean TBSA% covered by skin grafting of 8.9% (SD 7). The mean graft take was 79% (SD 24). The mean time to reepithelialization was 52 days post-admission (SD 42, median 45, IQR 25-60) and a mean of 60 days post-injury (SD 41, median 58, IQR 34-67) (Table 3). In the subgroup of patients with severe burns who refused surgery (n=7), the mean time to reepithelialization was not available as they left the hospital before complete reepithelialization had occurred.

Table 3. Surgical interventions, safety and effectiveness

Interventions	n	%
Patients that refused grafting	7	19%
Patients that underwent grafting	29	81%
Total procedures	70	100%
Split skin grafting	41	59%
- Early excision & grafting (0 - 10 days)	4	10%
- Delayed (>10 days)	37	90%
Debridement	18	26%
Escharotomy	4	6%
Amputation	5	7%
Muscle flap	1	1%
Transposition flap	1	1%
Patient safety: surgical complications	n	%
Partial graft necrosis	9	22%*
Complete graft necrosis	3	7%*
Burn wound infection	5	12%*
Donor site infection	3	7%*
Haemorrhage	2	3%
Wound infection	1	1%
Skin grafts: effectiveness		
%TBSA in need of grafting		
Mean %	10%	
STD	9%	
Range	1-39%	
Timing of first skin graft, days		
Mean (STD)	39 (STD 43)	
Median (IQR)	23 (IQR 15-47)	
Time from admission to reepithelialization, days		
Mean (STD)	52 (42)	
Median (IQR)	45 (25-60)	
Range	6-203	
Time from injury to reepithelialization, days		
Mean (STD)	60 (41)	
Median (IQR)	58 (34-67)	
Range	6-206	
Mean graft take		
Mean % take (STD)	79 (24)	

* percentage of total skin grafts (total skin grafts = 41)

In the subgroup of patients with severe burns the mean patient disability score was 0.63 (n = 34, SD 0.23) at admission. At 1.5 months post-injury, this improved to 0.35 (n=31, SD 0.23, p<0.001) and at 3 months to 0.20 (n = 32, SD 0.2, p<0.001) (Figure 4). The number of patients with disability-free survival at admission were 2 out of 34 (6%), which improved to 9/31 (29%) at 1.5 months, and to 22/32 (69%) at 3 months post-injury. Similar results were observed in the subgroup of patients who received skin grafting: at admission the mean disability score was 0.64 (n = 27, SD 0.25), at 1.5 months it was 0.36 (n = 26, SD 0.24, p<0.001), and at 3 months it was 0.21 (n=25, SD 0.16, p<0.001).

In the subgroup of patients with severe burns the mean QoL score was 0.25 at admission (n = 34, SD 0.25). At 1.5 months post-injury, this score improved to 0.53 (n = 33, SD 0.27, p<0.001), and at 3 months it had further improved to 0.73 (n = 30, SD 0.26, p<0.001) (Figure 4). None of the 34 patients reported a full QoL score at admission, 2/33 patients (6%) reported a full score at 1.5 months, and 8 (8/30, 27%) reported a full score at 3 months post-injury. Similar results were observed in the in subgroup of patients who received skin grafting: at admission the mean QoL score was 0.22 (n = 29, SD 0.26), at 1.5 months the score was 0.53 (n = 29, SD 0.30, p<0.001), and at 3 months the score was 0.70 (n = 26, SD 0.702, p<0.001).

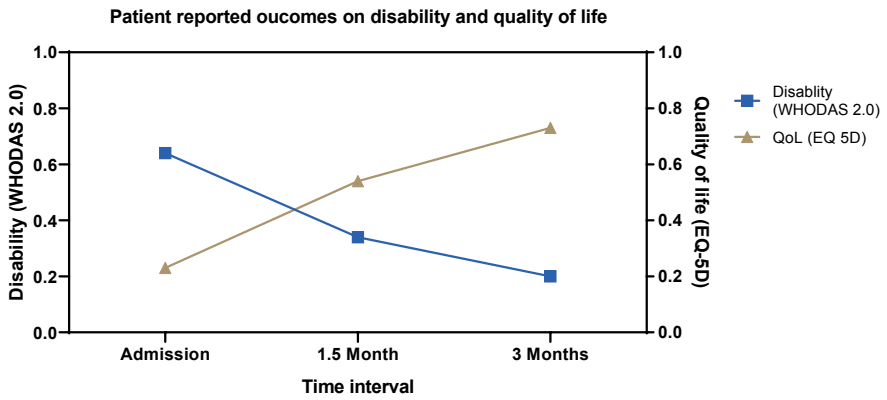


Figure 4. Patient-reported outcomes on disability and QoL.

5a. Admission post-injury day 4

5b. Post-injury day 18

5c. First skin graft post-injury day 26

5d. Second skin graft post-injury day 55

5e. Third skin graft post-injury day 90

5f. Result at 9 months

5g. Contractures developed in the both axilla

Figure 5. Example of an 8-year-old patient who sustained a burn on the back

Photo release consent was provided by the patient and the caregivers after extensive counseling.

Discussion

According to the World Health Organization (WHO), the burden of burn injuries is high in low- and middle-income countries. There is currently a lack of understanding of burn treatment and burn care outcomes in these settings. Therefore the WHO called for efforts to collect data and promoted research on this topic. In an answer to this call, this is the first study performed in a rural area in a resource-limited setting that evaluated the outcomes of acute burn care by assessing the safety and effectiveness of burn care, including the use of validated Patient-Reported Outcome Measures (PROMs). Our results showed that patients often presented after a prolonged delay at the emergency room with life-threatening complications. Patients had a high risk of in-hospital mortality in the first two weeks after admission. The safety of surgical procedures was considered satisfactory, since no surgery-related mortality or life-threatening complications were observed. This study also demonstrated that delayed skin grafting was effective by achieving reepithelialization at a mean of 60 days post-injury without major complications. Partial graft necrosis (25%) was a predominant complication. During follow-up patients reported a reduction of disability and an improvement of QoL.

The in-hospital mortality reported in our study (11.4% for all burns) is in line with the literature dealing with similar resource-limited settings. A recent systematic review of burn care in sub-Saharan African countries by our group showed an overall mortality of 13.1% for all, and 27.9% for severe burns.[29] However, individual studies presented a widely varying mortality of 1% to 39%.[45–53] This diversity may be attributed to differences in study methods, quality of follow-up and differences in healthcare settings with different levels of burn care available.[29,47,48]

Compared to HICs, the mortality reported in LMICs is considerably higher. Large burn registries report a mortality rate of 3.3% in the United States,[2,3] 4.1% in The Netherlands,[1,4] and a mortality rate from severe burns (defined as burns >15% TBSA burned) of 15.7% in Australia.[54] In the literature these vast differences are partially explained by the limitations in access to, and the quality of, burn care services in LMIC.[22,23]

Our findings suggest that a delayed grafting technique was safe and effective in a resource-limited setting. Patients with burns who survived the first two weeks

after admission were able to undergo skin grafting at a median of 23 days post-injury, and reepithelialization was achieved without life-threatening complications. Several approaches have been proposed in the literature to optimize burn care in low-income countries. Regarding surgery, studies suggest that early eschar excision and grafting within 72 hours improve the outcome of burn wound treatment by reducing bacterial wound colonization, infection and length of hospital stay.[55,56] However, controversy remains as to whether early excision or a more conservative approach is the preferred technique in resource-limited settings.[8,27] The few studies available reached different conclusions.[29] Three studies supported early excision and grafting.[57–59] On the other hand, Gallaher et al. showed that early excision and grafting were associated with increased mortality compared to delayed grafting after burn day five.[60] Apart from the safety considerations, our experience is that patient delay, the condition of the patient at admission, out-of-pocket payments and the limited availability of supplies and products (e.g. blood products) contribute to the delay in surgery. These factors should be considered when discussing the optimal timing of wound closure in a resource-limited setting.

The ISBI guidelines were challenging to apply regarding fluid management and antibiotic usage. Fluid management was not performed according to the guideline in 22% of the cases. This was due to various shortcomings: medical doctors were not aware of the current international guidelines, fluids were temporarily not available, or fluids were not provided due to shortages of staff. The guidelines recommend the avoidance of prophylactic use of antibiotics; however, 100% of our population received oral antibiotics at admission while only a quarter of the patients presented with an infected burn wound and even fewer presented with septicemia. This inappropriate antibiotic usage has been described earlier in the setting of Tanzania.[61,62] Clinicians may have thought it likely that infection prevention and hygiene control could not yet match the high standards of high-income countries and therefore prescribed prophylactic antibiotics. The above findings show that there is room for improving guideline adherence, and thus potentially outcome.

Furthermore, more advanced techniques of burn wound treatment were not yet available in our setting. Enzymatic debridement of eschar with Bromelain (Nexobrid©) is effective and reduces the need for blood products, surgical excisions and skin grafting; however it requires adequate regional anesthesia and is not cost-effective in low-income countries.[55,63,64] Cerium-flammazine is a relatively

expensive topical therapy that needs to be applied soon after injury. It prevents bacterial wound colonization, reduces the risk of sepsis, and helps to safely postpone surgery until patients are stabilized.[8,65–69] However, before considering these techniques for use in resource-limited settings, patient delay, availability of regional anesthesia, costs and cost-effectiveness should be addressed first.

This is the first study on burns which shows the value and feasibility of applying validated PROMs in a resource-limited setting. Our findings seem to be in line with existing studies from High-Income Countries on the effects of burns on disability and quality of life.[17,40] These studies have shown that the impact of burns on disability and QoL diminishes shortly after injury, but can be persistent in a small group of patients, particularly those with severe burns that require multiple surgeries.[17,40] Our study shows that standardized assessments of PROMs on disability and QoL can be applied in a LMIC setting. These PROMs may aid the improvement of burn care quality in LMICs.[70]

Globally, no consensus exists as to which patient-reported outcome measures (PROMs) should be used in burn survivors to determine effectiveness.[40] Burn-specific PROMs are available, such as the Burns Specific Health Scale-Brief (BSHS-B),[71] or the BOQ_{0-5} for pediatric populations.[72] However, these PROMs are specified for populations and their behaviors in HICs. Therefore, we chose PROMs that were generic, feasible and applicable to our study population and cultural setting.

Our study indicates that patients present after a delay with significant morbidity and have a high risk of mortality. Based on these findings, the most promising first step to improve burn care in resource-limited settings is to improve timely access to safe burn care in areas of underserved populations. The few studies available have suggested several barriers to access to burn care:[22,23,73–75]

- Socio-economic barriers, e.g. lack of insurance and out-of-pocket payments
- Geographical barriers, e.g. the limited number of facilities providing burn care services
- Limitations of the surgical workforce, e.g. the lack of adequately trained medical personnel
- Limitations in resources, e.g. the lack of infection prevention, monitoring, intensive care and mechanical ventilation, or surgical equipment

To improve access to burn care these barriers should be addressed.[22,23,73] Examples of possible initiatives include awareness and prevention projects,[76] initiatives that limit out-of-pocket payments and ensure financial protection of patients,[73] or training of local healthcare workers.[22,23,73] Essential requirements of such initiatives are that they should have a needs-driven approach, are tailored to the local settings and communities,[22] and are based on existing burn care guidelines and protocols.[77] LMIC actors should include leading organizations in burn care such as national burn care centers. HIC organizations should collaborate with these organizations. Potential actors from HICs include burn care specialists who aim to strengthen the surgical capacity, academics that empower the local academic culture and non-governmental organizations that generate awareness and mobilize resources.

The strengths of this study are the high follow-up rate and the evaluation of disability and QoL using validated PROMs. It is the first study to answer the call of the WHO to improve our understanding of burn care in resource-limited settings

Limitations

This study has limitations. It is a single-center study without a control group, thus limiting its generalizability. Given our setting, several parameters, such as burn wound depth and burn wound infection, were solely based on clinical diagnosis and therefore have limited accuracy. Due to the nature of this observational study, it was not possible to compare different treatment approaches, e.g. early escharectomy and grafting versus delayed skin grafting, and its effect on the safety or effectiveness of the treatment. It should also be noted that disability and QoL were observed over time, rather than a sole outcome of the burn care provided.

Conclusion

This study on burn care performed in a rural area in a low-income country showed that patients present with burn injuries after a substantial delay with life-threatening complications. The in-hospital mortality is high (11.4%). The vast majority of patients with severe burns survived received surgical treatment, which was found to be safe. The burn care was effective in achieving reepithelialization, reducing disability and improving Quality of Life over time. First experiences with

the ISBI guideline showed that it is indeed an appropriate and useful tool to guide burn care in a resource-limited setting. Overall adherence to the ISBI guideline can be improved, particularly regarding appropriate antibiotic usage and fluid resuscitation. To improve burn care worldwide, we recommend improving timely access to safe burn care in areas of underserved populations in resource-limited settings.

Declarations

Ethics approval and consent to participate

Ethical clearance was obtained from the National Institute of Medical Research, Tanzania (NIMR/HQ/R.8a/Vol.IX/2652).

Consent for publication

Patient consent was obtained, including photo release consent.

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Chapter 4

The development of burn scar contractures and their impact on joint function, disability and quality of life in low- and middle-income countries: a prospective cohort study with one-year follow-up

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Chapter 5

Access to burn care in low-and middle-income countries: An assessment of timeliness, surgical capacity, and affordability in a regional referral hospital in Tanzania

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Abstract

This study investigates patients' access to surgical care for burns in a low-and-middle-income setting by studying timeliness, surgical capacity, and affordability. A survey was conducted in a regional referral hospital in Manyara, Tanzania. In total, 67 patients were included. To obtain information on burn victims in need of surgical care, irrespective of time lapsed from the burn injury, both patients with burn wounds and patients with contractures were included. Information provided by patients and/or caregivers was supplemented with data from patient files and interviews with hospital administration and physicians. In the burn wound group, 50 percent reached a facility within 24 hours after the injury. Referrals from other health facilities to the regional referral hospital were made within three weeks for 74 percent in this group. Of contracture patients, seventy four percent, sought healthcare after the burn injury. Of the same group, 70 percent never received surgical care or a referral. Combined, both groups indicated that lack of trust, surgical capacity, and referral timeliness were important factors negatively impacting patient access to surgical care. Accounting for hospital fees indicated patients routinely exceeded the catastrophic expenditure threshold. It was determined that healthcare for burn victims is without financial risk protection. We recommend strengthening burn care programs in similar settings, using a more comprehensive health system approach to identify and address both medical and socio-economic factors that determine patient mortality and disability.

Introduction

Every year, nearly 11 million people suffer from burns that require medical attention, ranking it fourth among all injuries.[1] In low-and middle-income countries (LMICs), fire-related burns are among the leading causes of disability and life years lost, with children as the most affected age group.[1,2] Worldwide, the mean burden of child burn deaths is 2.5 per 100,000 across 103 countries, with the largest burden in Sub-Saharan Africa (4.5 per 100,000).[3] In a review of burns in sub-Saharan Africa, children aged 10 years and below represent more than 80 percent of the burn patient population.[4]

Since 2015, a team of physicians from the Netherlands have collaborated in Tanzania with physicians from Haydom Lutheran Hospital, a regional referral hospital in Manyara region. The aim of this collaboration is to improve surgical care. This is done by organizing twice-yearly surgical training camps that focus on acute burn management and burn contracture release surgery.

The safety and surgical capacity in the hospital were evaluated between 2017-2018. Analysis of capacity showed that the surgical care provided was safe and effective for patients with severe burn wounds or burn contractures.[5–7] However, the data also showed, that despite the Dutch-Tanzanian training program, there was high mortality among burn victims arriving late to the hospital, as well as a high rate of disabled burn contracture patients—all of whom were part of the twice-yearly reconstructive surgery training camps.

Based on these observations, several questions were raised: what factors contribute to delayed arrival of acute burn wound patients? And why are burn injuries that occur still developing into severe contractures?

Prior to data collection the leading assumption is that geographical and socio-and-economic factors, cultural beliefs, and/or barriers related to traditional notions of illness and healing could be attributable to poor burn management at nearby healthcare facilities. Essentially, social, and economic barriers persist for patients in the area despite the provision of adequate and safe burn care at the regional referral hospital. If so, then these barriers may involve factors that delay, or hamper patients access to burn care.

Access to healthcare stems from a complex interaction of factors between patients' health-seeking behaviors and healthcare provision. The interplay of both has been defined as "the opportunity to reach and obtain appropriate healthcare services in situations of perceived need for care".[8] In 2015, Alkire and colleagues studied access to surgery in 180 countries based on four criteria: Timeliness, safety, affordability, and surgical capacity.[9] Based on their probability models, 4.8 billion people, which is 68 percent of the world's population, lack access to safe and affordable surgical care, most of them living in LMICs.

Little information is available on access to care for burn victims in LMICs. The limited data available is from studies in Nigeria, Ethiopia, Malawi, and Ghana. This research suggests that only few patients can access burn care in a timely fashion; that few patients know the potential consequences of delayed burn care; and that resource constrained populations are at risk of inaccessibility.[2,10,11] Therefore, more detailed information on access to burn care in LMICs is needed to improve the current situation.

Gaining more detailed information on access to burn care in LMICs is the aim of this article. The data presented assess access to burn care in terms of timeliness, surgical capacity, and affordability in a regional referral hospital in Manyara, Tanzania. The obtained insights, in turn, can be used to reduce barriers to accessing burn care in LMICs. Doing so, the article contributes to the goal of improving burn-related mortality and disability where most burn injuries occur, globally.

Methods

An in-hospital survey was conducted at Haydom Lutheran Hospital, which services an area estimated to have between two and seven million people. The hospital does not have an official burn center, so burn care is provided by a team of nurses, doctors, physiotherapists, and medical specialists (surgeons and pediatricians).

Data collection was undertaken between December 2017 and June 2019. It must be disclosed that not all patients admitted with severe burns were included, due to time constraints during data collection. Sampling was purposeful, identifying and enrolling patients presenting with severe burns in this LMIC setting.

Participants

Two groups of patients were eligible:

1. Patients of all ages with severe burns, defined as partial thickness burns greater than 10 percent of the total body surface area (TBSA); burns to the face, hands, feet, genitals, perineum, or across major joints; and any full thickness burns.[12]

2. Patients of all ages with contractures of joints after burn injury in need of contracture release surgery.

All patients provided informed consent.

Ethical clearance

Ethical approval was obtained from the National Institute for Medical Research in Tanzania. (NIMR/HQ/R.8a/Vol.IX/2652). Written informed consent was obtained from all participants, but if a participant was functionally illiterate, a thumbprint with an additional signature from a literate witness was obtained. For individuals younger than 18 years, a parent or guardian provided written consent.

Access to burn care survey

To assess access to burn care, a survey was developed based on the Surgeons Overseas Assessment of Surgical (SOSAS) need population-based survey.[13] Questions were modified in line with participant observations. The survey was divided into four parts: Basic characteristics, timeliness, surgical capacity, and affordability.

Differences in patient groups mandated two versions of the survey: One for the burn wound group (Appendix 1) and one for the contractures group (Appendix 2). Each version consisted of 30 questions and was completed after admission. The surveys were conducted Swahili, Iraqw, or English. Language assistance was provided by a translator. For pediatric patients were surveyed by proxy through caregivers.

Basic characteristics and socio-economic factors

The following basic characteristics were collected: Age, gender, etiology, TBSA affected, and maximum depth of the burn wound. Socioeconomic factors like literacy, education level, occupation, and tribe were registered. For children under 18, the primary earner of the household provided socioeconomic characteristics and highest level of education were registered.

Timeliness

Timeliness is defined as the physical ability to reach a healthcare facility and health-seeking behavior of the patient and the caregiver.[14] Regarding geographical accessibility, time between the accident and presentation at first health care facility, mode of transport, waiting time for transport and total transport time to the hospital were collected. Transport data for burn wound patients consisted of transport data to Haydom Lutheran Hospital, or if Haydom was not the first healthcare facility reached, then transport data to the first healthcare facility and transport data from this facility to Haydom Lutheran Hospital was collected. For contracture patients, transport from home to Haydom was investigated. Participants who arrived more than 24 hours after the burn accident took place, were asked to share their reasons for being delayed. Answers were categorized into geographical barriers, lack of trust, lack of money, and health seeking beliefs.

Surgical capacity

With respect to both groups, data were collected on:

1. Type of facility, other than Haydom Lutheran Hospital, first consulted after the initial burn injury (traditional healer, clinic/dispensary/hospital/referral hospital),
2. Treatment provided during initial presentation elsewhere (e.g. conservative treatment, skin grafting, amputation, etc.),
3. Days between initial presentation elsewhere and referral to Haydom Lutheran Hospital
4. Types of surgical procedures, as part of treatment, provided at Haydom Lutheran Hospital
5. Reasons for not receiving surgical care at Haydom Lutheran Hospital when indicated otherwise.

Affordability

Regarding affordability, data was collected on the patient's health insurance coverage. This included national health insurance covering most primary and secondary healthcare services, and community health insurance covering primary healthcare services, including emergency surgery and five-day hospital stay.

Data was also collected on daily available budget (in Tanzanian shillings) per head of household. The amount was converted to U.S. dollars, using the official exchange rate of the World Bank (July 2019). In addition, patients' hospital fee information was retrieved from the financial department of the Haydom Lutheran hospital, which included total fee covered by the patient one months after the data collection period (July 2019) and the outstanding amount at that moment.

'Catastrophic healthcare expenditure' has been defined in previous studies as an out-of-pocket cost equal to or greater than 10 percent of an individual's yearly expenditure.[15] This definition was used to calculate the percentage of patients facing a catastrophic expenditure in the study cohort. Haydom Lutheran Hospital utilizes a cost-sharing model to protect patients from catastrophic healthcare expenditure. This means that the treatment costs are shared by the hospital and the patients. Additionally, patients who face a potential catastrophic expenditure are assisted through a counseling process, led by social healthcare workers who consult with patients' respective family and village leaders. After consensus between all parties, patients are offered a payment arrangement, in which costs can be paid over installments.

The survey data was supplemented with quantitative information supplied by the hospital administration, including treatments provided, which were then with compared with hospital bills and payments already received. Additional qualitative data was obtained through participant observation and through discussion groups, evaluation meetings of the training program, and unstructured interviews with patients' immediate health care providers.

Statistical analyses

For dichotomous parameters, calculated percentages per group were used. Differences between groups were tested with Chi-squared tests. To describe differences between groups, use of means (SD) and t-tests if variables were

normally distributed, medians and interquartile ranges (IQR) and Mann-Whitney tests if data were measured at ordinal level or not normally distributed. Data were analyzed with SPSS version 25. An alpha of 5 percent was adopted.

Results

Basic characteristics and socio-economic factors

The surveys were completed by all eligible patients: 36 patients in the burn wound group and 31 patients in the contracture group. *(Table 1)* Most of the patients were children, defined as research participants aged below 18 years (86 percent in the burn group, and 84 percent in the contracture group, ns p=0.82). Median age was four years (IQR 2-9) in the burn wound group, and six years (IQR 4-12) in the contracture group. Among burn wound patients, 53 percent of the burns were scalds. Among contracture patients, fire burns were most common (65 percent). This difference is not significant (p=0.32), with medical histories of the participants indicating that these injuries were occurring almost exclusively around open cooking and fireplaces. The median TBSA in the burn wound group was 10 percent (IQR 7-18). In the contracture group, it was estimated to be 4 percent (IQR 2-9) with fingers as the most common location for the contractures.

Low education levels were documented for both patients and patients' caregivers. For the burn group, 97 percent of the caregivers (for children) or patients (adults) had no formal education or only reached primary school level. This number was at 84 percent for the contracture group (p=0.07). *(Table 2)* Patients and patients' caregivers were primarily subsistence-based farmers (i.e., families that farm for their own living with limited landownership, (67 percent in the burn wounds group versus 65 percent in the contracture group, p= 0.86)).

Table 1. Basic characteristics

	Acute Burns	Contractures
Total number of patients, N (%)	36 (100)	31 (100)
Females, N (%)	18 (50)	20 (65)
Males, N (%)	18 (50)	11 (35)
Age, median years (IQR)	4 (2-9)	6 (4-12)
Etiology (N,%)		
Scalds	19 (53)	11 (35)
Fire	14 (39)	20 (65)
Contact	3 (8)	0 (0)
Electricity	0 (0)	0 (0)
Burn characteristics		
TBSA, median % (IQR)	10 (7-18)	4 (2-9)
Depth (N, %)		
Superficial	0 (0)	NA
Superficial-partial thickness	6 (17)	NA
Deep partial-thickness	9 (25)	NA
Full-thickness	18 (50)	NA
Deeper injury	3 (8)	NA

Table 2. Socio-economic factors

	Acute burns	Contractures
Education, N (%)		
None	5 (14)	7 (23)
Primary education	30 (83)	19 (61)
Secondary	1 (3)	3 (10)
Tertiary	0 (0)	2 (6)
Literacy, N (%)		
Yes	30 (83)	24 (77)
None	6 (17)	7 (23)
Occupation, N (%)		
Unemployed	2 (5)	4 (13)
Domestic helper	2 (5)	0 (0)
Subsistence farmer	24 (67)	20 (65)
Shop owner/self-employed	5 (14)	4 (13)
Government employee	1 (3)	0 (0)

	Acute burns	Contractures
Non-government employee	2 (5)	1 (3)
Studying	0 (0)	2 (6)
Tribe, N (%)		
Iraqw	18 (50)	16 (52)
Datooga	8 (22)	5 (16)
Nyiramba	4 (11)	2 (6)
Nyaturu	2 (6)	1 (3)
Sukuma	1 (3)	0 (0)
Ngoni	0 (0)	0 (0)
Maasai	1 (3)	0 (0)
Makonde	1 (3)	0 (0)
Nyakyusa	1 (3)	0 (0)
Pare	0 (0)	2 (6)
Chagga	0 (0)	1 (3)
Rangi	0 (0)	1 (3)
Gogo	0 (0)	2 (6)
Zigula	0 (0)	1 (3)

Timeliness

Many patients from the burn wound group reached their first healthcare facility within one day (median 1, IQR 1-1 days). *(Table 3)* That was also the case for patients who came directly to Haydom Lutheran Hospital (median 1 day, IQR 1-6 days). Seven patients did not visit a health care facility within 24 hours and arrived at the first health care facility, up to 49 days after the burn injury. Reasons given were lack of trust and/or money. No differences were found in basic characteristics, socio-economic factors, or the travel times of these seven patients when compared to the group that did reach the facility within 24 hours. The median time for patients to reach Haydom after visiting another health care facility was three days (IQR 1-8). Eleven burn patients (33 percent) visited a traditional healer first, and for this group it also took a median of three days before coming to Haydom (IQR 1-13). Overall, 18 (50 percent) of the burn wound patients reached Haydom within 24 hours. The median traveling time to reach the first healthcare facility was one hour (IQR 0.4-3.0). Waiting time for transport was half an hour (median, IQR 0.15 – 1.0). (See Table 3 for details on the transportation component of the study)

For the contracture group, despite participants' difficulties remembering how long it took to reach their first healthcare facility after the burn injury, the median time between the injury and presenting their contractures at Haydom Lutheran Hospital was 650 days (median, IQR 410-1566 days). The median travel time to Haydom Lutheran Hospital was two hours (IQR 0,5-4.0 hours), and the median waiting time for transport was half an hour (IQR 0-1.75 hours).

Table 3. Timeliness

	Acute burns	**Contractures**
Timing of presentation, median days (IQR)		
Time between burn injury and presentation at any healthcare facility	1 (1 - 1)	NA
Time between burn injury and presentation at HLH	1 (1 - 6)	650 (410 - 1566)
Time between consultation of the first healthcare facility and arrival at HLH	3 (1 - 8)	NA
Patients that were admitted at HLH within 24 hours, N (%)	18 (50)	NA
Main reason for not consulting a health facility within 24 hours		
Total patients, N (%)	7 (19%)	NA
Believed that it would heal without hospital care	1	NA
No money for healthcare or transport	3	NA
No trust/fear	3	Na
Mode of transport to first healthcare facility (multiple answers possible), N		
Ambulance	4	4
Bus or public landcruiser	11	11
Taxi	10	3
Motorbike taxi	10	9
Private motorbike	3	1
Bicycle	1	1
On foot	7	4
Transport time to reach first health care facility, median (IQR)		
Hours of traveling	1 (0.5- 3.0)	NA
Hours waiting time for transport	0,5 (0,15 - 1.0)	NA
Transport time to reach HLH for contracture patients, mean (IQR)		
Hours of traveling	Not known	2 (0,5- 4)
Hours waiting time for transport	Not known	0.5 (0 - 1,75)

Surgical capacity

Nineteen burn wound patients (53 percent) consulted another healthcare facility (a dispensary/clinic or a hospital) before coming to Haydom Lutheran Hospital (Table 4). The healthcare provided at these other facilities was conservative wound care in 95 percent, with patients' reported treatment frequently lacking consistency in the use of antibiotics, pain medication, fluid resuscitation, and/or dressing. Only one patient was treated surgically in another facility, for a debridement without skin grafting (Table 4 and 5).

All 19 burn wound patients that had previously consulted another health care facility had an indication for surgical care when arriving in Haydom later. In this group, 14 patients (74 percent) indicated that they were referred within three weeks from the day of the injury. Two patients indicated that they were not referred at all, and three patients reported being were referred in time but waited a long time before consulting Haydom Lutheran Hospital out of a lack of trust and/or money.

In the contracture group, 23 patients (74 percent) indicated that they had visited a health care facility before for their burn injury. Among these patients, only four (17 percent) received previous surgical treatment at that time: Three received only surgical debridement and one patient skin grafting. Sixteen (70 percent) of the contracture patients who consulted another health care facility after the accident, indicated that they were never referred to a hospital providing surgical burn care or burn contracture release surgery.

At the time of presentation at Haydom Lutheran Hospital, surgical care was indicated in 27 patients (75 percent) of the burn group and all contracture patients. All contracture patients had an indication for contracture release and received surgical care. However, in the burn group, seven patients (26 percent) with an indication for surgery did not receive surgical care although it was available. The reasons given were lack of trust in the surgical techniques (five patients) and lack of money (two patients). The mean length of hospital stay was 38 days for the burn patients and 11 days for the contracture patients. The most common procedure for the burn group was delayed skin grafting after surgical or spontaneous debridement (51 percent). Different techniques were used for contracture release surgey, including full thickness grafts and local flaps (Table 5).

Table 4. Initial burn care

	Acute burns	Contractures
Pts that consulted another health care facility first, N (%)	19 (53)	23 (74)
Pts that consulted HLH as first facility , N (%)	17 (47)	8 (26)
Oher health care consulted (multiple answers possible), N		
Traditional healer	11	8
Dispensary/healthcare clinic (primary)	8	8
Hospital (secondary)	11	22
Type of treatment received since burn injury at other health care facilities, N (%)		
Total number of patients that received treatment	19 (100)	23 (100)
A conservative treatment (iv fluids, pain medication, antibiotics and/ or dressings)	18 (95)	23 (100)
Surgical debridement	1 (5)	3 (12)
Amputation	0 (0)	0 (0)
Skin grafting	0 (0)	1 (4)
Reasons for not receiving surgical treatment at other health care facilities, N (%)		
Total patients that did not receive any form of surgery before	35 (97)	29 (94)
Believed that it may heal without surgery	1	1
No money for healthcare or transport	0	8
No trust/fear	0	4
It was not available elsewhere according to patient or caregiver	34	16
Referral from other facility to HLH, N (%)		
Referral indicated (definition: need for skin grafting/ contracture release)	19 (100)	23 (100)
Referral (and arrived in HLH within 3 weeks)	14 (74)	NA
Not referred according to the patient/caregiver	2 (10)	16 (70)
Patient did not follow-up referral within 3 weeks	3 (16)	NA

Table 5. Treatment at HLH

	Acute burns		**Contractures**
Only conservative treatment indicated, N (%)	9 (25)		0 (0)
Surgery indicated, N (%)	27 (75)		31 (100)
Surgery provided, N (%)	20 (55)		31 (100)
Length of stay at HLH, mean days (range)	**38 (2-203)**		**11 (3-28)**
Reason for not receiving surgery when indicated at HLH			
Total number of patients that did not receive surgical care	7 (100)		NA
No money for healthcare	2 (29)		
No time	0 (0)		
No trust/fear	5 (71)		
No care available at HLH	0 (0)		
Surgical procedures (multiple answers possible)			
Total number of procedures, N (%)	39 (100)	Total number of techniques	60 (100)
Escharotomy	3 (8)	Five flap plasty	9 (15)
Amputation	0 (0)	Classic Z-plasty	14 (23)
Only debridement	14 (36)	Interposition flap	7 (12)
Early debridement with skin grafting	2 (5)	FTG	24 (40)
Delayed skin grafting	20 (51)	SSG	6 (10)

Affordability

The results on affordability show that 25 percent of the burn patients and 26 percent of the contracture patients had their costs covered by health insurance (See Table 6). The mean treatment fee was $378 per patient for the burn group and $167 per patient for the contracture group. The longer hospital stays and the cost of daily wound dressing in the burn group contributed to the difference. The mean daily budget of families of the patients was $0.73 (SD 0.68) for burn patients and $0.70 (SD 0.62) for contracture patients.

Given these figures, the hospital patient fees exceeded the catastrophic health expenditure threshold by up to six times for the contracture groups, and up to 15 times for the acute burn wounds group.

For patients with limited resources, payments were accepted in small installments over a longer period. However, most patients still could not accomplish micro-payments. At the end of the data collection period of this study (June 2019), it was decided to cancel the outstanding debt for all patients—a mean $171 per patient (i.e., 45 percent paid). For the contracture group, the mean amount covered was $104, corresponding to 63 percent of the total fee.

Qualitative results

Participant observation during the treatment and during patient follow-up identified patients' and caregivers' beliefs and fears. Traditional means for treating illness and injury reported the application of ash and eggs on the burn wounds; a treatment perceived by patients and caregivers to be the preferred first step in burn treatment. The patients expressed that the hospital in Haydom was trusted for its medical care, but fear of costs for treatment was common. This was not without reason. During observations and patient outreach activities for follow-up up to two years after the injury, it became apparent that debts faced, even after accepting payments in installments, became a large burden for families involved. It was not uncommon for half of families' owned-land and most animals to be sold, and that neighbors had to help feed children.

In Haydom, skin grafting was available during the entire inclusion period of the research. Despite availability, seven burn patients did not receive grafting surgery when indicated. Lack of patient trust was identified as the cause during discussion groups with Haydom physicians. The physicians also shared that skin grafting was primarily performed with a Humby knife. These Humby patients experienced deep donor site wounds, causing secondary conditions. Haydom physicians speculated that these experiences may have resulted in patients' fears or resistance to skin-grafting techniques. To counter complications resulting from the Humby knife, the surgical training program included a donated electric dermatome. Access to this technology resulted in fewer donor site complications. However, it was observed that fears of the skin grafts were slow to dissipate. Taking into consideration the qualitative information, indicates the importance of the presence, handling, and maintenance of essential surgical tools, and provides additional insight into the effect of complications on patients' confidence in treatment methods.

Discussion

The aim of this study was to assess potential barriers against access to burn care in a LMIC. The results show that timely and affordable access to burn care is limited and needs to be improved strategically. Prior to this study, the surgical capacity and the safety of the care provided at the referral hospital itself were found to be adequate. [5-7] It is important to consider that despite a twice-yearly surgical training program to improve skills and equipment for burn care had been organized, after 2 years, the lack of timeliness, surgical capacity, and affordability were still found to be important barriers for burn patients in the hospital's catchment area.

Firstly, timeliness in reaching a healthcare facility where adequate burn care can be provided is clearly a factor that needs improvement for patients with severe burns in need of emergency care. Acute burn care in Haydom has been shown, elsewhere, that delayed presentation was associated with higher mortality.[7] In the present study it became clear that, although arriving in a health care facility within 24 hours was achieved by 80 percent of the burn patients, only half of the burn patients reached a facility providing surgical burn care within 24 hours.

Secondly, survey responses on surgical capacity indicate that other healthcare facilities rarely provide surgical treatment. Patients coming from a large area covering several general hospitals, in which burn care including skin grafting should be part of the standard care. Our finding is consistent with the literature on surgical burn care in sub-Saharan Africa showing a high need for improvement of surgical burn care in this setting.[4,16] When surgical burn care is unavailable at the first health facility, then referral knowledge is key for a good outcome. Within the burn wounds group, 74 percent of the group indicated receiving a referral to Haydom. Physicians from Haydom stated that surrounding health facilities were aware of the surgical training camps and the availability of improved burn care. In the contracture group, only 30 percent were referred to Haydom and if so, only for the contracture release and not after the acute burn injury happened. Haydom physicians indicated that a possible explanation is the timing of the burn trainings, which happen after the injury (median 650 days before admission).

Thirdly, affordability is another very important factor of access to burn care. Surgical care was unaffordable for majority of patients in the study; regardless of a cost-sharing model. This cost-sharing model keeps patients' fees at an average

$378 per patient, per admission is comparable with other low-cost initiatives to provide burn care in similar settings.[17] However, the mean income of $0.73 per day implies that any hospital fee that exceeds $26 would already be a catastrophic expenditure for the family.[15] However, for the contractures group the mean hospital bill was six times higher, and for the burn wounds group it was 15 times the catastrophic expenditure threshold. It is important to understand that this calculation does not include indirect costs. It is also important to realize, that due to previous expenditures during the acute phase of the burn wound, the contracture patients face a second financial burden. Observations during the follow-up of the patients showed that the possibility of paying in installments made the treatment possible on the short-term, but the financial repercussions on the long term had catastrophic effects for the families. More research into sustainable local strategies is needed to assure affordable burn care for the future. In Haydom, the team proposed to start organizing local fundraising events to improve the actual situation. This is a first step; however, more action is needed on a larger scale. In sub-Saharan Africa, where burn injuries are most common, structural support is lacking. We observed that affordability issues were not only faced by burn patients, but they represented a much wider problem for the poor population in this setting to access health care. If families must sell their means of livelihood to pay for the healthcare for a burn victim, how willing will other families in the same environment be to accept future medical interventions? Financial risk protection requires a health system approach to achieve universal health coverage in 2030.[18] The rise in coverage of the national health insurance in Tanzania over the past years is a promising sign, but the national health insurance coverage is still under ten percent.[19] Strengthening financial risk protection strategies is needed to improve timely access to health care, including burn care, in the coming years.

Additionally, this wider health system strengthening approach should focus on creating and distributing prevention strategies around improving cooking practices and promoting at-home safe environments. Guidelines from international experts and organizations, like the standards of Interburns, are available to assist in this process to improve burn care in similar settings.[20]

Limitations

This study has several limitations. Timeliness, surgical capacity, and affordability were assessed using a survey, and by collecting data from the Haydom Lutheran Hospital administration and patient files.

Thereby, all data was obtained from patients that came, early or late after the burn injury, to Haydom Lutheran Hospital. This selection bias defines that we cannot extrapolate the result of this study to the patients in the catchment area that never went to the hospital for healthcare. The researchers could also not provide absolute confirmation that skin grafting was seldom performed elsewhere because of the design of this study. However, the lack of skin grafting in the area was confirmed by health care workers from other facilities with the main reason provided that a well-functioning dermatome was not available in many of the smaller hospitals.

There were also limitations with recording details beyond the quantitative elements. This gap is especially impactful since timeliness, and lack thereof, may result in multiple social, cultural, and psychological factors still need further investigation. While the study indicated that affordability is a primary concern for patients leading to delays in access to burn care, secondary factors may exist. These factors, which discussed with Haydom Physicians, likely involve localized traditional beliefs and social obligations to traditional healing, that deserve greater attention than this study could accommodate.

Surveyed answers provided by caregivers must be interpreted due to gaps in the levels of education between study participants and investigators, trust issues with clinicians, and perceived personal gain in relation to optimal survey responses. Additionally, this study accounts for unintentional researcher bias, as the investigators were part of the treatment team. Setting and sponsor biases must also be considered, due to the context in which patients were surveyed within the Haydom hospital environment, possibly prompting them to respond in a specific manner that could optimize healthcare benefits.

Conclusion

This study identified timeliness—lack of trust and adherence to traditional beliefs; surgical capacity; and affordability as important barriers to accessing burn care in rural Tanzania. Only half of acute burn patients reached a facility capable of treating burns within 24 hours after injury. Seventy percent of the patients with contractures had never received surgical care or a referral before coming to Haydom Lutheran Hospital despite the contracture had already developed. Almost all patients were confronted with a catastrophic healthcare expenditure, indicating that adequate burn care remains unaffordable in such settings.

To assure timely, safe, and affordable burn care in similar settings in LMICs, access to adequate care needs to be improved. We recommend strengthening burn care with a comprehensive approach beyond a single hospital management team. An approach that may benefit from support from foreign experts, but it should be owned and coordinated by regional and national bodies. The roles for actors within the health care system to support this strategy should include improving health-seeking action via raising awareness in local communities, and reinforcing knowledge and skills of healthcare providers by including all facility levels in a health catchment area to assure emergency burn care, stabilization, and timely referral. This wider approach should also include financial risk protection. The lack of affordable treatment options for patients in need, undermines all efforts to improve quality of care. Future initiatives should go hand in hand with new research projects, needed to identify and address both medical and socio-economic factors to tailor the comprehensive health system approach to the local needs, to effectively reduce burn related mortality and disability in LMICs settings.

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PART III

BURN SCAR CONTRACTURE RELEASE SURGERY

Chapter 6

The effectiveness of burn scar contracture release surgery in low- and middle-income countries: a pre/post intervention study with long-term follow-up

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Abstract

Background

Worldwide many scar contracture release surgeries are performed to improve range of motion (ROM) after a burn injury. Particularly in Low- and Middle-Income Countries (LMICs) there is a need for such procedures. However, well-designed longitudinal studies on this topic are lacking globally. The present study therefore aimed to evaluate the long-term effectiveness of contracture release surgery performed in an LMIC.

Methods

This pre-post intervention study was conducted in a rural regional referral hospital in Tanzania. All patients undergoing contracture release surgery during surgical missions were eligible. ROM data were indexed to normal values to compare various joints. Surgery was considered effective if the ROM of all planes of motion of a single joint increased at least 25% postoperatively, or the ROM reached 100% of normal ROM. Follow-up was at discharge, 1, 3, 6 and 12 months postoperatively.

Results

A total of 70 joints of 44 patients were included. Follow-up rate at 12 months was 86%. Contracture release surgery was effective in 79% of the joints ($p<0.001$) and resulted in a mean ROM improvement from 32% to 90% of the normal value ($p<0.001$). A predictive factor for a quicker rehabilitation was lower age ($R^2=11\%$, $p=0.001$). Complication rate was 52%, consisting of mostly minor complications.

Conclusions

This is the first study to evaluate the long-term effectiveness of contracture release surgery in an LMIC. The follow-up rate was high and showed that contracture release surgery is safe, effective and sustainable. We call for the implementation of outcome research in future surgical missions.

Background

Burn injuries are a major global health issue, causing substantial mortality and morbidity worldwide. Each year 200,000 to 300,000 people die due to fire-related burns, with the highest incidence and mortality reported in Low- and Middle-Income Countries (LMICs),[1–3] with LMICs as defined by The World Bank.[4] Survivors of severe burns may face devastating sequelae due to the development of burn scar contractures.[5,6] Contractures are defined as the replacement of skin by excessive scar tissue of insufficient extensibility, which results in a loss of range of motion (ROM).[7] Contractures can also be disfiguring or painful.[8]

Although adequate burn management can prevent the development of scar contractures, it is often not accessible to patients in LMICs.[2] The need of contracture release surgery in LMICS is unknown. However, as five billion people have limited access to safe surgical care in LMICs, and 11 million people require medical attention for severe burns each year, the need for reconstructive interventions is evident.[1,2,9] Even in High-Income Countries (HICs) contractures are still frequently observed in severely burned patients and reconstructive surgery is often indicated.[10] In the Dutch burn centers, for example, 20.9% of joints with burns develop a contracture and 13.3% of joints undergo reconstructions.[11,12]

The principle of contracture release surgery is to release or excise the scar and to cover the defect with tissue that lengthens the scar. Many surgical techniques are described in literature.[13] If adjacent tissue is available, local transposition flaps are recommended.[14–16] There is a wide variety of local flaps. They provide healthy tissue, thereby adding pliability and extensibility, which further improves joint function.[14,17,18] If enough adjacent tissue is not available for a local flap, skin grafts are mostly used, preferably autologous full-thickness grafts (FTGs), as they re-contract less than split skin grafts (SSGs).[18–20]

Although various techniques are available for contracture release surgery, the evidence of its effectiveness is lacking globally.[13,21,22] A systematic review of this topic showed that all included studies had methodological and statistical shortcomings.[22] The authors called for future studies to use validated outcome measures and clear statistical analyses.[15,22]

In LMICs, in underserved populations, contracture release surgery is often provided by volunteer surgeons during surgical missions.[9,23,24] These missions are frequently debated, for example due to limitations in quality of care and aftercare, which might impair their long-term results.[25–27] A recent systematic review of the effectiveness of reconstructive surgical missions showed that currently no quality studies are available.[28]

Therefore , the present study aimed to evaluate the effectiveness of contracture release surgery during surgical training missions in a LMIC, with follow-up up to one year postoperatively, using range of motion as validated outcome measure.

Methods

This pre-post intervention study was conducted at the Haydom Lutheran Hospital (HLH), a rural tertiary hospital in Tanzania, sub-Saharan Africa. Patients who underwent contracture release surgery between December 2017 and October 2018 were eligible and included if they provided written informed consent. Ethical approval was obtained from the Medical Research Coordinating Committee of the National Institute for Medical Research of Tanzania (NIMR/HQ/R.8a/Vol.IX/2652).

In Tanzania, plastic surgeons are only scarcely available, and at the HLH they are not present. At HLH contracture release surgery is therefore performed during bi-annual surgical training missions of two weeks, supported by the Dutch NGO Doctors of the World. Interventions were performed by accredited plastic surgeons from the Netherlands, always together with local surgeons of the HLH. The team from Doctors of the World consisted of one anesthetist, a coordinator, and two surgeons, providing supervision on aftercare by telecommunication all year round. The team from the HLH consisted of three surgeons and several residents. The HLH provided all the equipment, medication and staff for the perioperative care, including anesthesia and the aftercare.

Intervention

Treatment planning was according to international guidelines, specified to the resource-limited healthcare setting of the HLH.[21] In this study, local fasciocutaneous flaps were used when feasible (e.g. z-plasty, five-flap plasty, or interposition

flap).[14,18,20] When local flaps were not sufficient, or not available to fully cover the defect, the flaps were combined with an additional skin graft, preferably FTGs. The flap design was marked preoperatively. Local infiltration with adrenaline diluted in saline was applied to limit blood loss.[29] Tourniquets were not applied. All procedures were performed under general anesthesia.

Local physiotherapists provided rehabilitation services during admission, consisting of instructions for active and active-assisted ROM exercises. All patients received explicit exercise instructions during follow-up.

Data collection

Patient and treatment characteristics

Patient characteristics including age, sex, weight and comorbidity were documented. We classified contractures of the large joints and fingers using a modified classification of Ogawa et al.:[5] Type I, superficial with adipose layer preserved; Type II, linear band; Type III, linear band with diffuse scarring surrounding the band; and Type IV, broad band scar. Location of contracture, time since burn injury, and etiology were documented, as were contracture release surgery technique, adverse events, and graft take or flap failure were documented. Effective take was defined as more than 80%, partial graft or flap necrosis was defined as tissue survival between 30% and 80%, and complete graft or flap necrosis as tissue survival of less than 30%.

Outcome assessment and analysis

Passive ROM of the large joints was measured using lateral goniometry according to the protocol of Norkin and White.[30] Finger ROM was measured in the fist position, according to Richard et al.[31] In burns, joint ROM can be assessed accurately with a goniometer.[32]

ROM data were indexed to percentages of normal values, rather than absolute ROM values to control for different normal ROM values of the various joints. Normal values were retrieved from the American Academy of Orthopedic Surgeons (AAOS) for large joints[33] and from Richard et al. for fingers[31] (Supplemental Digital Content 1). Assessments were done before surgery and at 1, 3, 6 and 12 months after surgery. Loss to follow-up was minimized by extensive counseling of patients by telephone and compensation for traveling costs.

Sub-analyses were performed at three levels to evaluate outcome:

Planes of motion level (e.g. shoulder abduction): We analyzed the difference in percentage ROM preoperatively versus postoperatively. Only planes of motion that were affected were included (<100% of normal ROM preoperatively). It was verified whether excluded motions were still 100% of normal ROM at 12 months' follow-up.

Joint level (e.g. shoulder): We analyzed the number of joints that were effectively corrected. Effective surgery was defined as follows: when all planes of motion in a single joint showed an increase of at least 25% in ROM postoperatively, or ROM reached the 100% of normal ROM, if increase of ROM in all planes of motions was less than 25%.

Patient level: We analyzed the best joint (joint with most improvement) and worst joint (joint with least improvement) of a single patient. For both categories we calculated the percentage of joints that were effectively corrected, with "effectively" defined as described above.

Sample size calculation and statistics

We performed an a priori power analysis (G*Power 3 version 3.0.3.) to estimate the required sample size. We hypothesized that if patients were not treated, the ROM of their joints would not change: the known proportion is 0% improvement. If surgery could improve ROM by 25% in at least 60% of patients, eight patients would be needed to find a statistically significant difference between treatment and no treatment (alpha 5%, power 90%).

Data were analyzed using IBM SPSS Statistics version 22.0 (IBM Corp., Armonk, NY, USA). Data were described with summary statistics for continuous variables or number and percentage for the calculation of categorical variables. For analyses at the level of planes of motion, the difference in ROM preoperatively versus postoperatively was tested for statistical significance using the paired-t test. The difference between effective surgery at different measurement occasions was tested with chi-square tests to examine the long-term effects.

Results

A total of 44 patients, both children and adults, underwent contracture release surgery between December2017 and October 2018. The mean age of patients was 9 years (median 5.5, IQR 3.0-11.5). Patients underwent reconstruction at a mean of 1 141 days after the burn injury had occurred (IQR 471-1620 days) (Table 1).

A total of 70 joints were reconstructed if the fingers of one hand were counted as one joint. If all the fingers were counted separately, a total of 117 joints were corrected. Location and types of contractures are listed in Table 2.[34]

Table 1. Patient characteristics

Patient characteristics		
Total patients	44	100%
Males	20	45%
Age		
Mean, SD	9	9.1
Median, IQR	5.5	3.0-11.5
< 14 years	35	80%
>= 14 years	9	20%
Time after injury: mean days, IQR	1141	471-1620
Travelling time to hospital: mean hours, SD	5	8
ASA classification		
ASA I	42	96%
ASA II	2	4%
ASA III	0	0%
Hb, mean (SD)	11.9	1.3
Weight-for-age (< 10 yrs): mean SD, SD	-1.2	1.1
Weight-for-height (<10 yrs): mean SD, SD	-0.9	1.3
BMI: mean, SD	23.5	2.1
Smoker	0	0%

Table 2. Scar characteristics

	N	%
Etiology		
Scalds	17	39%
Fire	27	61%
Estimated TBSA, mean (SD)	7	8
Total joints	70	100%
Location		
Head/neck	0	0%
Upper extremity	33	47%
Axilla	7	10%
Elbow	14	20%
Wrist	12	17%
Hand digits	22	32%
Thumb	11	16%
Dig II	12	17%
Dig III	17	24%
Dig IV	15	21%
Dig V	14	20%
Lower extremity	15	21%
Hip/groin	7	10%
Knee	4	6%
Ankle	2	3%
Greater toe	2	3%
Type of contractures		
Type I: Superficial	0	0%
Type II: Linear	18	26%
Type III: Diffuse	24	34%
Type IV: Broad band	28	40%

In the group of linear scars, local flaps without graft were used in 12 cases (12/18: 67%), flaps combined with grafts in 4 cases (4/18, 22%), and grafts without local flap in 2 cases (2/18: 11%). In broadband contractures, local flaps without FTG were applied in 3 cases (3/28, 11%), local flaps combined with graft were applied in 12 cases (12/28, 43%), and grafts only in 13 cases (13/28: 46%) (Table 3 and Figure 1). Postoperative immobilization of hand joints with k-wires was preferred over a plaster splint (15/22: 68%).

Table 3. The type of contracture and the type of surgical technique applied

Type	N	%	Local flap only		Local flap + graft		Grafts only	
Linear	18	26%	12	67%	4	22%	2	11%
Diffuse	24	34%	9	38%	9	38%	6	25%
Broad band	28	40%	3	11%	12	43%	13	46%
Total	**70**	**100%**	**24**	**34%**	**25**	**36%**	**21**	**30%**

Notes: Local flap only, without additional grafts. Local flap + graft is a flap combined with grafts, preferably a FTG. Grafts only: grafts were used without a flap.

Figure 1a. Classified as broad band contracture.

Figure 1b. Results at 12 months after releasing the right hand.

Figure 1c. Markings for the contracture release surgery of the left hand.

Figure 1d. Infiltration with adrenaline solution to prevent blood loss.

Figure 1e. Incision of the scar contracture, proximal to the metacarpal joints, and releasing the contracture.

Figure 1f. Raising the FTG from the abdomen area to cover the defect.

Figure 1g. Direct postoperative result of the left hand, with K-wires inserted in the MCP joints in flexion.

Figure 1h. Result of the left hand at 9 months.

The follow-up rate at one year was 86% (38/44 patients, mean length of follow-up 329 days, SD 52). Mean graft take was 76% (SD 28%), with an effective graft take in 18 of 32 joints (56%). Complications are listed in Table 4. Overall, 41 complications occurred in 52% of patients (23/44). Flap tip necrosis occurred in 3 out of 30 large joints, and partial flap necrosis occurred in 3 out of 30 large joints (10%). Regarding major complications, one death occurred due to respiratory insufficiency caused by bilateral pneumonia.

Table 4. Surgical characteristics

Total procedures	44	
Total joints	70	
Average operation time, minutes	129	
Hospital stay, mean (SD)	11	7.7
Graft take		
Mean take	32	76%
Effective take (>80%)	18	56%
Partial necrosis (30-80%)	11	34%
Complete necrosis (<30%)	3	9%
Total complications		
Patient with complications, n (%)	23	53%
Total number of complications	44	100%
Major complications, n (%)		
Death	1	2%
Bilateral pneumonia	1	2%
Flap failure (major joints)		
No failure	22	68%
Tip necrosis (>80%)	7	22%
Partial failure (30-80%)	3	10%
Complete failure (<30%)	0	0%
Other minor complications, n (%)		
Surgical site infection	6	14%
Wound dehiscence	5	11%
Pin tract infection	5	11%
Re-admission (Secondary SSG)	3	7%
Re-release	2	5%
Donor site infection	2	5%
Re-admission (amputation dig V)	1	2%
Pneumonia	1	2%

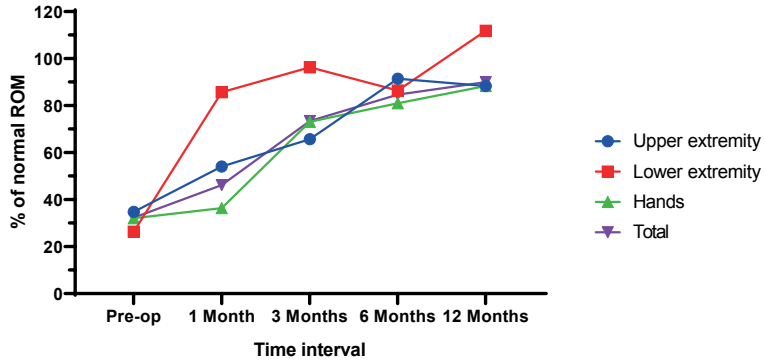

Figure 2a. The mean ROM of planes of motion (i.e. shoulder abduction).
Notes: the ROM data are indexed to % of normal ROM values, rather than absolute ROM values to control for different normal ROM values of the various joints.

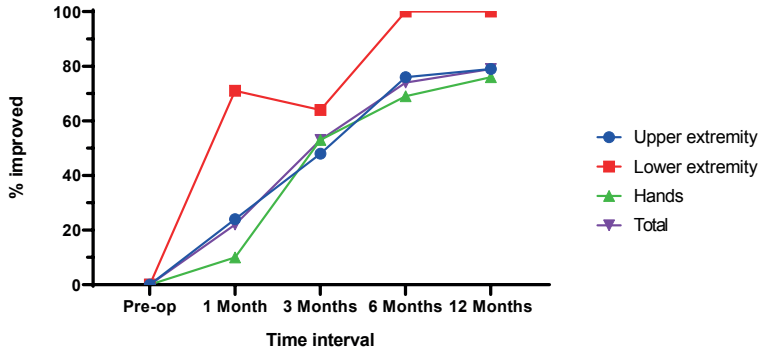

Figure 2b. The percentage of joints that effectively improved over time.

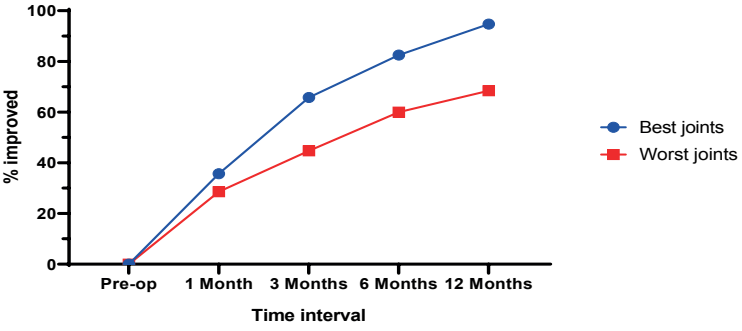

Figure 2c. The percentage of patients with an effectively improved joint over time.
Notes: the best joint was defined as: the joint with the most improvement. The worst joints was defined as: the joint with the least improvement.

Surgical outcomes

Planes of motion level

The mean preoperative ROM of all motions pooled was 32.3% of the normal value (n=228, SD 31.3). One month after surgery, the mean ROM was 46.2% (n=220, SD 39.9), at 3 months 73.3% (n=201, SD 36.4), at 6 months 84.7% (n=212, SD 31.8), and at 12 months 90.0% (n=207, SD 32.0). On all follow-up occasions the mean ROM increased statistically significantly ($p<0.001$) (Table 5 and Figure 2a). Similar improvements of ROM were observed in different types of contractures (Table 6).

Preoperatively, 0% of the planes of motion reached 100% of normal ROM. At one month this was 12.7% (n=28/220), at 3 months 33.3% (n=67/201), at 6 months 49.5% (n=105/214) and at 12 months 59.0% (n=124/207).

Sub-analysis of the upper extremity (n=66), lower extremity (n=24) and hands (n =137) showed that on all follow-up occasions the mean ROM values had improved statistically significantly compared to the mean preoperative ROM ($p<0.001$). One year after surgery, the mean improvement for the upper extremity was 53.5% of normal ROM ($p<0.001$), for the lower extremity 85.5% ($p<0.001$), and for hands 56.2% ($p<0.001$).

Joint level

At one month, 25 out of 115 joints (22%) were effectively corrected, i.e. the ROM improved more than 25% or reached 100% of normal ROM (95% CI: 14-29%, $\chi 2=33.2$, $p<.001$), at 3 months 56 out of 105 joints (53%, 95% CI: 44-63%, $\chi 2=88.7$, $p<.001$), at 6 months 81 out of 109 (74%, 95% CI: 66-83%, $\chi 2=152.9$, $p<.001$) and at 12 months 83 out of 105 joints (79%, 95% CI: 71-87%, $\chi 2=159.1$, $p<.001$). The sub-analyses of joint groups (i.e. upper extremity, lower extremity and hands) showed statically significant improvement between all follow-up occasions (Table 5 and Figure 2b).

Regarding age, at 1 and 3 months it was predictive for effectiveness (Nagelkerke $R^2=11\%$ and 11% respectively); a higher age was associated with a lower chance of effect on these measurement occasions ($p<.001$). After 6 months, the predictive power was less ($R^2 = 6\%$) and at 12 months age was no longer a predictor of effect ($R^2=3.6\%$; $p=0.11$). Thus the improvement of ROM was equal in older patients

but took longer. The number of days post-injury was only a significant additional predictor for effectiveness at 3 months (R^2=0.22; p=0.01).

Patient level

Examining each individual's most effectively treated joint, at 1 month follow-up, 15 of 42 patients had effectively improved in their best joint (35.7%, 95% CI: 21-50 %, χ2=18.8, p<.001). At 12 months, 36 out of 38 patients had effectively improved (94.7%, 95% CI: 88-102 %, χ2=73.35, p<.001) (Table 5 and Figure 2c).

Examining each individual's least effectively treated joint, at 1 month follow-up, 12 out of 42 patients had effectively improved in their worst joints (28.6%, 95% CI: 15-42 %, χ2=14.5, p<.001), p<.001). At 12 months 26 out of 38 patients had effectively improved (68.4%, 95% CI: 54-83 %, χ2=43.5, p<.001) (Table 5 and Figure 2).

Table 5. Analysis of planes of motion, joints and patient level over time

Planes of motion level*	**Pre-op**		**1 M**		**3 M**		**6 M**		**12 M**		**difference pre-op vs. 12M**	***p*-value**
total, n	228		220		201		212		207			
	Mean ROM	SD	Mean ROM	SD	Mean ROM	SD	Mean ROM	SD	Mean ROM	SD	Mean ROM	
upper extremity (n=66)	34.8	31.9	54.1	33.1	65.7	30.3	91.4	32.1	88.3	31.0	53.5	0.001
lower extremity (SD) (n=24)	26.3	28.5	85.7	42.7	96.3	46.0	86.4	39.5	111.8	51.3	85.5	0.001
hand digits (n=137)	32.1	31.5	36.4	38.3	73.1	35.9	81.0	30.0	88.3	28.9	56.2	0.001
overall (n=228)	32.3	31.3	46.2	39.9	73.3	36.4	84.7	31.8	90.0	32.2	57.7	0.001
Joint level**	**Pre-op**		**1 M**		**3 M**		**6 M**		**12 M**		**difference pre-op vs. 12M**	***p*-value**
total, n	117		115		105		109		105			
	%	95% CI	%	95% CI	%	95% CI	%	95% CI	%	95% CI	%	
upper extremity (n=33)	0	0	24	11-48	48	26-82	76	49-111	79	51-115	79	0.001
lower extremity (n=15)	0	0	71	34-131	64	29-122	100	52-174	100	48-184	100	0.001
hand (fingers) (n=69)	0	0	10	5-22	53	37-74	69	50-93	76	56-101	76	0.001
overall (n=117)	0	0	22	14-29	53	44-63	74	66-83	79	71-87	79	0.001
Patient level: best joint	**Pre-op**		**1 M**		**3 M**		**6 M**		**12 M**		**difference pre-op vs. 12M**	***p*-value**
total, n	44		42		38		40		38			
	n	%	n	%	n	%	n	%	n	%	%	
best joint effectively improved	-	-	15	36	25	66	33	83	36	95	95	0.001
Patient level: worst joint	**Pre-op**		**1 M**		**3 M**		**6 M**		**12 M**		**difference pre-op vs. 12M**	***p*-value**
total, n	44		42		38		40		38			
	n	%	n	%	n	%	n	%	n	%	%	
worst joint effectively improved	-	-	12	29	17	45	24	60	26	68	68	0.001

Notes: ROM data are expressed as a % of normal values (according to AAOS), rather than absolute ROM values due to different normal ROM values for the various joints

Mean differences displayed at 12 months. All other time intervals were statistically significant

*Analysis of the mean ROM of planes of motion (i.e. shoulder abduction, elbow extension, etc.) over time. ROM data values are expressed as a % of normal values (according to AAOS), rather than absolute ROM values due to different normal ROM values for the various joints

** Analysis of joints. Percentage of joint that had effective surgery. Effective is defined as: all directions in a single joint showed an improvement of at least 25% or reached 100% of normal values

Table 6. The type of contracture and the mean ROM over time*

Type	N**	Pre	1M	3M	6M	12M	Difference pre-post
Linear	30	48%	60%	79%	97%	102%	55%
Diffuse	95	41%	50%	86%	90%	96%	55%
Broad band	103	20%	37%	57%	74%	81%	61%
Overall	**228**	**33%**	**37%**	**46%**	**83%**	**90%**	**57%**

Notes: *ROM is indexed to normal ROM values according to AAOS. **N=number of planes of motion measured.

Discussion

This is the first longitudinal study which assessed the effectiveness of contracture release surgery, using ROM as a primary outcome measure and a clear statistical analysis. Our results demonstrate that in a rural setting in a LMIC, contracture release surgery could be performed safely and was effective in the vast majority of cases, resulting in significant improvement in ROM. Furthermore, it was effective on the long-term. At one year the follow-up rate was 86%, which was above expectations. A possible explanation is the effective collaboration between local and visiting doctors, hospital management and patients.

The few other studies that evaluated the effectiveness of contracture release surgery used various different outcome measures, which makes the comparison of outcomes difficult.[19,35–42] A systematic review of this topic concluded that most of these previous studies did not describe the type of contracture, or failed to conduct a proper statistical analysis, which further limited the interpretation of results.[22,35,37–39,43] ROM was the most frequently used outcome measure.[28-33]

In accordance with earlier studies, our study showed that ROM using lateral goniometry is a feasible outcome measure to evaluate burn scar contractures.[31,32,44,45] However, we developed a new strategy to assess the effectiveness of contracture release surgery. The change in ROM was analyzed on three levels: planes of motion, joints and patient level. This was done because a single plane of motion is not representative of the complete joint or patient.

In the present study local flaps were most frequently applied in linear contractures, as opposed to broad contractures, in which FTGs were more frequently applied. Interestingly, independent of the type of contracture, similar improvements in

ROM were observed up to one year postoperatively. In our experience, local flaps are still preferred over FTGs when possible, because they have less risk of tissue loss and provide a better quality of skin.[14–16] However, future studies with large cohorts are needed to determine which technique is more effective. Currently, our study suggests that surgical teams which are limited to one single surgical technique, can effectively use this single technique when no other options are available.

The complication rate was high (52%). The majority of cases, however, were minor and were treated conservatively. This rate is substantially higher compared to other studies, which reported complications of 0%[38–40], 14.8%[43] and 17%.[18] As our study was performed in a rural area of an LMIC, the higher rates may be partially explained by limitations in sterility or the non-availability of wound dressing materials. Compared to studies conducted in similar settings, our complication rate also seems high, as such studies report complication rates between 15% and 56%.[28,46,47] The reason for that may be the strict registration of complications and longer follow-up period of our study. However, even with the complications, surgery was effective.

Our results were obtained in a setting of reconstructive surgery missions. Such missions, which provide patients with reconstructive surgical care in LMICs, are often criticized for their lack of quality of care or sustainability, although data to substantiate this are frequently not available.[26–28,48] A recent systematic review found five studies reporting on contracture release surgery performed during missions. The quality of these studies was indeed generally low, with short-term follow-up and none using ROM as an outcome measure.[28]

Strengthening surgical burn care for the 11 million burn victims annually, who live predominantly in LMICs, is desperately needed.[2] Our study demonstrates that there are opportunities for a collaborative model of surgical missions, which implement outcome research during follow-up. The combination of the high complication rate and the follow-up rate shows that providing follow-up after missions is important and feasible; therefore a dedicated local team should be trained and supported. Adequate duration of follow-up would be 6 months, given that almost all complications and major improvements occurred in this period. Implementing outcome measurements in future surgical missions yields several advantages. It empowers local researchers and helps building an academic culture.

The data can be used for quality improvements, or can be reported to healthcare authorities and donors to improve accountability.

Limitations

This study has limitations. To determine whether surgery was effective or not, we chose an improvement of 25% of ROM or reaching 100% of the normal ROM value in all planes of motion in a single joint. This threshold is debatable, however, there are no previous studies to indicate when an operation was considered effective. The threshold of 25% was chosen as this seemed feasible and provided a substantial clinical improvement.

Our study used standard lateral goniometry to measure the ROM of the large joints. However, Parry et al. recently questioned this method in burn survivors.[31,44] Standard goniometry does not take into account the influence of adjacent joint positions and pliability of the skin when measuring motions. Future studies should consider using the method proposed by Parry et al.[44]

We are aware that this is a descriptive single-center study, presenting patient outcomes of various techniques in various contractures. This has several disadvantages: it cannot show superiority of one technique over another, and generalizability is limited. However, our study was conducted in a clinical setting in rural Tanzania, focusing on improving patient outcomes, using a common dataset and promoting quality improvements. As such, this pragmatic study provides urgently needed knowledge and evidence that is applicable to clinical practice in LMICs.[49] In addition, we suggest that our results can be used as a benchmark for future studies performed in similar settings.

Conclusion

Our study shows that contracture release surgery performed during surgical training missions in LMICs, can be performed safely and is effective in the long term. Findings show that minor complications are common; however, the follow-up rate was high, joint flexibility improved significantly and surgery was effective in the vast majority of patients.

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Chapter 7

Contracture release surgery effectively improves functional range of motion, disability and quality of life: a pre/post intervention cohort study with long-term follow-up

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Abstract

Objective

Burn scar contractures limit range of motion (ROM) of joints and have substantial impact on disability and the quality of life (QoL) of patients, particularly in a Low- and Middle-Income Country (LMIC) setting. Studies on the long-term outcome are lacking globally; this study describes the long-term impact of contracture release surgery performed in an LMIC.

Methods

This is a pre-post cohort study, conducted in a referral hospital in Tanzania. Patients who underwent burn scar contracture release surgery in 2017–2018 were eligible. ROM (goniometry), disability (WHODAS 2.0) and QoL (EQ-5D) were assessed. The ROM data were compared to the ROM that is required to perform activities of daily living without compensation, i.e. functional ROM. Assessments were performed preoperatively and at 1, 3, 6 and 12 months postoperatively.

Results

In total, 44 patients underwent surgery on 115 affected joints. At 12 months, the follow-up rate was 86%. The mean preoperative ROM was 37.3% of functional ROM (SD 31.2). This improved up to 108.7% at 12 months postoperatively (SD 42.0, $p<0.001$). Disability-free survival improved from 55% preoperatively to 97% at 12 months ($p<0.001$) postoperatively. QoL improved from 0.69 preoperatively, to 0.93 (max 1.0) at 12 months postoperatively ($p<0.001$). Patients who regained functional ROM in all affected joints reported significantly less disability ($p<0.001$) and higher QoL ($p<0.001$) compared to patients without functional ROM.

Conclusions

Contracture release surgery performed in an LMIC significantly improved functional ROM, disability and QoL. Results showed that regaining a functional joint is associated with less disability and higher QoL.

Background

Burn scar contractures are an important cause of disability in burn survivors globally.[1–6] Contractures are problematic scar formations, causing a limited range of motion (ROM) of a joint.[2,7–9] They can be disfiguring, severely limit joint function,[3] and may have a substantial impact on quality of life (QoL).[10] Without adequate treatment patients might be left with lifelong disabilities.[1]

Several interventions are available to prevent the development of scar contractures, such as skin grafting, splinting, positioning, or physiotherapy.[11–14] However, even with adequate treatment, contractures are still common worldwide, with its prevalence varying between 38% and 54% at discharge.[2,3,8,15]

Regarding Low- and Middle-Income Countries (LMICs), only a few epidemiological studies are available concerning burns,[16–18] and the prevalence of contractures in these countries is still unknown.[2,3] However, studies report a high incidence of contractures in LMICs,[1,6,18–20] and contracture release surgery is frequently performed to alleviate disability.[21–25]

Although frequently performed, current knowledge remains limited regarding functional recovery after contracture release surgery.[26,27] A systematic review on this topic concludes that few studies are available,[26–35] providing limited information about the effectiveness of surgery due to limitations in study methodology and heterogeneity of outcome measures.[26]

Moreover, while the relevance of burn scar contractures lies in their limiting effect of joint function and the performance of daily activities,[36] none of the studies assessed whether function was attained and only a few assessed disability or QoL after contracture release surgery.[23,26] To determine recovery of function, it was recently proposed to use functional ROM.[36,37] Functional ROM is a function-based cut-off value, defined as the ROM required to perform activities of daily living.[37] Therefore, this study aimed to evaluate the impact of contracture release surgery performed in an LMIC by assessing the change in functional ROM, disability and QoL up to one-year postoperatively.

Methods

This pre/post intervention study, was conducted in Haydom Lutheran Hospital (HLH), a rural referral hospital in Tanzania. Patients who underwent burn scar contracture release surgery in 2017- 2018 were eligible. Children and adults were eligible. All patients gave written informed consent. Authorities of Tanzania granted ethical clearance (NIMR/HQ/R.8a/Vol.IX/2652).

Surgery was performed according to international guidelines, specified to resource-limited settings.[38,39] In burn scar contracture release surgery, the scar is released and covered by tissue that lengthens the scar. In this study local fasciocutaneous flaps were preferred to grafts, and full-thickness grafts to split skin grafts.[40] Joint capsules and soft tissues around joints were not intervened.⁴⁰ During admission, physiotherapists provided rehabilitation services, consisting of instructions for ROM exercises. All patients received explicit exercise instructions during follow-up.

Data collection

Functional ROM is defined as "the movement angle required of a joint, to naturally perform activities in daily life"[37,41] as opposed to normal ROM, which is the maximal ROM value of healthy individuals.[42] Functional ROM cut-off values were retrieved from Korp et al.[37] ROM values were indexed to percentages of functional ROM values instead of absolute values, to enable comparisons of different joints.

In affected large joints, all planes of motion were measured passively according to the goniometry measurement protocol by Norkin and White.[42,43] Fingers were measured in a functional fist position according to the protocol by Richard et al.[44] The minimal detectable change at the ankle joint was defined as 5 degrees and at all other joints 9 degrees, in accordance with a reliability study in burns.[45] Joints were divided into three groups: joints of the upper extremity, lower extremity, and fingers. (Figure 1)

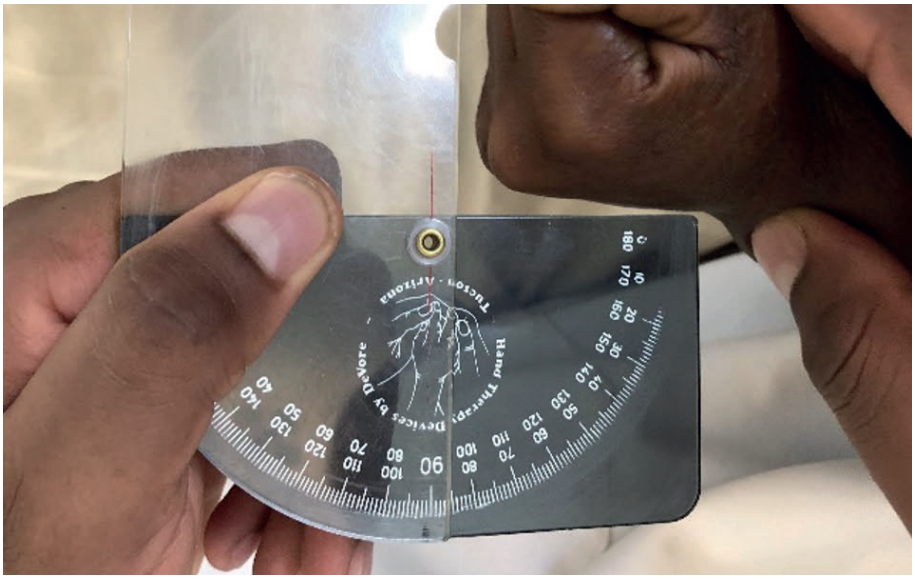

Figure 1a. Examples of goniometry. Measurement of the hand in a fist position (composite measurement) according to Richard et al.[44]

Figure 1b. Examples of goniometry. Measurement of a large joint according to the lateral goniometry protocol of Norkin and White.

Disability was assessed using the World Health Organization Disability Assessment Schedule version 2.0 (WHODAS 2.0) in Kiswahili language.[46,47] The instrument contains 12 items, scored on a 5-point Likert scale. It is interculturally applicable and validated for postoperative disability assessment.[46–49] In children 1-18 years of age, the questionnaire was administered by proxy.[50] An overall score was calculated, ranging between 0-1, with higher scores reflecting greater disability. Disability-free survival was assessed, defined as a score below 0.25 according to Shulman et al.[46]

Health-related Quality of Life (QoL) was assessed using the EuroQoL-5D-3L questionnaire. The instrument contains 5 items, scored on a 3-point Likert scale. It is available in Kiswahili language, and adapted for children of 8 years and older (EQ-5D-Y).[51–53] The questionnaire is validated to assess QoL after surgery and burns, and can be used by proxy in children 1-7 years of age.[54–56] An index measure was calculated ranging between 0-1, with higher scores reflecting better QoL.[51]

Assessments were performed preoperatively, 1, 3, 6 and 12 months postoperatively. To ensure follow-up, patients were contacted by telephone and outreach, and received reimbursement for travelling costs.

Sample size calculation

We performed an a priori power analysis (G*Power 3 version 3.0.3.) to estimate the required sample size. We hypothesized that after surgery, all movements in a single joint would reach functional ROM.[37,41] We assumed that the ROM would not change if mature scars were not treated, meaning that 0% improvement is the known proportion. If 20% of patients regained functional ROM after surgery, 17 patients or 8 patients (alpha 5%, power 80%) are needed to be included to find a statistically significant difference.

Data analyses

Analyses were performed at three levels.

Planes of motion level (e.g. elbow extension): the difference in percentage of functional ROM preoperatively versus postoperatively was analyzed. Only affected

planes of motion were included in this analysis, defined as planes of motions <100% of functional ROM preoperatively. It was verified whether excluded motions were still 100% of functional ROM 12 months postoperatively.

Joint level (e.g. elbow): the number of functional joints was assessed. A functional joint was defined as a single joint in which movements in all planes of motion reached a ROM of at least 100% of the functional ROM value. The isolated ROM of three joints in a single finger were analyzed aggregately, because all three joints are involved in flexion of a functional fist position.[44]

Patient level: the best and worst treated joints of each individual patient were analyzed. The best joint was defined as the joint with most improvement in percentages of functional ROM. The worst joint was defined as the joint with least improvement. For both we calculated the percentage of patients who regained a joint with full functional ROM.

Paired t-tests were performed to analyze changes in preoperative versus postoperative measurements. Due to the small sub-groups, non-parametric one-sided Mann-Whitney-U tests were performed to assess differences in disability and QoL between patients who regained functional ROM and patients who did not. For these analyses, the worst joint per patient was chosen, because the worst joint informs about the function of all other affected joints of a patient. Data were analyzed using IBM SPSS Statistics version 22.0 (IBM Corp.), with alpha at 5%.

Results

In total 44 patients underwent contracture release surgery. The median age was 5.5 years (IQR 3-11.5, range 0.5-48 years), 80% of the patients were under 14 years. Patients received treatment at a median of 681 days post-burn (IQR 471-1 620 days). The follow-up rate was 86% after 12 months (38/44 patients) with a mean follow-up duration of 329 days (SD 51.9). Surgical intervention and complications are listed in Table 1.[40] (Table 1)

Table 1. Patient, scar and surgical characteristics and complications

Patient characteristics	n	%
Total patients	44	
Males	20	45%
Age, median years (IQR)	5.5 (3-11.5)	
< 14 years	35	80%
>= 14 years	9	20%
Time after injury		
Mean days (SD)	1 141 (1 800)	
Median days (IQR)	681 (471-1620)	
Travelling time to hospital, mean hours (SD)	5 (8)	
Scar clinical characteristics		
Etiology		
Scalds	17	39%
Fire	27	61%
Estimated TBSA, mean (SD)	6.9 (8)	
Total joints*	70	100%
Location		
Head/neck	0	0%
Upper extremity	33	47%
Lower extremity	15	21%
Fingers	22	32%
Surgical characteristics		
Total procedures	44	
Total joints	70	
Hospital stay		
Mean days (SD)	11 (7.7)	
Median days (IQR)	10 (5-17)	
Surgical techniques		
Local flap only	24	34%
Local flap combined with graft	25	36%
Graft only	21	30%
Postoperative complications		
Patient with complications	23	52%
Total number of complications	44	100%
Minor complications	42	96%
Partial graft necrosis (30-80%)	11	34%
Complete graft necrosis (<30%)	3	9%
Partial flap necrosis (30-80%)	3	10%
Complete flap necrosis (<30%)	0	0%
Surgical site infection	6	14%
Wound dehiscence	5	11%
Pin tract infection	5	11%
Re-admission (Secondary SSG)	3	7%
Re-release	2	5%
Donor site infection	2	5%
Re-admission (amputation dig V)	1	2%
Pneumonia	1	2%
Major complications	2	5%
Death	1	2%
Bilateral pneumonia	1	2%

Functional range of motion

Planes of motion level

In total 158 affected planes of motion were assessed. The preoperative mean ROM was 37.4% of functional ROM (n=158, SD 31.2%). At 1 month postoperatively, the mean ROM was 79.1% (SD 50.6%), at 3 months 91.6% (n=141, SD 44.8%), at 6 months 100.0% (n=151, SD 39.9%), and at 12 months it was 108.7% of the functional ROM (n= 146, SD 42.0%). At all time-intervals, differences were statistically significant with all p-values <0.001. (Table 2 and Figure 2a)

Preoperatively all 158 planes of motion were below the functional ROM cut-off value (0%). At 1 month postoperatively, 35% of planes of motion reached the functional ROM (n=154; 95% CI: 28-43%), at 3 months 44% (n=141; 95% CI: 36-50%), at 6 months 52% (n=151; 95% CI:46-60%) and at 12 months 62% (n=146; 95% CI: 54-70%).

A sub-analysis of the upper extremity (n= 46), lower extremity (n=13) and fingers (n=99) showed that at 12 months the improvement in functional ROM was 62.4% (p<0.001), 99.7% (p<0.001) and 72.9% (p <0.001), respectively. At all other occasions, mean differences were also statistically significant. (Table 2)

Table 2. Functional ROM analyses at planes of motion, joint and patient level

Planes of motion: mean functional ROM	**Pre-op (n=158)**		**1 M (n=154)**		**3 M (n=141)**		**6 M (n=151)**		**12 M (n=146)**		**difference pre-op vs. 12 M**	***p*-value**
	%	SD	%	SD	%	SD	%	SD	%	SD	%	
Upper extremity (n = 46)	34%	31.4	61%	39.2	71%	34.6	89%	39.4	97%	39.1	62%	0.001
Lower extremity (n =13)	25%	23.5	85%	34.0	94%	26.4	11%	29.8	124%	51.0	100%	0.001
Fingers (n=99)	40%	31.7	87%	54.7	99%	47.5	104%	40.4	113%	41.8	73%	0.001
Total	37%	31.2	79%	50.6	92%	44.8	100%	39.9	109%	42.0	71%	0.001
Joints: percentage of joints with functional ROM	**Pre-op (n=115)**		**1 M (n=113)**		**3 M (n=105)**		**6 M (n=107)**		**12 M (n=103)**		**difference pre-op vs. 12 M**	***p*-value**
	%		%		%		%		%		%	
Upper extremity (n = 33)	3%		18%		33%		48%		58%		55%	0.001
Lower extremity (n =13)	15%		50%		57%		70%		75%		60%	0.001
Fingers (n=68)	18%		16%		53%		64%		66%		48%	0.001
Total (SD)	13%		20%		49%		60%		64%		51%	0.001
Patients: percentage of best and worst joints with functional ROM	**Pre-op (n=43)**		**1 M (n=41)**		**3 M (n=37)**		**6 M (n=39)**		**12 M (n=36)**		**difference pre-op vs. 12M**	***p*-value**
	%		%		%		%		%		**%**	
Best joint of a patient	19%		34%		65%		74%		83%		65%	0.001
Worst joint of a patient	5%		20%		46%		62%		61%		56%	0.001

Notes: ROM data are expressed as a % of functional ROM values. Values were obtained from Korp et al. For the analyses at the level of planes of motion, the difference was tested using the paired-t test. For analyses at joint level and patient level, the difference between was tested with the chi-square tests.

Joint level

Recovery of functional ROM was assessed in 115 affected joints. Preoperatively, 13% of joints were functional (n=15). At 1 month postoperatively, 20% of joints were functional ($p<0.155$), at 3 months 49% ($p<0.001$), at 6 months 60% ($p<0.001$) and at 12 months 64% ($p<0.001$). In the sub-analysis of the upper extremity, lower extremity and fingers, statistically significant improvement was observed over time, except for the fingers at the first month. (Table 2 and Figure 2b)

Patient level

Regarding the best operated joints, 8 of the 43 (19%) patients had a functional joint preoperatively. At 1 month postoperatively, 14/41 (34%) patients ($p=.034$), at 3 months 24/37 (65%) patients ($p<0.001$), at 6 months 29/39 (74%) patients ($p<0.001$) and at 12 months 30/36 (83%) patients had a functional joint ($p<0.001$).

Regarding the worst operated joints, 2 out of 43 (5%) patients had a functional joint preoperatively. At 1 month postoperatively 8/41 (20%) patients ($p=.0037$), at 3 months 17/37 (46%) patients ($p<0.001$), at 6 months 24/39 (62%) patients ($p<0.001$) and at 12 months 22/36 (61%) patients had a functional joint ($p<0.001$). (Table 2 and Figure 2c)

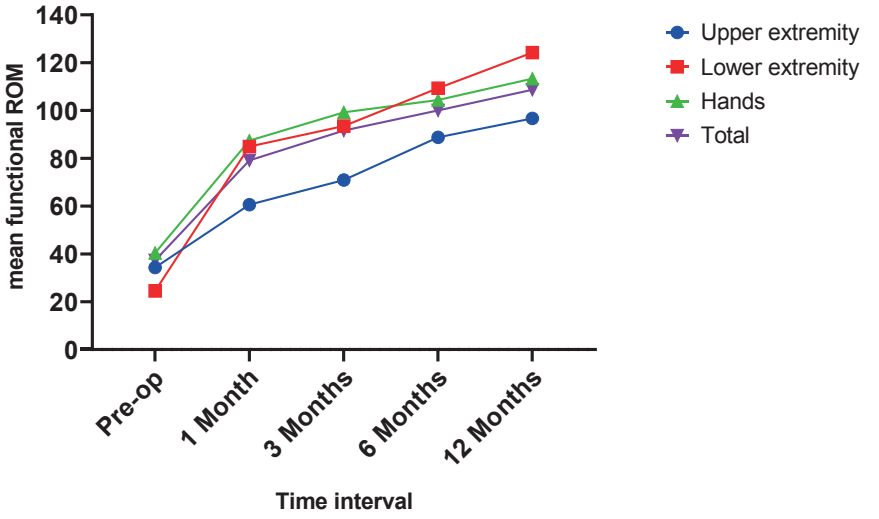

Figure 2a. The mean functional ROM over time. Analysis at the level of planes of motion (i.e. shoulder abduction).

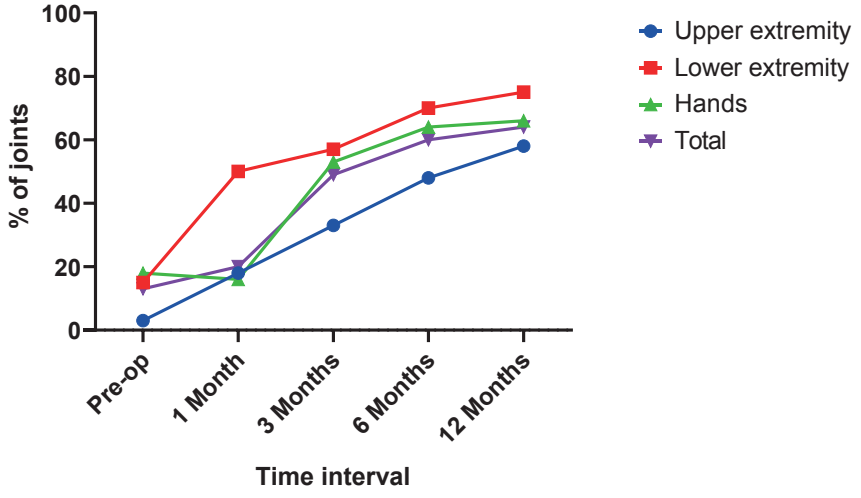

Figure 2b. The percentage of joints with functional ROM over time. Analysis at the level of joints.

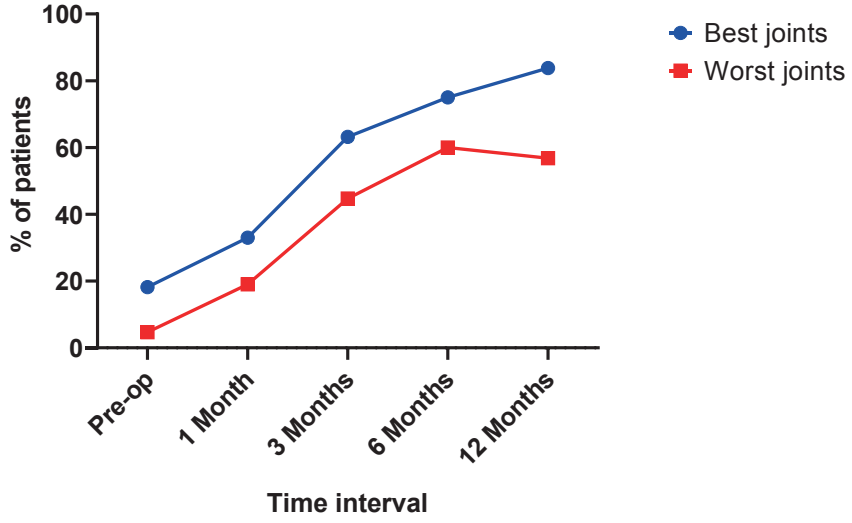

Figure 2c. The percentage of best and worst joints with a functional ROM. Analysis at the level of patients.

Disability (WHODAS 2.0)

At group level, the preoperative mean disability score was 0.22 (n=44, SD 0.13). At 1 month postoperatively it improved to 0.13 (SD 0.10, $p<0.001$), and up to 0.03 at 12 months (SD 0.06, $p<0.001$). At individual level, 24 out of 44 patients (55%; 95% CI 41-69%) reported to be disability-free preoperatively, which improved to 37 out of 38 patients at 12 months (97%; 95% CI 82-100%). (Table 3 and Figure 3)

There was an association between functional ROM and disability. Patients with functional ROM in all operated joints reported significantly less disability, compared to patients who did not ($p<0.001$). Overall differences and at 6 months were statically significant ($p=0.04$). At all other measurement occasions there was a trend towards less disability in patients with functional ROM. (Table 4 and Figure 4a)

Table 3. Patient-reported outcomes on disability, quality of life

Disability (WHODAS 2.0)	**Pre-op (n=44)**		**1 M (n=42)**		**3 M (n=38)**		**6 M (n=40)**		**12 M (n=38)**	
	score	SD	score	SD	score	SD	score	SD	score	SD
Disability, mean (SD)	0.22	0.13	0.13	0.10	0.06	0.07	0.05	0.06	0.03	0.06
% Disability-free survival*	54%		90%		95%		98%		97%	
Quality of Life (EQ-5D)	**Pre-op (n=44)**		**1 M (n=42)**		**3 M (n=38)**		**6 M (n=40)**		**12 M (n=38)**	
	score	SD	score	SD	score	SD	score	SD	score	SD
QoL , mean (SD)	0.69	0.14	0.79	0.12	0.86	0.12	0.89	0.13	0.93	0.10

* The proportion of patients with disability-free survival assessed with the WHODAS 2.0 instrument. A score below 0.25% was defined as disability-free.[46]

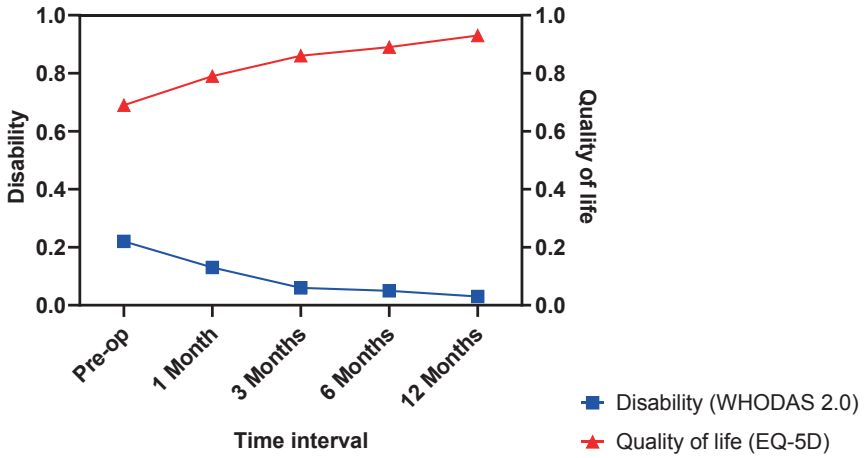

Figure 3. Patient-reported outcomes over time on disability and QoL.

Quality of Life (EQ-5D-3L)

The preoperative mean QoL score was 0.69 (n=44, SD 0.14). At 1 month postoperatively the mean QoL score improved to 0.79 (p=.006), at 3 months to 0.86 (p<0.001), at 6 months to 0.89 (p<.001), and at 12 months to 0.93 (p<.001). (Table 3 and Figure 3)

There was an association between functional ROM and QoL. Patients who regained a functional ROM in all operated joints reported significantly higher QoL, compared to patients who did not (p<0.001). Significant differences were found at 3, 6, 12 months and overall, with higher QoL for patients with functional ROM (p=0.01, p=0.02 and 0.03 respectively). (Table 4 and Figure 4b)

Table 4. Disability and QoL; differences between patients with a functional ROM and patients without a functional ROM

Disability (WHO DAS 2.0)									
		Functional ROM +			Functional ROM -			Z-score	*p*-value
	n	n	Median	IQR	n	Median	IQR		
Pre-op	42	2	0.13	0.00-0.01	40	0.20	0.13-0.28	0.89	0.215
1 M	42	8	0.05	0.02-0.18	34	0.13	0.07-0.21	1.19	0.125
3 M	38	17	0.00	0.00-0.04	21	0.08	0.04-0.10	2.40	0.09
6 M	40	24	0.01	0.00-0.06	16	0.06	0.00-0.10	1.77	0.038*
12 M	37	21	0.00	0.00-0.00	16	0.02	0.00-0.08	1.81	0.07
Total	199	72	0.00	0.00-0.05	127	0.20	0.04-0.21	6.34	<0.001*
Quality of Life (EQ5D-3L)									
		Functional ROM +			Functional ROM -			Z-score	*p*-value*
	n	n	Median	IQR	n	Median	IQR		
Pre-op	42	2	0.89	0.77-0.94	40	0.72	0.58-0.77	1.58	0.065
1 M	42	8	0.78	0.75-0.81	34	0.77	0.70-0.81	0.70	0.25
3 M	38	17	1.00	0.83-1.00	21	0.81	0.77-0.86	2.22	0.0145*
6 M	40	24	1.00	0.82-1.00	16	0.85	0.75-1.00	2.00	0.0225*
12 M	37	21	1.00	1.00-1.00	16	0.86	0.83-1.00	2.25	0.0255*
Total	199	72	1.00	0.81-1.00	127	0.77	0.70-0.84	6.28	<0.001*

Notes: Non-parametric one-sided Mann-Whitney U tests were performed to assess differences in disability and QoL between patients who regained functional ROM and patients who did not. *Statistically significant differences

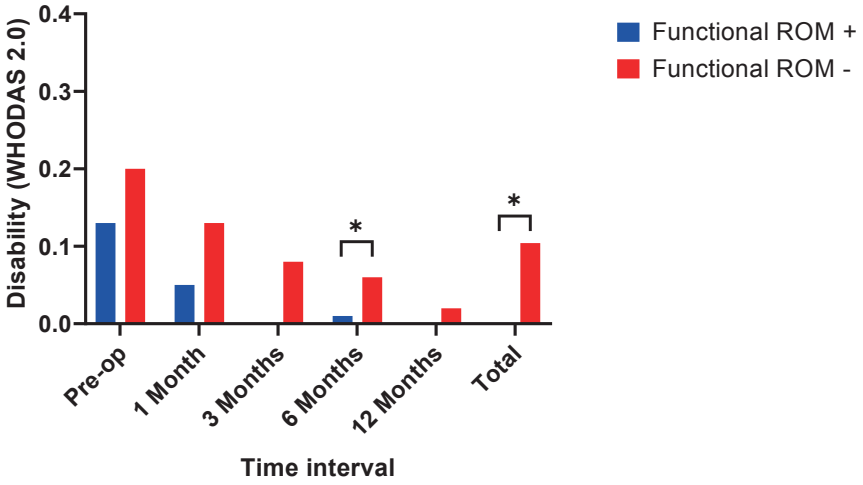

Figure 4a. Difference in disability between patients who had a functional ROM and patients who did not have a functional ROM. One-sided Mann-Whitney U tests were performed. Regarding disability, the median of the total disability score was used (WHODAS 2.0).

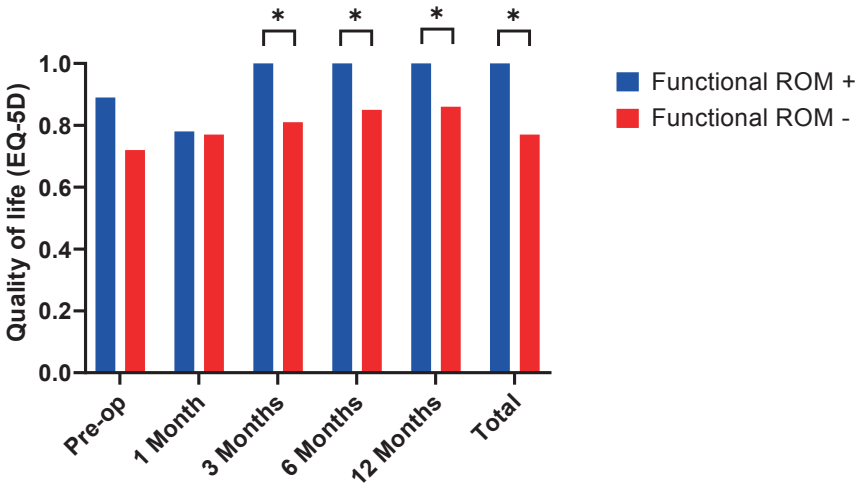

Figure 4b. Difference in QoL between patients who had a functional ROM and patients who did not have a functional ROM. For QoL the median of the index score was used (EQ-5D).

Figure 5a. Preoperatively.

Figure 5b. Dissecting the flaps of the five-flap plasty in the elbow.

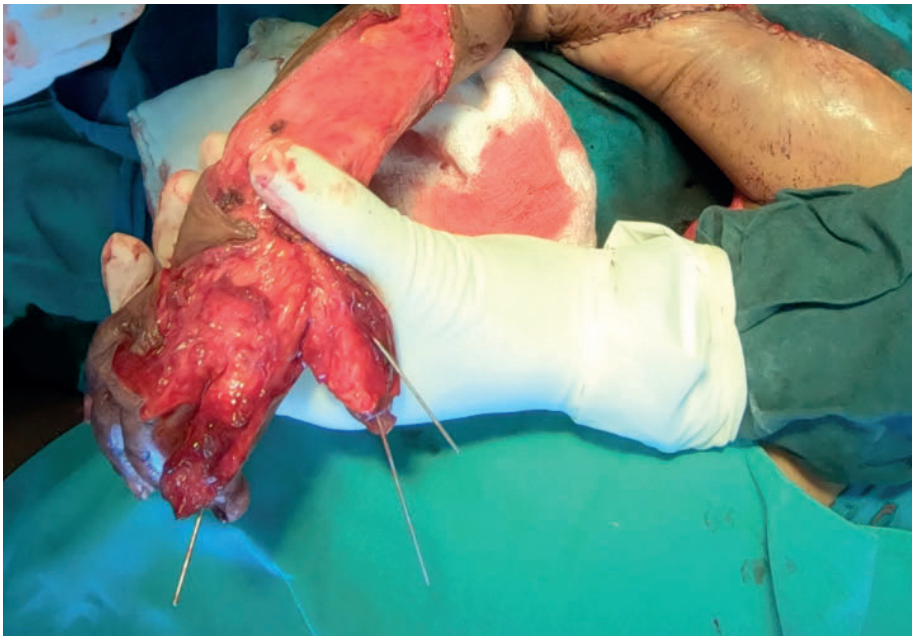

Figure 5c. The defect that remained at the wrist and dorsum of the hand after releasing the scar.

Figure 5d. Direct postoperative results.

Figure 5e. Result at 12 month follow-up.

Figure 5f. Result at 12 month follow-up.

Discussion

This is the first longitudinal study globally that evaluated the functional impact of burn scar contracture release surgery. It showed that contracture release surgery, performed in a low-income country, significantly improved functional ROM, reduced disability and improved the QoL. Moreover, we showed that patients who regained functional joints after surgery were associated with having less disability and higher QoL compared to patients who did not regain functional joints.

The strengths of this study are its evaluation of surgery in the setting of an LMIC, its long-term and high-rate follow-up, which offer a greater understanding of contracture release surgery than previous studies.[26] The setting of this study is relevant, as the majority of severe burns occur in LMICs, and improved access to effective treatment can have substantial impact.[6,18–20,57]

We showed that the mean functional ROM and the number of functional joints improved significantly. In previous studies, scar contractures were assessed by comparing ROM to normal ROM values. None of the existing studies, all performed in HICs, evaluated the regaining of functional ROM,[26,28–35,58] whereas the problem with scar contractures is their hindering of daily activities.[36] The use of normal ROM is only relevant if it approximates the ROM required to perform daily activities – functional ROM. For several joints and planes of motions, however, there is a large discrepancy between normal ROM and functional ROM values.[36,37,42] To better understand the effect of contractures on loss of function, we agree with Oosterwijk et al. that the actual ROM should be compared with the functional ROM.[36]

Results also showed that regaining functional ROM after surgery is associated with less disability and higher QoL. Disability and QoL have been assessed in the rehabilitation of burn survivors,[55,59,60] but regarding contracture release surgery only in one other study. This study lacked an analysis of functional ROM and had a short follow-up.[23]

Our study, in line with the framework of the International Classification of Functioning,[61] suggests that the combined assessment of functional ROM, disability and QoL is feasible and valuable. This combination provides insight into the performance of joints and performance of patients in daily life;[62] valuable indicators of the results of treatment. It is our strong contention that this method

should be incorporated into future studies, not exclusively of contracture release surgery, but all studies concerning joint flexibility.

Overall, the sub-analyses of the upper, lower extremity and fingers showed significant improvements of joints with minor variations between groups. Such variations can partially be explained by discrepancies between functional and normal ROM values.[37,41] Functional ROM of elbow extension e.g. is 100% of normal ROM, whereas for shoulder abduction it is 50% of normal ROM.[37,42] Achieving functional ROM after surgery is therefore more difficult in the elbow than the shoulder.

These discrepancies in functional and normal ROM also explain why 13% of the patients underwent reconstructive surgery while having functional ROM prior to surgery; ROM may have been functional, but normal ROM could still be substantially reduced.

Standard lateral goniometry in the anatomical position was used to measure ROM of the large joints. However, Parry et al. recently questioned this method in burn survivors and recommended a revised protocol based on cutaneous functional units and functional positions of joints.[7,44]

This study has some limitations. Caution is needed when comparing with results from HICs, as resources to prevent and treat burn scar contractures differ significantly,[63] and scar contractures appear less severe in HICs. Functional ROM allows classification of joints as 'functional' or 'not functional' in daily activities,[2,37] which is valuable information for patients and clinicians. Functional ROM values, were retrieved from studies that conducted and validated in HIC populations.[37,41] Since daily activities vary between different populations and cultures, functional ROM values will vary accordingly.[37]

Currently no consensus exists on which Patient-Reported Outcome Measures (PROMs) should be used in burn survivors.[55] We chose questionnaires which were feasible and appropriate for our population and setting. Others questionnaires, e.g. the QuickDASH, were regarded less appropriate as they were either specified for populations in HICs, or they were considered too extensive for a resource-limited setting.[64,65] Finally, it was necessary to use proxy results for children under the age of 8 (EQ-5D) and 18 (WHODAS), which calls for a more cautious interpretation of the results.

Conclusion

This pre-post intervention study demonstrated that burn scar contracture release surgery performed in an LMIC, significantly improved joint functionality, reduced disability, and improved QoL. Results showed that regaining a functional joint after surgery is associated with less disability and higher QoL. It is recommended that future studies combine the assessment of functional ROM, disability and QoL.

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Chapter 8

Discussion and future perspectives

Discussion

This thesis addresses three main themes of burn care in resource-limited settings. The first part is dedicated to short-term reconstructive surgical missions. The second part reviews acute burn care in resource-limited settings. The third part studies contracture release surgery performed in resource-limited settings.

Aim of this thesis

The aim was to evaluate current burn care practice in a resource-limited setting and to gain insights into the strengths and weaknesses of the practice. These insights may guide future improvements and can contribute towards improving the equity of burn care for underserved populations that live in resource-limited settings.

The current state of burn care in resource-limited settings

A vast disparity in burn care worldwide

There is a vast disparity in burn care worldwide. This thesis confirms that mortality and disability rates are disproportionally high in resource-limited settings, and that children and people in lower socioeconomic classes are particularly vulnerable.

Previous studies have pointed out that evidence of the clinical outcomes of burn care is scarcely available.[1,2] This thesis contributes by shedding light on the burn care in a large rural referral hospital in a resource-limited setting. Our studies showed that the in-hospital mortality rate is high. Patients present with life-threatening complications after a prolonged delay of several days. In the first days after admission, patients face a high risk of mortality, with 88% of deaths occurring within two weeks after admission. Common causes of death are comparable to those of high-income countries (HICs), and include sepsis and multi-organ failure.[3] The mortality rate in our cohort was 11.4% for all burns, which is in line with the results of studies dealing with comparable settings. A systematic review from our group reported an overall mortality rate of 13.1% for burn patients in sub-Saharan Africa.[4] Compared to the figures for HICs, this mortality rate is considerably higher. Large burn registries of these countries report a mortality rate of 1.5%.[3,5,6]

Patients who survive may face long-term physical consequences of burns, such as burn scar contractures. In this thesis we show that the prevalence of burn scar

contractures is high at one year post-injury. In our study described in Chapter 4, we show that contractures developed in 25% of all joints with burns and in 31% of operated joints (i.e. the joints that underwent skin grafting). Similar studies performed in HICs report a lower prevalence.[7,8] A comparable study by Schouten et al., for example, reported a prevalence of 20.9% in operated joints after one year post-injury. We further show in Chapter 4 that these burn scar contractures have a major impact on patients and their lives. The contractures that develop in joints frequently cause limitations in the performance of daily activities. The patients who developed a contracture suffer considerably more disability and lower quality of life. Our findings show that these patients reported significantly more disability and lower quality of life compared to patients who did not develop a contracture.

The strengths of our studies are the long-term follow-up, high-follow-up rate and the use of validated outcome measurements. Our studies therefore provide relevant and valuable information based on clinical data derived from a setting that until now remained largely concealed. However, it is important to note that we performed single-center studies and therefore our findings have a limited generalizability and cannot be extrapolated to all resource-limited settings worldwide. This holds particularly true for public health issues, because these issues are contextually and culturally dependent. For example, healthcare financing, health-seeking behavior, or the strengths of local healthcare services, may vary between different settings.

Limited access to safe and timely burn care

We found that in our setting burn care is only delivered to a limited extent to the poor populations in need. Chapter 5 discusses the fact that prior to admission to a burn care center, patients face three fundamental barriers that cause substantial delays in care. These are the affordability of burn care, the timeliness of reaching a healthcare facility that can provide burn care and the lack of capacity of local hospitals to provide surgical treatment for burn wounds.

An inadequate healthcare workforce may contribute to the latter two barriers, namely timeliness and the lack of surgical capacity. The Tanzanian healthcare authorities and training institutes are making substantial progress towards addressing the shortages of the surgical workforce. For example, Haydom

Lutheran Hospital successfully trains nurses and associate clinicians (i.e. physician assistants). The training incorporates burn care.[9] Haydom also trains over 20 medical doctors annually during their final clinical rotations. Another example is the College of Surgeons of East, Central and Southern Africa (COSECSA). This is a training institute that provides a surgical training program in rural areas, which runs alongside the programs of national universities. COSECSA aims to scale up their training efforts and have an annual increase in the number of trainees and graduates. In 2020 over 760 trainees were enrolled in COSECSA programs and 450 specialist surgeons have graduated since 2004.[10,11] However, despite these initiatives, the Lancet Commission on Global Surgery points out that the current training efforts still need to be increased to address the shortages of the surgical workforce.[12] Our findings in this thesis indicate that, next to the national and regional training programs, sustainable training partnerships can be of value.

Affordability is a predominant barrier for access to burn care, both for patients and hospitals. Our findings show that only a small proportion of patients have healthcare insurance and the majority of them face financial catastrophe due to out-of-pocket expenditures for burn care. Concerning hospitals, several aspects make burn care resource intensive. It requires long-term nursing care, wound care materials, medication and often multiple surgeries that require specialized surgical equipment. As a consequence of the current unaffordability, initiatives are urgently needed that can limit out-of-pocket payments, ensure financial protection of patients, and can finance the burn care services of hospitals.

After admission to a burn care center, new barriers arise that cause delays in providing appropriate care in time. From our experiences in Chapter 4 we learned that simply providing care for patients with large, deep burns can be a challenge. In our setting patients present after a delay of several days with life-threatening complications, such as sepsis, acute kidney failure and severe acute malnutrition. Although these conditions require intensive and advanced care, such options are only available to a limited extent. This may be due to the lack of monitoring systems, laboratory facilities and mechanical ventilation, the shortages of adequately trained intensive-care nurses, poor health worker motivation and the level of organization at a hospital. These factors contribute to the high mortality rate seen in the first days post-admission.

Furthermore, there are limited treatment modalities available to prevent and treat contractures. Several factors seem to contribute to delays in wound closure, and these may contribute to excessive scar formation and the development of contractures. We put forward four important factors that might explain the high prevalence of contractures:

A. When patients present with a life-threatening condition, considerable time and effort are needed to improve their condition, which prevents a shift of attention and resources towards optimal wound healing and wound closure.

B. Positioning of joints and appropriate wound care dressing poses a challenge, given the limited number of wound-care nurses, limitations in topical therapies, splints, wound dressings and sterile materials.

C. Physiotherapy and rehabilitation services are only available to a limited extent. Even if they are available, only a limited number of physiotherapy staff is available during admission due to limited financial resources. These services are often unaffordable after discharge. Rehabilitation therapists are often not available in resource-limited settings.

D. Only limited appropriate surgical treatment is available due the limited number of doctors and nurses who have experience of skin grafting, the limited availability of equipment, supplies and products (e.g. blood products), and out-of-pocket payments.

When healthcare workers are adequately trained, surgery can be performed safely and effectively in a resource-limited setting

In our studies we found evidence that surgery for burn injuries and scar contractures is safe and effective in a resource-limited setting when healthcare workers have been given adequate training, resources are available and the organization is able to meet the complex needs of patients. Chapter 4 shows that patients can safely undergo skin grafting at a delayed stage, and that reepithelialization is achieved without severe adverse events. Our studies in Chapters 6 and Chapter 7 are the first worldwide to show that contracture release surgery can be performed safely during sustainable surgical training partnerships. These studies also showed that these procedures result in significant improvement in joint function and disability of patients.

It is important to note that these surgical procedures are performed in a setting where healthcare workers, including nurses, medical doctors, surgeons and anesthetists are adequately trained and have appropriate equipment available. In our setting, healthcare workers are given a two-week training course twice yearly organized by Haydom Lutheran Hospital in collaboration with the Dutch NGO Doctors of the World, and facilitated by volunteer surgeons from Global Surgery Amsterdam. The training is embedded within the local healthcare structures and augments the training activities at Haydom Lutheran Hospital. They comprise on-the-job training, including clinical work such as basics of surgical techniques and procedures involved in burn surgery, outpatient clinics, follow-up, wound care and group discussions. Off-the-job training comprises practical workshops on suturing and skin grafting, and local flap courses or lectures on burn care management given by trainees.

Several factors possibly explain why our approach of a "sustainable training partnership" appears to be successful. Burn care training is embedded within the local healthcare structures and supplements the other healthcare training provided at the hospital. The training has a needs-driven approach, is based on the local context, and makes use of local supplies and equipment. Another aspect which can yield a more sustainable result is that the training curriculum has a broader focus than burn care alone and includes the basics of surgical care. This may build the surgical capacity of the hospital over the longer term. To improve future training activities, they should be aligned with regional and national training programs. For example, our collaborative group initiated a process to embed our training at Haydom Lutheran Hospital with other international training organizations such as COSECSA. However, until now this collaboration has still not been fully established and remains a goal for the future. The thesis of M. Botman, entitled "Beyond short-term surgical missions: on the role of surgeons from high-income settings to help improve surgical care in resource-limited settings" further elaborates on the training activities and effectiveness of these sustainable surgical partnerships.

Our study of acute burn care in Chapter 4 also raised several interesting questions regarding the optimal timing of skin grafting. Controversy remains as to whether early excision and skin grafting or delayed skin grafting is the preferred approach in resource-limited settings.[13,14] While our study suggests that delayed skin grafting

is safe and effective, other studies support early excision as it can reduce wound contamination, sepsis and duration of admissions.[15,16] The few studies available from resource-limited settings reach different conclucions.[4] Three studies show favorable results of early excision,[17–19] while another study reports that early excision is associated with increased mortality and suggests that it is less safe.[20] Apart from these considerations, it is our experience that the barriers to burn care, e.g. affordability, timeliness and surgical capacity at the regional level, should be taken into consideration when discussing the optimal timing of wound closure in a resource-limited setting.

Furthermore, it would be interesting to evaluate the timing of skin grafting and its effect on the development of burn scar contractures. As our study is an observational cohort study, a comparison of surgical approaches with differences in the timing of grafting is not possible. Future studies are needed to evaluate whether delayed skin grafting is responsible for a higher prevalence of contractures.

The studies on burn scar contracture release surgery in Chapter 6 and Chapter 7 raised interesting questions regarding the preferred and most effective surgical technique. The principle of contracture release surgery is to release or excise the scar and to cover the defect that remains after releasing the scar, with the aim of increasing the Range of Motion (ROM) of the affected joint. Until now no consensus exists globally as to which technique is preferred for which type of contracture.[21,22] In our studies, full-thickness grafts were more frequently applied in broadband contractures, whereas local flaps were more frequently applied in linear contractures. Interestingly, comparable improvements in ROM were observed up to one year after surgery, independently of the type of contracture. These findings indicate that teams that have one single surgical technique for contracture release surgery in their armamentarium can effectively apply this technique when no other options are available. Future studies with larger cohorts are needed to determine which technique is more effective.

Assessment of burns and contractures using functional ROM, disability and quality of life

The significance of burn scar contractures is that they can limit the ability to perform daily activities by restricting joint mobility.[23] Previous studies that assessed burn

scar contractures only used normal ROM as an outcome measure.[21,24] However, when considering the functional recovery of joints the use of the functional ROM seems to be more appropriate. The functional ROM is the ROM required to perform daily activities. For the majority of joints and planes of motions, there is a large difference between normal ROM and functional ROM values.[23,25,26] For example, the functional ROM of shoulder abduction is 90 degrees, whereas the normal ROM is 180 degrees. To better understand the effect that contractures have on joint function, our research group agrees with Oosterwijk et al. that the actual ROM should be compared with the functional ROM.[23]

The study described in Chapter 4 and Chapter 7 has several strengths. It was performed in a setting with a high incidence of burns and burn scar contractures, it had a long-term follow-up with a high follow-up rate and used validated outcome measures. Our studies provide compelling evidence that the combined assessment of functional ROM, disability and quality of life is a valuable method to assess the recovery of joint function. This combination is also in accordance with the framework of the International Classification of Functioning.[27] It gives information about the performance of joints and the performance of patients in daily life, which are important indicators of the result of treatment.[28] It is therefore our strong conviction that this methodology should be applied in future studies that assess joint flexibility.

A critical view of current efforts that aim to improve burn care worldwide

There are several international initiatives that aim to empower the burn care capacity in resource-limited settings. The International Society for Burn Injuries (ISBI) created a practice guideline with recommendations for the treatment of burns applicable everywhere in the world, including in resource-limited and resource-abundant settings. This valuable guideline describes consensus recommendations for burn management that are cost-effective and based on the best evidence available.[13] However, due to its purpose, the guideline is extensive. To improve the dissemination and increase the practical application of the guideline, it would be interesting to develop an easily accessible educational tool based on the guideline. This tool should be intended and appropriate for use by nurses, associate clinicians and doctors around the world. Global Surgery

Amsterdam is currently developing such a tool. Lastly, concerning the board of the ISBI, regional representation from sub-Saharan Africa could be strengthened.

In 2007 the World Health Organization (WHO) collaborated with the ISBI and 14 country representatives to establish a 'WHO Plan for Burn Prevention and Care', which entailed a broad global strategy for the prevention, treatment and research of burns.[29] It even included a plan for a Global Burn Registry for the collection of burns data. However, after 10 years these plans have not yet been implemented and still need to be disseminated among the health workers in the field.[29] The WHO has concluded that there is still a lack of knowledge of what works to prevent and treat burns, and calls for research into burns in resource-limited settings.[30] Our clinical studies address this concern of the WHO.

There is an urgent need to increase the number of healthcare workers in burn care. At the local level, multiple organizations aim to improve burn care quality and capacity by training doctors and surgeons. Some also invest in creating an academic culture by stimulating a scientific approach by performing longer-term follow-up and outcome research. Fruitful examples of such sustainable training partnerships can be found at Haydom,[31] Moshi,[32,33] Mwanza,[34] and Dar es Salaam in Tanzania, and in Lilongwe in Malawi.[35] These initiatives are concurrently running their own local burn care programs, which are supported by smaller NGOs. During our studies, particularly those in Chapter 3 and Chapter 6, we found that these initiatives commonly have a 'vertical approach', as they work on a solitary basis, lack strong collaboration with other initiatives and lack coordination by the regional and national health authorities.

In settings where time and resources are constrained, there are other strategies available to effectively address the lack of sufficient trained doctors. Substantial parts of burn care can be performed by associate clinicians. In Sierra Leone, for example, CapaCare trains associate clinicians to manage essential surgical conditions, which includes burn care and skin grafting.[39,40] This principle of training is called task-sharing, in which surgeon's tasks are delegated and shared with associate clinicians with the goal of optimizing the efforts of the existing health workforce. CapaCare programs show favorable results, demonstrating that task-sharing is a safe strategy to improve access to surgical care in areas where there are insufficient doctors.[41]

Future perspectives: a paradigm shift in the access to burn care in resource-limited settings

There is an urgent need to alter the disparity in burn care worldwide. Many burn injury-related deaths and disability can be prevented if access to safe and adequate burn care is improved. In this section we describe important considerations in the building of sustainable and effective improvements in the access to burn care for underserved populations.

Based on these considerations we propose a list of recommendations, which are given at the end of the discussion. The aim of our recommendations is to work towards providing equitable burn care worldwide so that all patients have access to burn care which is safe, timely and affordable, irrespective of their geographical location, socio-economic status, gender, age, race or religious affiliation.

Invest in surgical care and simultaneously build the burn care capacity in resource-limited settings

Over the last decade a major change occurred regarding the importance of surgery in the strengthening of healthcare systems. This led to the establishment of the "Global Surgery" community, the work field that "seeks to improve the access to safe and affordable surgical care for all people, with an emphasis on underserved populations."[12,42]

Several large initiatives have been committed to address this issue. For example, the Lancet Commission on Global Surgery provides compelling evidence that surgical care in low- and middle-income countries is affordable, saves lives, and promotes economic growth. It also presents an outline for the development of national surgical plans.[12] Our research group published the Amsterdam Declaration on Essential Surgical Care to raise awareness and to call for action. Together with 51 organizations we put out a call to make surgical care available in low-income countries. This publication also lists 15 of the most critical surgical conditions and corresponding procedures that should be made available in resource-limited settings, and unquestionably includes burn care.[43] These and many other initiatives put global surgery on the global health agenda. As a result of all these initiatives, the 68th World Health Assembly in 2015 adopted a resolution on "strengthening surgical care and anesthesia as a component of Universal Health Coverage." With

this resolution governments worldwide recognized surgery and anesthesia as key components of healthcare systems.[44,45] In response to these developments, national health authorities of several countries, including the Ministry of Health in Tanzania, have partnered with organizations to develop National Surgery and Anesthesiology Plans.[46]

These large initiatives have established common grounds and provide great momentum to initiate efforts in building burn care capacity. The investments made in burn care simultaneously strengthen the surgical healthcare system and vice versa (i.e. a horizontal approach of health system strengthening). This means that the national surgical plan of Tanzania should include a well-established plan concerning the essential care which the many burn victims need.

Future initiatives should have a strong foundation of community ownership

In this thesis surgical treatments were performed for burn wounds and contracture in the setting of sustainable burn care training partnerships. As described in Chapter 3 and Chapter 6, the training partnerships of Haydom Lutheran Hospital, the NGO Doctors of the World, and Global Surgery Amsterdam, provided training for the local medical team to improve comprehensive burn care.

From this process and through discussions with our Tanzanian team members, our research group learned that it is essential for such initiatives to have a strong foundation of community ownership. The local experts in burn care have a pivotal role in creating sustainable improvements. They understand the local culture and context, have knowledge of the local healthcare system, and can build relationships with regional and national governments. Therefore training partnerships should have a needs-driven approach, and should be tailored to the local setting and community with local experts taking responsibility. The local actors can include burn experts and leading organizations in burn care, such as burn care centers and regional healthcare authorities.

An important consideration is that members of visiting teams should be aware of their background. A recent paper discussed the fact that surgical missions can disempower the communities they intend to help if they undermine local healthcare workers and local healthcare systems.[47] In a paper by our group we

encourage visitors to be aware of the ethical implications of their work, and call for equal and sustainable partnerships that support the local healthcare workers.[48]

The power of long-term partnerships is key to sustainable improvements

Building burn care services in resource-limited settings presents a major challenge and requires long-term collaboration between all the stakeholders involved. This was experienced particularly during the studies in Part II and Part III of this thesis, when we learned that the majority of burn care training partnerships work largely on a solitary basis, have their training activities confined to a local level and lack national coordination.

There are several large renowned international organizations that can serve as best examples of successful partnerships. Examples are the Global Fund, a public-private partnership that has been combating AIDS, tuberculosis and malaria since 2002.[49] Another example is the Global Alliance for Vaccines and Immunization (GAVI), also a public-private partnership that supports vaccination and healthcare system strengthening in low-income countries.[50]

Based on these examples, several stakeholders could be involved in building the burn care services. National and regional healthcare authorities should be involved. They can effectively coordinate efforts, drive change and implement healthcare policies. These authorities can be supported by international organizations such as the World Health Organization (WHO) Program for Surgical and Anesthesia Care and the International Society for Burn Injuries (ISBI). These organizations can advise and support policy making. The World Bank can sustainably finance the healthcare costs of national governments. Local burn care experts have the knowledge to provide quality care for their populations. Networking platforms can be established that empower experts to share results and stimulate bilateral knowledge exchange. Private sector donors, non-governmental organizations (NGOs), advocacy groups and burns foundations are needed to mobilize experts and resources. Researchers and technical health institutes are needed to evaluate and develop the burn care provided.

Make burn care affordable for patients and hospitals

Chapter 5 shows that affordability is the predominant barrier of access to burn care, both for patients and hospitals. Initiatives are urgently needed that ensure

financial protection of patients and that can finance the burn care services of hospitals.

Previous reports showed that increased mobilization of domestic revenues from the public and private sector is needed to finance the scale-up of burn care services. A possible solution is to increase revenues from national health insurance schemes, a strategy that is greatly supported by the Lancet Commission on Global Surgery.[12,51] Insurance schemes pool the risks of individuals over the larger population, making healthcare more accessible to the population. However, consensus exists that increasing revenues from insurance alone will not be sufficient to finance the scale-up.[52] For example, in Tanzania health insurance coverage is growing steadily, but is still limited. From the time of the inception of our research project in 2017 until 2019, the coverage grew from 7% to 9%.[53] The majority of the insured are government workers and company employees, while hard-to-reach people in lower socio-economic groups and the informal sector are lagging behind. Therefore, as the literature points out, external sources of financing should be included to finance the scale-up of burn care services.[12] A sustainable solution should include a mixture of organizations, involving health insurance organizations, national health authorities and consortia of donors and NGOs.

From our experience we learned that investment by a single stakeholder should be avoided, like donor pledges from NGOs or private donors to provide free care. There is an abundance of reasons: donor pledges disturb the checks and balances of a fragile financial system, create a dependency of patients and hospitals, undermine the investments in health insurance and cause tensions among social workers who deal with financial settlements between the patient and the hospital. And above all, it is not a sustainable solution. When donor pledges end, the hospital will struggle to rebuild its financial position.

The training program of sustainable training partnerships needs to be complementary to, and in support of, the existing training programs

Another important limitation of access to burn care is the limited capacity of healthcare facilities to provide adequate surgical treatment for burns, as detailed in Chapter 5. One of the major causes of this is the shortage of appropriately trained staff.[12,30]

A possible solution is to scale up the training of the burn care workforce. The studies described in Chapter 3 and Chapter 6 show that a sustainable training partnership can result in appropriate training that empowers the local burn care team to provide surgical treatment for burns and basic surgical conditions. This was further assessed by our research group in a separate study, which is outlined in the thesis of M. Botman, entitled "Beyond short-term surgical missions: on the role of surgeons from high-income settings to help improve surgical care in resource-limited settings". In this study we assessed three levels of the training: reaction, learning and behavior. Results show that training the same participants in consecutive training sessions effectively improved their surgical skills, suggesting a sustainable impact of the surgical training partnership.[56]

Based on our experience, one of the most important features of training partnerships is that their program is complementary to the existing training programs of the national and regional training bodies. The partnerships' training should be embedded within the local healthcare infrastructure. To prevent duplication of efforts, national and regional authorities should coordinate the training partnerships. We suggest that future training partnerships should include all healthcare workers involved in burn care, comprising nurses, associate clinicians, anesthetist-associates, medical doctors and surgeons.

Use competency-based and technology-enhanced learning to improve training efforts

Training partnerships frequently use conventional training models to train doctors and surgeons.[36–38] The conventional curriculum is based on the master-apprentice model, which has proven its strengths since its inception in the 17th century and still forms the backbone of surgical training worldwide. In this conventional model, students learn on-the-job during clinical work, by exposure and by observing supervisors. The learning features offline (e.g. books), passive and classroom learning. It also requires faculty members who provide subjective feedback.[36–38] With this model, the training of a surgeon currently takes eight years in Tanzania and 14 years in The Netherlands.

To increase efficiency and to train a larger number of healthcare workers, future training partnerships could implement innovative ways of learning. An example is the competency-based and technology-enhanced learning model.[36,37,54,55] In

this model, training is continued off-the-job (i.e. outside the clinical work) and uses technology-enhanced simulation. Examples are skin graft simulations using a mobile phone application or hands-on practical workshops, like cadaver training or a flap course. Trainees structurally receive objective feedback, using a proven format. This innovative way of learning is associated with substantial positive effects on the outcomes of knowledge, skills and behavior of healthcare workers.[36] This model is being increasingly adapted worldwide, including in The Netherlands.[36,37,54,55]

To support this model of learning, an accessible online training and education tool that features technology-enhanced learning should be made available for training and education in burn care. Therefore Global Surgery Amsterdam partnered with Haydom Lutheran Hospital, Med Learning Experience (MLX), the Amsterdam Skills Centre, and Doctors of the World Netherlands, to develop a training tool that is accessible to, and free of charge for, resource-limited settings. It is an open-source platform, makes use of the highest digital standards and is accessible to all bandwidths globally. A burn care curriculum is generated on this platform which is interactive, uses videos and includes practical workshops that can be provided at remote locations. It also encourages interactions between trainees, trainers and experts. Our research group is currently setting up a research project in Tanzania to evaluate the effectiveness of a sustainable training partnership that uses this innovative (competency-based and technology-enhanced) way of learning and training, with the goal of training the much-needed burn care workforce in resource-limited settings.

There is an urgent need for research into burns in resource-limited settings

This thesis contributes to our understanding of the availability of treatment and outcomes of burn care in resource-limited settings. It provides convincing evidence that longer-term outcome research generates valuable feedback, enables evaluation of the current burn care and can guide future improvements of burn care quality in resource-limited settings. We therefore call on other organizations to initiate collaborative efforts in collecting data and promoting research into burn injuries in resource-limited settings.

Findings from Chapter 2 and Chapter 6 also have large implications for organizations that organize 'short-term surgical missions' in resource-limited settings. We show that there are opportunities for a collaborative model of sustainable surgical training partnerships that implement longer-term outcome research during follow-up. The combination of a high complication rate and a high follow-up rate found in our studies shows both the vital necessity and feasibility of providing follow-up after missions. To accomplish this, a dedicated local team should be trained and supported. Implementing outcome measurements in future surgical training partnership missions yields several advantages. It empowers local researchers to build an academic culture. The data generated can be used for quality improvement and can be reported to healthcare authorities and donors to improve the accountability of training partnerships.

The list of proposed recommendations

- Invest in surgical care and simultaneously build burn care capacity in resource-limited settings
- Future initiatives should have a strong foundation of community ownership
- The power of long-term partnerships is key to sustainable improvements
- Make burn care affordable for patients and hospitals
- The training program of sustainable training partnerships need to be complementary to, and in support of, existing training programs
- Use competency-based and technology-enhanced learning to improve training efforts
- There is an urgent need for research into burns in resource-limited settings

Conclusion

There is a large disparity in burn care worldwide. Burn injuries continue to burden resource-limited settings. Our thesis confirms that these settings face high mortality and morbidity due to burns. The patients that survive have a high risk of developing burn scar contractures. These contractures have a major impact on joint function, and thereby on disability and quality of life of the patients. This

thesis shows that the disparity in burn care stems from the lack of access to care that is affordable, timely and safe. Collaborative efforts that sustainably address the lack of access to burn care are urgently needed to reduce the global burden of burns.

This thesis demonstrates that there are opportunities to improve access to burn care worldwide. In in a resource-limited setting surgical care for burns can be effectively delivered by local burn care teams if adequate training of healthcare workers is provided and equipment is available. Findings suggest that sustainable training partnerships may aid in the training of the burn care workforce; however, more research on this topic is needed. The essential requirements for future training partnerships are that they have a foundation of community ownership, have a needs-driven approach, are tailored to the local setting, and are embedded within the local structure of healthcare training.

This thesis contributes to our understanding of the treatment and outcomes of burns in resource-limited settings. We recommend that future studies on burn scar contractures and related joint flexibility issues should include the combined assessment of functional ROM, disability and quality of life. This thesis also shows that longer-term outcome research is one of the backbones of sustainable quality improvements of burn care in resource-limited settings. Longer-term outcome research can generate valuable feedback, enable evaluation of the current care and can guide future improvements. We therefore call upon other organizations to initiate collaborative efforts to collect data and promote research into burn injuries worldwide.

We proposed recommendations that can be used as a potential first step towards sustainable and effective improvements in burn care in resource-limited settings. The aim of our recommendations is to build towards burn care that stimulates equity worldwide, where all patients have access to burn care which is safe, timely, affordable and accessible irrespective of their background. We suggest that these future initiatives should be built on sustainable and equal partnerships that stimulate bilateral knowledge exchange. Efforts are needed to train the burn care workforce including nurses, associate clinicians and doctors. Innovative ways of learning can be implemented to enhance the effectiveness of future training. We also recommend that all future initiatives should assess their impact by data collection and research.

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"Kusema
karubi ni rahis
Kusema kwaheri

Appendices

Summary

The few studies that are available show that the burden of burn injuries remains disproportionally high in resource-limited settings. These settings have a high incidence of burns, and due to limited access to safe burn care the mortality and morbidity remains high in these settings. Of all fire-related cases of mortality worldwide, 95% occur in resource-limited settings. Patients who survive are likely to face serious complications, such as burn scar contractures. During my work as a global health specialist, we, the Tanzanian doctors and I, were indeed confronted with a high incidence of burn injuries. We had limited treatment options available and experienced high mortality and morbidity due to burns.

From the literature it became evident that little evidence was available regarding burn care in resource-limited settings. Few studies are available on the outcomes of skin grafting procedures, no studies were available that showed how often burn scar contractures developed, and none of the studies were able to prove whether contracture release surgery was effective in the longer-term. There are valuable and useful treatment guidelines available from the International Society for Burn Injuries, specifically aimed for resource-limited settings. However, the Society also pointed out that the evidence for the guidelines was scarce and recommendations were frequently based on expert opinion.

Outline of this thesis

To evaluate the current state of burn care and to guide future improvements in burn care of underserved populations in resource-limited settings, insight into current treatment and its outcomes is of vital importance. The studies described in this thesis concentrate on three areas: short-term reconstructive surgical missions (Part I); acute burn care (Part II); and burn scar contracture release surgery (Part III).

Part I: reconstructive surgical missions

Many medical missions have been carried out globally by a wide variety of non-governmental organizations (NGOs), and several reviews of these missions are available. These reviews provide valuable insight into medical missions in general. However, due to the diversity of medical and surgical missions, the reviews do not specifically provide insight into the outcomes of short-term reconstructive surgical missions.

Hence it was necessary to carry out an initial step to improve our understanding of the reconstructive surgical missions that provide burn care. An extensive literature study was performed and is described in Chapter 2. The aim of the literature study was to systematically review evidence of the impact of reconstructive surgical missions specifically, and critically analyse the quality of the available data. In this review four key aspects were evaluated, namely: the basic characteristics of missions, patient safety, health gains for patients and the sustainability of missions.

The review points out that the evidence of these missions is scarce and of low quality. Missions frequently report inconsistently and incomprehensively on follow-up, which suggests a high risk of reporting bias. Missions that do not report on follow-up length and follow-up rate might miss potential complications, and are therefore likely to overestimate their safety. By contrast, the few missions that performed high-quality, long-term follow-up reported substantially higher complication rates.

It was encouraging to see that the missions that were engaged in sustainable development of the local healthcare systems were also able to report comprehensively on follow-up. For example, the missions that reported on the length and rate of follow-up were also involved in long-term sustainable activities. These activities included the training of local healthcare workers, capacity building of the local healthcare systems, or longer-term outcome research projects. This suggests that more sustainable missions may be better able to follow up their patients for a longer period.

Burn scar contracture release surgery is often performed during surgical missions and many burn victims receive valuable treatments. Despite this, our systematic review points out that there is a dearth of evidence of effectiveness of these procedures performed during short-term missions. Only one study reported on the effectiveness of contracture release surgery. It assessed the change of disability after contracture release surgery using a validated Patient-Reported Outcome Measurement (PROM). None of the existing mission studies reported whether contracture release surgery improved the range of motion, joint function, or the quality of life of patients.

Our systematic review provides the groundwork for the clinical studies that we conducted at Haydom Lutheran Hospital in northern Tanzania. It shows that there

is an urgent need for studies that report on the long-term outcomes of burn care performed during surgical missions, using validated outcome measurements such as range of motion (ROM), functional ROM and PROMs.

Part II: Acute burn care

The early outcome of burn care

There are a few practice guidelines available that outline recommendations for the treatment of burn wounds in resource-limited settings. However, the guidelines and the literature indicate that the evidence for burn care treatment these settings is scarce and of limited quality. In Chapter 3 describes our study which evaluated the outcomes of burn care provided in a resource-limited setting up to three months after injury.

The findings show that in-hospital mortality in resource-limited settings is high. In our study the mortality was 11.4% for all burn victims. This is in line with the literature dealing with similar settings. Our study contributes by showing that the cause of this high mortality stems from the limited access to safe and timely burn care. Patients typically present after a delay, between 1 to 4 days post-injury, and arrive at the emergency room with life-threatening complications. Common complications include sepsis, severe acute malnutrition and acute kidney failure. The patients who die present after a longer delay (14 vs. 5 days), compared to all patients admitted with burn wounds. The mortality is highest in the first days after admission: 55% of the deaths occur within four days and 88% within two weeks of admission. The common causes of death include sepsis and hypovolemia. These causes are comparable to the causes reported in high-income countries (HICs).

Our study demonstrated that after two weeks after admissions, burn care was considered safe and effective. Patients who survived the first days after admission and were stabilized, were able to undergo surgical treatment. No surgically related mortality or life-threatening complications were observed. Patients underwent skin grafting at a delayed stage (i.e. >10 days post-injury) without severe adverse events. Our findings showed that the burn care treatment was effective in achieving wound closure,significantly reduced disability and improved the quality of life over time. Although minor complications such as partial graft necrosis were frequently observed, it did not prevent wound closure.

The development of burn scar contractures and their impact on joints and patients

Patients who survive severe burn injuries may develop debilitating complications, such as burn scar contractures. The relevance of contracture is that it can limit joint function and cause disability, thus reducing the quality of life. If severe contractures go untreated, patients may be left with lifelong disabilities which lead to stigma and even social isolation.

Globally, our understanding regarding the functional impact of contractures is limited. A systematic review revealed that the prevalence of contractures is inconsistently reported due to the different definitions of contractures and the timing of measurements. Few studies have been performed worldwide on the impact that contractures can have on joint function, or their contribution to the disability or QoL of patients. The dearth of studies from resource-limited settings is even more worrying, since burn scar contractures are more extensive and disabling in these settings.

In this part of the thesis the focus was on the magnitude of the problem of burn scar contractures and the impact that they can have on patients. Such knowledge is important as it helps to evaluate current burn care, set international benchmarks and direct the development of burn care in resource-limited settings. The study described in Chapter 4 shows that the prevalence of burn scar contractures in a resource-limited setting is high at one year post-injury. Findings show that contractures developed in 25% of all joints and in 31% of operated joints at one year post-injury. Patients have a higher risk of developing burn scar contractures when they present with large full-thickness burns after a prolonged delay. The prevalence of contractures in resource-limited settings is substantially higher compared to the results of studies done in HICs. For example, Schouten et al. performed a study that used the same definition of a contracture and applied lateral goniometry, had a similar timing of measurements, and reported a prevalence of 20.9% in the operated joints at 12 months post-burn.

Our study was conducted in a resource-limited setting, which is characterized by limited access to burn care. For the patients who do receive care, limited options are available that can prevent post-burn scar contractures. Surgical treatments are available to a limited extent, causing delays in wound closure. There are

also limitations on rehabilitation services, including positioning of joints or physiotherapy. All these factors may contribute to the higher prevalence of burn scar contractures and should be taken into account when comparing the results with studies done in high-income countries.

As our study was an observational study, it was not possible to compare groups of patients with early excision and skin grafting versus a group with delayed skin grafting. It would be interesting to determine the effect of the timing of skin grafting on the frequency of contracture development. This remains an interesting topic for future studies.

Our unique study demonstrated that burn scar contractures frequently limit joint function and have a major impact on the patient. Findings showed that the joints that developed a contracture frequently limit the performance of activities of daily life. In our cohort, 22% of all the joints and 13 out of 36 patients (36%) developed a contracture that limited joint function at one year post-injury. Our study also showed that contractures have a large impact on the disability experienced by patients. For example, patients who develop a contracture are associated with significantly more disability and lower quality of life. These results emphasize the need for adequate prevention and optimal treatment of burn scar contractures in resource-limited settings.

Access to burn care

The current barriers to burn care in resource-limited settings are unknown. To gain greater insight into the existing barriers to access to burn care, we performed a study described in Chapter 5. Our results show that the populations at risk of sustaining burn injuries are the socio-economically disadvantaged, who are commonly rural people whose highest educational qualification is primary school and work as subsistence farmers (i.e. peasants). We identified three essential barriers to burn care in a resource-limited setting. The first and most prominent barrier is the affordability of care. The vast majority of patients do not have healthcare insurance and have to finance their own healthcare through out-of-pocket expenditure. In this study we showed that these expenditures are 6 times above the catastrophic healthcare expenditure threshold, which means that such expenditures can cause bankruptcy. The second barrier is the limited surgical

capacity at the regional level. The capacity to deliver surgical services for burn treatments remains limited, as none of the neighboring healthcare facilities and hospitals in the region deliver these services on a regular basis. This is important to note, as these facilities cover a catchment area of two million inhabitants. The third barrier is the timeliness of reaching a healthcare facility that can provide comprehensive burn care. Only half of the patients reach a facility that provides adequate surgical burn care services within 24 hours of suffering a burn injury.

Part III: Burn scar contracture release surgery

The study in the third part of this thesis focused on surgical techniques to release burn scar contractures. Contractures are defined as the replacement of (burned) skin by excessive scar tissue that can contract over time and can be insufficiently extensible. When such a scar is located over a joint, it can limit the range of motion (ROM) of the joint. As such, these contractures is can impair the performance of daily activities.

To alleviate disability, contracture release surgery is frequently performed worldwide. In the Dutch burn centers, for example, 21% of joints with burns develop contractures and 13% of joints undergo reconstructive surgery. While scar contracture release surgery is frequently performed, current knowledge remains limited regarding its effectiveness. A systematic review of this topic shows that few studies have been done and concludes that there is limited information on the effectiveness of surgery. This is due to limitations of the study methodology and the heterogeneity of outcome measurements.

Therefore in a prospective cohort study, the effectiveness of contracture release surgery was evaluated using ROM as a primary outcome measurement. Chapter 6 demonstrates that in a resource-limited setting, contracture release surgery can be performed safely and is effective in the vast majority of cases. Our findings showed that the surgical procedures resulted in a significant improvement in ROM over the long-term. Of the 115 joints that underwent contracture release surgery, 83 (79%) were effectively corrected at 12 months postoperatively, i.e. the ROM improved by more than 25% or reached 100% of normal ROM values. At one year the follow-up rate was 86%, which was above our expectations. This can be attributed to the effective collaboration between local and visiting doctors, hospital management and the patients and their relatives.

An interesting finding was the high complication rate reported in our cohort (52%). The predominant complication was partial tissue loss which included flap tip necrosis (10%) and partial flap necrosis (10%). It should be noted that the majority of the complications were minor and it was possible to treat the complications conservatively. The complication rates were substantially higher than those found in the studies from HICs, which report a complication rate of up to 17%. However, even with these complications, surgery was effective.

In this study, local flaps were most frequently used in linear contractures. This was in contrast to broad contractures, in which full thickness skin grafts (FTGs) were more frequently used. An interesting finding was that irrespective of the type of contracture, the ROM improved to the same extent up to one year postoperatively. Other studies suggested that local flaps are still preferred over FTGs when possible, because they have less risk of tissue loss and provide a better skin quality. Our study suggests that surgical teams which have only one single technique in their reconstructive armamentarium can effectively apply this single technique when no other options are available.

The relevance of burn scar contractures is that they impair joint function and the ability to perform daily activities. Despite this, none of the existing studies of contracture release surgery evaluated whether function was attained and only a few assessed the change in disability or quality of life after surgery. To better understand the effect on the recovery of function following surgery, we carried out a study described in Chapter 7. In this study the contracture release surgery was evaluated by assessing the change in joint function, disability and QoL up to one-year postoperatively. It came to light that the surgical procedures effectively improved joint function. Preoperatively 13% of the joints were functional, which improved to 64% of the joints becoming functional at 12 months postoperatively. We also showed that patients who regained joint function after surgery exhibited less disability and higher QoL compared to patients who did not regain joint function.

This study has several strong points: it was conducted in a setting with a high incidence of burns and burn scar contractures; it had a long-term follow-up with a high-follow-up rate; and it applied validated outcome measures. This study provides compelling evidence that the combined assessment of functional ROM, disability and QoL is a feasible and valuable method. It provides insight into the

performance of joints and the performance of patients in daily life, which are both valuable indicators of the results of treatment. We recommend that this method should be incorporated into future studies, not exclusively of contracture release surgery, but all studies concerning joint flexibility issues.

Conclusion

In Chapter 8 the conclusions of this thesis were reviewed and future perspectives were outlined. From the studies described in this thesis our group has obtained a deeper understanding of current burn care in resource-limited settings, concerning both acute burn injuries and burn scar contractures.

Resource-limited settings are burdened by high mortality and morbidity rates due to burns. This stems from a lack of access to safe and affordable burn care. Collaborative efforts that address the lack of access to burn care are urgently needed to reduce the global burden of burns.

There are opportunities to improve access to burn care worldwide. We show that in resource-limited settings surgical care for burns can be effectively provided by local burn care teams if healthcare workers are given adequate training. Our findings suggest that sustainable training partnerships may aid in the training of the burn care workforce; however, more research into this topic is needed. These partnerships and their training programs should be in support of, and complementary to, existing national and regional training bodies.

This thesis shows that longer-term outcome research is the backbone of sustainable quality improvements of burn care in resource-limited settings. Research provides valuable information and can drive change and quality improvements. We call on other organizations to initiate collaborative efforts to carry out research into burn injuries worldwide.

We proposed recommendations to build towards burn care that will stimulate equity worldwide, so that all patients have access to burn care. Future initiatives should have a strong foundation of community ownership, and should be built on sustainable and equal partnerships that stimulate bilateral knowledge exchange. Efforts are needed to train the burn care workforce including nurses, associate clinicians and doctors. All initiatives should assess their impact through data collection and research.

Nederlandse samenvatting

Brandwonden veroorzaken een grote ziekte last in lage-inkomenslanden en dit is een nijpend probleem voor de wereldwijde gezondheid. In vergelijking met hoge-inkomenslanden komen brandwonden er zeer vaak voor. Bovendien is de overlijdenskans door brandwonden erg hoog. Van alle brandwond gerelateerde doden wereldwijd, vindt 95% plaats in lage-inkomenslanden. De mortaliteit onder kinderen is 7 keer hoger in vergelijking met hoge-inkomenslanden. Patiënten die ernstige brandwonden overleven, lopen bovendien het risico ernstige complicaties te ontwikkelen. Een belangrijke complicatie is het ontstaan van een dwangstand van een gewricht. Dit kan ontstaan door overmatige groei van littekens, waardoor de bewegingsvrijheid van een gewricht verminderd wordt of zelfs geheel beperkt kan worden. Een dwangstand wordt in de medische literatuur ook wel een 'brandwond contractuur' of kortgezegd 'contractuur' genoemd.

In het Haydom Lutheran Hospital, het ziekenhuis waar waar wij dit onderzoek hebben uitgevoerd, kwamen veel brandwond patiënten. Er waren echter beperkte behandelingsmogelijkheden. De medische literatuur gaf daarnaast weinig handvaten, omdat er nog maar zeer weinig bekend is over adequate behandeling van brandwonden in gebieden met beperkte middelen; er is namelijk nauwelijks wetenschappelijk onderzoek naar gedaan. Er zijn bijvoorbeeld weinig studies gedaan die de behandeling van brandwonden met huidtransplantaties hebben onderzocht. Dat is belangrijk want met huidtransplantaties kunnen wonden worden gesloten, en snelle wondsluiting vermindert de kans op het ontstaan van een contractuur. Er zijn wereldwijd maar enkele studies die beschrijven hoe vaak contracturen voorkomen, en geen enkele studie is verricht in een lage-inkomensland. Er zijn geen studies verricht in lage-inkomenslanden, die aantonen of chirurgische reconstructies van contracturen op de langere termijn effectief zijn. Hoewel er nuttige richtlijnen beschikbaar zijn van de *International Society for Burn Injuries* waarin aanbevelingen staan voor de behandeling van brandwonden in gebieden met beperkte middelen, wijst diezelfde richtlijn erop dat het wetenschappelijk bewijs hiervoor zeer schaars is en het grotendeels gebaseerd is op de meningen van deskundigen.

De inhoud van dit proefschrift

Om de huidige stand van zaken in de brandwondenzorg in lage-inkomenslanden te evalueren en om richting te geven aan toekomstige verbeteringen in de

brandwondenzorg in gebieden met beperkte middelen, is inzicht in de behandeling van brandwonden en de uitkomsten van vitaal belang. De studies die in dit proefschrift worden beschreven concentreren zich daarom op drie gebieden: kortdurende reconstructieve chirurgische missies (deel I); acute brandwondenzorg (deel II); en reconstructieve chirurgie van brandwond contracturen (deel III).

Deel I: Kortdurende reconstructieve chirurgische missies

Wereldwijd worden er vele medische missies uitgevoerd door een grote verscheidenheid aan niet-gouvernementele organisaties (NGO's). Een groot deel van die missies zijn reconstructieve chirurgische missies, waarbij specialisten uit hoge-inkomenslanden afreizen naar lage-inkomenslanden om patiënten te behandelen in gebieden waar doorgaans geen specialistische zorg beschikbaar is. Er was tot op heden echter nog geen literatuur review gedaan die specifiek inzicht geeft in de uitkomsten van dergelijke reconstructieve chirurgische missies.

Om meer inzicht te krijgen in de missies die brandwondenzorg verlenen werd een uitgebreide systematische literatuurstudie uitgevoerd **(hoofdstuk 2)**. Deze studie toont aan dat de beschikbare gegevens over missies schaars en van lage kwaliteit zijn. Missies rapporteren vaak inconsistent en onvolledig over de follow-up, wat wijst op een hoog risico op *reporting bias*. Missies die geen verslag uitbrengen over de duur van de follow-up en het follow-up percentage zouden potentiële complicaties kunnen missen, waardoor de veiligheid en effectiviteit van deze missies waarschijnlijk wordt overschat. Zo lieten de missies die wel gedegen over hun follow-up rapporteerden, ook aanzienlijk hogere complicatie percentages zien.

Het was bemoedigend om te zien dat de missies die zich inzetten voor de duurzame ontwikkeling van lokale gezondheidszorgsystemen, wel in staat waren om uitvoerig te rapporteren over de follow-up. Voorbeelden van duurzame activiteiten waren het opleiden van lokale gezondheidsmedewerkers, het opbouwen van het lokale gezondheidszorgstelsel, of langdurige onderzoeksprojecten. Dit suggereert dat het organiseren van meer duurzame missies hand-in-hand gaat met het doen van gedegen patiënten follow-up.

Brandwond reconstructies worden wereldwijd vaak uitgevoerd, ook tijdens missies. Onze literatuurstudie laat echter zien dat er wereldwijd een gebrek

is aan wetenschappelijk bewijs voor deze procedures, zowel in hoge als lage-inkomenslanden settings. Slechts één studie rapporteerde over de effectiviteit van brandwond reconstructies tijdens een chirurgische missie, door gebruik te maken van een Patient-Reported Outcome Measure (PROM). Echter, geen van de bestaande studies rapporteerde of brandwondcontractuur operaties het bewegingsbereik van gewrichten, de gewrichtsfunctie of de kwaliteit van leven van patiënten verbetert.

Onze systematische review legt daarmee de basis voor de klinische studies die we hebben uitgevoerd in het Haydom Lutheran Hospital. Het toont aan dat er een dringende behoefte is aan studies die rapporteren over de lange termijn resultaten van brandwondenzorg uitgevoerd tijdens chirurgische missies. Deze studies dienen daarbij ook gebruik te maken van gevalideerde uitkomstmaten zoals *range of motion* (ROM), functionele ROM en PROM's.

Deel II: Acute brandwondenzorg

De vroege resultaten van brandwondenzorg

Het wetenschappelijk bewijs van de behandeling van brandwonden in een setting met beperkte middelen is schaars en van beperkte kwaliteit. In **hoofdstuk 3** beschrijven we een studie die wij deden om de uitkomsten van brandwondenzorg te evalueren tot drie maanden na het ongeval. De zorg werd verleend in een setting met beperkte middelen.

De bevindingen tonen aan dat het sterftecijfer als gevolg van brandwonden hoog is in onze setting (een mortaliteit van 11.4%; dus 1 op de 10 overlijdt). Onze resultaten maken daarnaast duidelijk dat de oorzaak van deze hoge mortaliteit te wijten is aan de beperkte toegang tot veilige en tijdige brandwondenzorg. Patiënten presenteren zich meestal met 1 tot 4 dagen vertraging in het ziekenhuis, vaak met levensbedreigende complicaties van de brandwonden. De vertraging was ook significant hoger in de groep patiënten die overleed (in deze groep was de gemiddelde dag van presentatie 14 dagen na het ongeval). Het sterftecijfer is het hoogst de eerste dagen na opname: 55% van de sterfgevallen doet zich voor binnen vier dagen en 88% binnen twee weken na opname. De meest voorkomende doodsoorzaken zijn septische en hypovolemische shock; beide complicaties van brandwonden.

Onze studie toont daarnaast aan dat de chirurgische zorg voor brandwond patiënten zowel veilig als doeltreffend kan worden beschouwd. Patiënten ondergingen een *delayed* huidtransplantatie (d.w.z. >10 dagen na het letsel) zonder ernstige complicaties. Er werden geen chirurgisch-gerelateerde mortaliteit of levensbedreigende complicaties waargenomen. De brandwondenbehandeling was effectief in het bereiken van wondsluiting, het verminderen van beperkingen en het verbeteren van de kwaliteit van leven van patiënten. Hoewel partiële necrose van het huidtransplantaat frequent voorkwam, kon de wond zonder problemen worden gesloten.

De ontwikkeling van contracturen en hun impact op gewrichten en patiënten

Patiënten die ernstige brandwonden overleven kunnen invaliderende complicaties ontwikkelen, zoals brandwond contracturen. Contracturen worden gedefinieerd als de vorming van overmatig littekenweefsel dat na verloop van tijd kan samentrekken en niet rekbaar is. Wanneer een dergelijk litteken zich over een gewricht bevindt, kan het de range of motion (ROM) beperken. Als ernstige contracturen onbehandeld blijven, kunnen patiënten levenslange beperkingen houden die kunnen leiden tot stigmatisering en sociale uitsluiting. In dit deel van het proefschrift lag de nadruk op de omvang van het probleem van brandwondcontracturen en de impact die ze kunnen hebben op patiënten. Dergelijke kennis is belangrijk, omdat het helpt bij het evalueren van de huidige brandwondenzorg, het vaststellen van internationale *benchmarks* en het kan richting geven aan de ontwikkeling van de brandwondenzorg in gebieden met beperkte middelen.

De studie beschreven in **hoofdstuk 4** toont aan dat de prevalentie van contracturen één jaar na het ongeval hoog is. De bevindingen laten zien dat op één jaar na het ongeval, contracturen ontstaan in 25% van alle gewrichten en in 31% van de - ten gevolge van de brandwond - geopereerde gewrichten. Patiënten hebben een hoger risico op het ontwikkelen van contractuur wanneer zij zich presenteren met grote brandwonden, een volledige huiddikte brandwond, of bij een late presentatie in het ziekenhuis. Onze percentages zijn aanzienlijk hoger dan de resultaten van studies die in hoge-inkomenslanden zijn uitgevoerd. Schouten et al. bijvoorbeeld, een studie uitgevoerd in Nederland, liet een prevalentie van 20.9% in de geopereerde gewrichten zien, één jaar na het ongeval.

Dit is te verklaren door de beperkte opties die beschikbaar zijn om contracturen te voorkomen. Het uitvoeren van huidtransplantaties is slechts in beperkte mate beschikbaar, waardoor de wondsluiting vertraging oploopt. Er zijn ook beperkingen op het gebied van rehabilitatie, waaronder het positioneren van gewrichten met adequate verbanden of mobiliseren onder begeleiding van een fysiotherapeut. Deze factoren moeten in overweging worden genomen bij de vergelijking van de resultaten met studies die in hoge-inkomenslanden werden uitgevoerd.

Het zou interessant zijn om het effect van het tijdstip van wondsluiting op contractuurontwikkeling te onderzoeken. Aangezien onze studie een observationele studie was, was het echter niet mogelijk om een groep van patiënten met *early* huidtransplantatie te vergelijken met een groep met *delayed* huidtransplantatie. Dit blijft een interessant onderwerp voor toekomstige studies.

Onze studie is uniek in het aantonen dat contracturen van brandwondenlittekens vaak de gewrichtsfunctie beperken en een grote impact hebben op de patiënt. Gewrichten met een contractuur lieten een beperking zien in het uitvoeren van dagelijkse activiteiten zoals wassen, aankleden, of schoonmaken. In ons cohort ontwikkelden 22% van alle gewrichten en 13 van de 36 patiënten (36%) met een brandwond ter plaatse van een gewricht een dergelijke contractuur. Patiënten met een contractuur hebben significant meer beperkingen en een lagere kwaliteit van leven, in vergelijking met patiënten die geen contractuur ontwikkelden. Deze resultaten benadrukken de noodzaak van adequate preventie en optimale behandeling van contracturen in een setting met beperkte middelen.

Toegang tot brandwondenzorg

De huidige barrières tot de toegang tot brandwondenzorg in een setting met beperkte middelen zijn onbekend. Om meer inzicht hierin te krijgen voerden wij een studie uit die beschreven wordt in **hoofdstuk 5**. Onze resultaten tonen aan dat de sociaal-economisch achtergestelde bevolkingsgroepen het hoogste risico hebben op het oplopen van brandwonden. Meestal betreft het plattelandsbewoners met de lagere school als hoogst genoten opleiding, vaak werkend als zelfvoorzienende boer. Wij hebben drie essentiële barrières geïdentificeerd. De eerste en meest prominente barrière is de betaalbaarheid van de zorg. De overgrote meerderheid van de patiënten heeft geen ziektekostenverzekering en moet de zorg uit eigen

zak betalen (*out-of-pocket payments*). In deze studie hebben we aangetoond dat deze uitgaven 6 keer hoger liggen dan de drempel voor catastrofale zorguitgaven, wat betekent dat dergelijke uitgaven tot een persoonlijk financieel bankroet kunnen leiden. De tweede belemmering is de beperkte chirurgische capaciteit op regionaal niveau. De capaciteit om chirurgische diensten te verlenen voor brandwondenbehandelingen is beperkt, aangezien geen van de zorginstellingen en ziekenhuizen uit de regio deze diensten op regelmatige basis verleent. Dit is belangrijk om op te merken, aangezien deze faciliteiten een verzorgingsgebied van twee miljoen inwoners bestrijken. De derde belemmering is de tijd die nodig is om een zorginstelling te bereiken die adequate brandwondenzorg kan bieden. Zo bereikt slechts de helft van de patiënten binnen 24 uur na het oplopen van een brandwond een instelling die chirurgische brandwondenzorg biedt.

Deel III: de chirurgische behandeling van brandwond contracturen

De studie in het derde deel van dit proefschrift richtte zich op chirurgische reconstructies van contracturen. Hoewel deze operaties veelvuldig worden uitgevoerd, is nog maar weinig bekend over hun effectiviteit, zowel in hoge als in lage-inkomenslanden. Daarom voerden wij een prospectieve cohort studie uit, die de operatie evalueert met ROM als primaire uitkomstmaat. In **hoofdstuk 6** tonen we aan dat de chirurgische reconstructies *("contracture release surgery"*) in een setting met beperkte middelen, veilig kunnen worden uitgevoerd en in de overgrote meerderheid van de gevallen effectief zijn. Onze bevindingen laten zien dat de chirurgische ingrepen resulteerden in een significante verbetering van ROM op de lange termijn. Van de 115 gewrichten die een ingreep ondergingen, waren er 83 (79%) effectief gecorrigeerd gemeten 12 maanden postoperatief. Daarnaast hadden we een hoog follow-up percentage van 86% na één jaar, wat het onderzoek betrouwbaar maakt. De hoge follow-up was boven onze verwachtingen. Dit kan worden toegeschreven aan de effectieve samenwerking tussen Tanzaniaanse en bezoekende artsen, het ziekenhuismanagement en de patiënten en hun familieleden.

In deze studie werden tijdens de chirurgische reconstructies lokale huidlappen (*local fasciocutaneous flaps*) het vaakst gebruikt bij lineaire contracturen. In tegenstelling tot de lineaire contracturen, werden er bij brede contracturen vaker

full-thickness huidtransplantaties gebruikt. Een interessante bevinding was dat ongeacht het type contractuur, de ROM in dezelfde mate verbeterde tot één jaar na de operatie. Andere studies suggereerden dat lokale huidlappen nog steeds de voorkeur genieten boven huidtransplantaties wanneer dat mogelijk is, omdat zij minder risico van weefselverlies hebben en een betere huidkwaliteit opleveren. Onze studie suggereert dat chirurgische teams die slechts één van deze technieken in hun reconstructief arsenaal hebben, dit veilig en effectief kunnen toepassen.

Het ontstaan van contracturen en het voorkomen daarvan is relevant omdat zij de gewrichtsfunctie en het vermogen om dagelijkse activiteiten uit te voeren nadelig beïnvloeden. Desondanks heeft geen van de bestaande studies geëvalueerd of er na chirurgische reconstructie ook functie herstel werd bereikt. Slechts een paar studies evalueerden de verandering in de mate van beperkingen of kwaliteit van leven na een dergelijke operatie. De studie in **hoofdstuk 7** evalueert de chirurgische behandeling van contracturen en beoordeelt de verandering in gewrichtsfunctie, invaliditeit en kwaliteit van leven tot één jaar postoperatief. Het laat zien dat chirurgische ingrepen de gewrichtsfunctie effectief verbeteren. Preoperatief was 13% van de gewrichten volledig functioneel, d.w.z. dat 13% van de gewrichten alle dagelijkse activiteiten zonder beperkingen kon uitvoeren. Eén jaar na de operatie verbeterde dit significant en was 64% van de gewrichten volledig functioneel. In deze studie tonen we ook aan dat patiënten die hun gewrichtsfunctie herwonnen na de operatie minder beperkingen ervaren en een hogere kwaliteit van leven hebben, in vergelijking met patiënten die hun gewrichtsfunctie niet herwonnen.

Deze studie heeft verschillende sterke punten: de studie werd uitgevoerd in een omgeving met een hoge incidentie van brandwonden en contracturen; had een lange termijn follow-up met een hoog follow-up percentage; én paste gevalideerde uitkomstmaten toe. Deze studie levert overtuigend bewijs dat de gecombineerde beoordeling van gewrichtsfunctie, mate van beperkingen en kwaliteit van leven een haalbare en waardevolle methode is. Het geeft inzicht in het functioneren van gewrichten en het functioneren van patiënten in het dagelijks leven, wat beide waardevolle indicatoren zijn voor de resultaten van de behandeling. Wij bevelen het aan om deze methode op te nemen in toekomstige studies, niet alleen betreffende contracturen, maar in alle studies die de flexibiliteit van gewrichten onderzoeken.

Conclusie

In **hoofdstuk 8** werden de conclusies van dit proefschrift besproken en werden de toekomstperspectieven geschetst. De studies in dit proefschrift hebben onze onderzoeksgroep inzicht gegeven in de huidige brandwondenzorg in lage-inkomenslanden, met betrekking tot zowel acute brandwonden als brandwond contracturen. In lage-inkomenslanden, met name in gebieden met beperkte middelen, is de ziektelast als gevolg van brandwonden hoog. Dit is het gevolg van een beperkte toegang tot veilige en betaalbare brandwondenzorg. Samenwerkingsverbanden die het gebrek aan toegang tot brandwondenzorg aanpakken zijn dringend nodig om de wereldwijde ziektelast van brandwonden te verminderen.

Er zijn mogelijkheden om de toegang tot brandwondenzorg wereldwijd te verbeteren. Wij tonen aan dat chirurgische zorg voor brandwonden effectief kan worden verleend door lokale brandwondenteams als deze gezondheidswerkers adequate training krijgen. Onze bevindingen suggereren dat duurzame opleidingssamenwerkingen kunnen helpen bij het opleiden van brandwondenzorgpersoneel; er is echter meer onderzoek naar dit onderwerp nodig. Opleidingssamenwerkingen en opleidingsprogramma's dienen de reeds bestaande nationale en regionale opleidingsprogramma's te ondersteunen en zo nodig aan te vullen.

Dit proefschrift toont aan dat onderzoek met een lange-termijn perspectief de ruggengraat vormt van duurzame kwaliteitsverbeteringen van brandwondenzorg in lage-inkomenslanden. Dergelijk onderzoek levert waardevolle informatie op en kan verandering en kwaliteitsverbetering stimuleren. We roepen organisaties op om gezamenlijke onderzoeksactiviteiten op zetten.

In het laatste deel van het proefschrift geven we een aantal aanbevelingen om de brandwondenzorg in lage-inkomenslanden te verbeteren en wereldwijde gelijkheid van brandwondenzorg te stimuleren, met als doel om alle patiënten toegang te verzekeren tot de noodzakelijke zorg. Toekomstige initiatieven dienen gebaseerd te zijn op een sterke inbreng van de lokale gemeenschap en de lokale experts. Van belang hierbij is dat er duurzame en gelijkwaardige samenwerkingen bestaan waarbij bilaterale kennisuitwisseling tussen experts uit hoge en lage-inkomenslanden gestimuleerd wordt. Inspanningen om

brandwondenzorgpersoneel op te leiden is van groot belang en daarbij dienen verpleegkundigen, verpleegkundig specialisten en artsen te worden opgeleid. Ook bevelen we aan dat alle toekomstige initiatieven hun impact evalueren door middel van dataverzameling en onderzoek.

Swahili summary / Muhtasari wa Kiswahili

Tanzania na nchi zingine za Kusini mwa Jangwa la Sahara zina matukio ya kuumgua moto na hupata vifo vingi na magonjwa kwa sababu ya kuungua moto. Ulimwenguni kote, idadi kubwa ya visa vyote vya vifo vinavyohusiana na moto hutokea katika nchi hizi. Wagonjwa ambao wanaokoka kuungua sana wanaweza kupata shida kubwa, kama vile makovu ya kuungua moto. Matibabu ya kuungu moto na makovu yake yanaweza kuwa changamoto, kwani nchi hizi zina rasilimali chache zinazopatikana kwa matibabu.

Hadi kufikia leo tafiti chache za kiamatibabu zinazopatikana ambayo zinaonyesha jinsi ya kutibu wagonjwa hawa kwa njia bora katika nchi zenye rasilimali chache. Tafiti chache zinapatikana juu ya matibabu ya vidonda vya kuungua moto kwa kupandikizwa kwa ngozi. Hamna tafiti iliyoko kuhusiana na matibabu ya makovu ya vidonda vya moto. Kuwa na uelewa mzuri jinsi ya kutibu vidonda vya moto na makovu ya vidonda vya moto, tumefanya tafiti kadhaa na zitaelezewa kwenye muhtasari huu.

Huduma ya kuungua moto.

Katika sura ya 3 tunaelezea utafiti wetu ulioanglia matokeo ya huduma kwa waliongua moto. Matokeo yanaonyesha kua idadi vifo vinavyotokea hospitali ni vingi. Hii ni kwa sababu wagonjwa wana ufikiaji mdogo wa huduma salama na za wakati unaofaa. Kikawaida wagonjwa hufika baad ya kuchelewa kati ya siku 1 hadi 14 baad ya kuumi, na hufika ktika chumba cha dharura wakiwa na madhara ya kutishia maisha. Vifo hutokea zaidi siku za mwanzo baada ya kulazwa. Asilimia 88 ya wagonjwa hupoteza maisha ndani ya wiki mbili za kulazwa wodini. Kisababishi kikubwa cha vifu ni pamoja na maambukizi ya bacteria kwenye damu, shoku na kupoteza uwezo wa viungo ving kufanya kazi.

Tafiti wetu umeonyesha kwamba wiki mbili baada ya kulazwa, huduma za kuungua kwa moto ni salama na zenye mafanikio. Wagonjwa walionusurika siku za mwanzo baada ya kulazwa hospitali waliweza kufanyiwa matibabu ya upasuaji. Hakuna vifo vitokanavya na matibabu ya upasuaji au viashiria vya hatari vya maisha vilivyoonekana. Wagonjwa walifanyiwa upandikizaji wa ngozi kwa kuchelewa bila madhara makubwa. Matokeo yetu yalionyesa kwamba matibabu ya vidonda vya moto ni ya kiufasaha kufikia kufunikwa kwa vidonda, ilipinguza ulemavu na kuboresha ubora wa maisha ya wagonjwa.

Kutokea kwa makovu ya vidonda vya moto.

Wagonjwa wahanga majereha makubwa ya moto huweza kupata madhara mkubwa, kama makovu ya vidonda vya moto. Kutokana na vidonda vya kuungua moto, makovu makubwa huweza kutokea. Makovu haya huwa hukakamaa na hayawezi kukunyooka kirahisi. Makovu haya yawapo makubwa na kutokea katika viungo huzuia mwendo wa kawaida wa viungo hivyo. Hii huitwa kukakama kwa vidonda vya moto.

Tafiti iliyoelezewa katika sura ya 4 ilionyesha kua makovu ya vidonda vya moto ylitoke sana kwa wagonjwa wetu. Inaonyesa kukakamaa kulitokea katika asilimia 25 y viungo vilivyopata kuungua moto. Wagonjwa wako kwenye hatari kubwa ya kupata makovu ya vidonda vya moto wanapofika na sehemu kubwa ya kuungua na kulikoingia ndani sana na kama watakuja ospitali baada ya kuchelewa sana. Asilimia 22 ya viungo vyote yenye vidonda vya moto vitpata kuwa na kukakamaa ambayo ni ya hali ya juu na kumzuia mgonjwa kufanya majukumu muhimu ya kila siku kama kupika, kuosha au kufanya kazi.

Tafiti katika sura ya 5, inaonyesha vizuizi vilivyopo katika kuzuia uptikanaji wa huduma kwa walioungua moto. Wagonjwa walio katika hatari ya kupata vidonda vya ajali ya moto ni watu wanaoishi katika mazingira ya vijijini na wanaofanya kazi za ukulima mdogo mdogo. Tuligundua vizuizi vikuu vitatu kwenye kupata huduma kwa wagonjwa wa moto katika sehemu zenye rasilimali chache. Ya kwanz ni kuweza kumudu garama y huduma. Idadi kubwa ya watu hawana bima za afya na huhitajika kugaramia garam zao za matibabu kwa kutumia pesa kutoka mfukoni kwao. Kizuizi ch pili ni uwezo mdogo wa kufanya upasuaji katika hospitali katika eneo husika. Na kizuizi cha tatu ni muda wa kufikia kituo cha afya kinachoweza kutoa huduma kwa wagonjwa wa moto pamoja na upasuaji wake. Ni nus utu ya wagonjwa huweza kufikia kituo cha afya ndani ya masaa 24 baada ya kupata ajali.

Upasuaji wa kufungua makovu ya moto yaliyokakamaa

Sehemu ya mwisho ya Makala haya yametilia mkazo katika njia za upasuaji za kutibu makovu ya moto yaliyokakamaa. Maranyingi upasuaji hutumika kutibu makovu haya. Aina hizi za upasuaji huulikana kama upasuaji wa kufungua mkunjamano wa makovu ya moto. Tafiti inayoelezew katika sura ya 6 inaelezea upasuaji wa makovu ya vidonda vya moto ni salama. Kati ya viungo 115 vilivyofanyiwa upasuaji

wa kuvifungua, viungo 83 (79%) zili rekebishwa kwa ufasaha ndani yam waka mmoja baada ya upasuaji. Viungo hivi viliweza kufanya kazi kwa uhuru na uwezo wa kunyooka uongezeka kwa kiasi kikubwa. Tafiti katka sura ya 7 inaonyesha upasuaji unaongeza ufasaha wa viungo katika kazi: asilimia 64 ya viungo sasa viliweza kufanya kazi zote katika maisa ya kawaida ya kila siku kama vile kupika kuosha vyombo na nguo na kufanya kazi katika mashamba. Pia unaonyesha wagonjwa kuonyesha udhaifu mdogo na kuwa na hali nzuri ya maisha baada ya upasuaji.

Hitimisho

Maeneo yenye rasilimali chahe huelemewa na kiwago kikubwa cha vifo na magonjwa yatokanay na kuungua moto. Moja ya visababishi ni kwamba katika maeneo haya ufikiaji wa matibabu ya visa vya moto yaliyo salama na kuweza kumudu garama ni mdogo.

Hospitali ya kiluthere Haydom tafiti mbali mbali kwa njia tofauti tofauti. Tunaonyesa kua huduma kwa walioungua na moto zinaweza kutolewa kwa usalama na njia za ufasaha. Na madonda ya moto na makovu ya kukakama yanaweza kutibiwa kwa njia za kiufasaha. Tunonyesha ufikiaji wa huduma kwa walioungua na moto ndani ya Tanzania uliboreshwa. Hii ilifikiwa kwa timu ya watu waliopatiwa mafunzo juu huduma kwa walioungua moto katika hospitali. Mafuno hayo yalitolewa na hosipitali ya kilutheri Haydom, kwa ushirikiano na madaktari wa dunia na global surgery Amsterdam. Mafunzo haya kwa ushirikiano yaliungwa mkono na timu y wato huduma wa afya walioko hosipitalini hapo n hospitali yenyewe.

Tunapendekeza kwamba shirikiano nyingine za kimafunzo kufunguliwa lengo likiwa no kuboresha huduma kwa walioungua moto ndani ya Tanzania na nchi za jirani. Mafunzo hya ya ushirikiano yatatakiwa kufanya kazi kwa ukaribu na wazoefu wa kitanzania na jamii na ni muhimu wakijumuisha wauguzi maafisa tabubu wasaidizi na madaktari.

Translation by Grayson Mtui, MD

PhD portfolio

Courses

BROK cursus | Nederlandse Federatie van Universitair Medische Centra

Research Integrity | VU Amsterdam

Dutch Course in Global Health | Medicine and research in Global Health | Royal Tropical Institute Amsterdam

Academic Writing | VU talencentrum

External work placement

Research position at Haydom Lutheran Hospital 20 months

Oral presentations

NVTG | Nederlandse Vereniging voor Tropische Geneeskunde congres 2017

'Turn the spotlights on Global Surgery'

Scarcon 2018

'The impact of short-term reconstructive surgical missions in low-income countries'

Traumaplatform symposium 2019

'Global Surgery at a local level'

ECPCA | European Cleft Palate Craniofacial Association 2019

'The impact of short-term reconstructive surgical missions in low-income countries'

EBA | European Burns Association congress 2019

'The outcome of burn scar contracture release surgery: 1 year follow-up'

NVPC | Nederlandse Vereniging voor Plastisch Chirurgie najaarscongres 2019

'De uitkomsten van brandwond contractuur chirurgie in lage-inkomenslanden'

ISBI | International Society for Burn Injuries congress 2021

'The development of burn scar contractures and their impact on joint function, disability and quality of life'

Honors and awards

Nederlandse Brandwonden Stichting

Research grant - PhD research project

Otto Kranendonkfonds

Research grant - PhD research project

WHO call for papers award

Call for papers award. Observatory on Health Research and Development

Guidance of researchers and research students

PhD-candidate: Anneloes Eleveld

MD, researcher: Grayson Mtui, Joost Binnerts

Medical student: Louise de Haas

Organizational

Symposium Global Surgery Amsterdam September 2018 – member

Global Surgery Amsterdam – cofounder and board member

List of publications

Hendriks TCC, Botman M, Rahmee CNS, Ket JCF, Mullender MG, Gerretsen B, Nuwas EQ, Mark KW, Winters HAH.

Impact of short-term reconstructive surgical missions: A systematic review.

BMJ Global Health 2019

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Burns 2021 (submitted)

Hendriks TCC, Botman M, Binnerts JJ, Mtui GS, Nuwass EQ, Niemeijer AS, Mullender MG, Winter HAH, Nieuwenhuis MK, Van Zuijlen PPM.

The development of burn scar contractures and their impact on joint function, disability and quality of life in low- and middle-income countries: a prospective cohort study with one-year follow-up.

Burns 2021 (accepted, in press)

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Experiences and views of medical doctors Global Health and Tropical Medicin.
Ervaringen en visies van artsen Internationale Gezondheidszorg en Tropengeneeskunde
Marlies Hummelen, Remco van Egmond, Thom Hendriks, et al. Edited by Matthijs Botman
Uitgeverij Boekschap 2017 (Dutch and English versions)
ISBN/EAN: 978-94-90357-22-1

Dankwoord

En dan nu het dankwoord! In augustus 2017 vertrok ik naar Tanzania voor een groot avontuur. Ik had toen veel dromen: werken als tropenarts, mij verdiepen in de chirurgische zorg, onderzoek doen naar de behandeling van brandwonden en misschien zelfs promoveren. Matthijs en ik sloegen de handen ineen en samen gingen we de uitdaging aan om onderzoek op te zetten, wat is uitgegroeid tot twee promoties. Het is geweldig dat het moment nu bijna daar is en alle dromen uitkomen. Dit resultaat heb ik niet alleen behaald. Er hebben veel mensen bijgedragen aan de totstandkoming van dit proefschrift, zonder jullie hulp was het nooit gelukt.

Beste Matthijs,

Wat een geweldige jaren hebben we samen beleefd. In 2013 ontmoette ik jou in Tanzania als student, je was een echte inspirator voor me. Een symposium over Global Surgery in 2014 was het beginpunt van onze nauwe samenwerking. Daarna hebben we met een grote groep enthousiaste collega's het boek 'Into the World' gemaakt, met als doel het binnenhalen van de financiering voor de tropengeneeskunde opleiding. Ook hebben we in 2018 Global Surgery Amsterdam opgezet en werken we met onze collega's aan mooie projecten om de toegang tot veilige chirurgische zorg te verbeteren. Toen je het idee had om onderzoek te doen naar de effectiviteit van de chirurgische missies in Tanzania, wist ik meteen dat ik dit wilde doen. Samen vormden we een perfect duo. Je visie, je charisma en je ideeën waren voor mij de perfecte brandstof. Werken en onderzoek doen, deels alleen vanuit Tanzania, kan soms ook heftig zijn. We hebben dat altijd op een goede manier kunnen delen en we vertrouwden elkaar volledig. Naast al het harde werk was er ook tijd voor fietstochten, varen over de Amsterdamse grachten, camping trips en feestjes. En nu gaan we allebei promoveren, dat maakt het compleet. Ik wil je van harte feliciteren en ik hoop nog lang met je te mogen samenwerken!

I would like to thank all the patients who participated in my studies. You traveled all over the country again and again, just to come back for follow-up. Some of you even traveled for two days and up to 700 km. Because of the intensive follow-up I was able to learn a lot from you. Not only about burns, but also about the Tanzanian healthcare system, the culture and of course the Swahili language. I

have a deep admiration and respect for your joy of life and resilience. Something I will take with me personally and as a medical doctor.

I would like to thank Haydom Lutheran Hospital and all the personnel who helped me making my stay in Haydom feel like being home, who helped me with the treatment of the patients and who helped to perform the studies. Without your cooperation and patience it wasn't possible to make this work. I have respect for the hard work you perform to help those patients in need. And I am grateful to you to allow me working together with you. Dr. Nuwass thank you for coordinating the research, your role as co-principal investigator and co-writing the manuscripts. I hope we can continue our fruitful collaboration the coming years and I am looking forward to your visit in the Netherlands. Special thanks to dr. Mdoe, who was head of research in 2017, you were the local co-principal investigator and made it possible to start this study. I also would like to thank the dr. Hayte as head of the surgical department and dr. Joshua as head of the pediatric department who were involved in the treatment of the burn patients. Also I want to thank all other colleagues, doctors, nurses, anesthesia associates and the secretariat of Haydom Lutheran Hospital. I am very grateful to all the work you have done and I am blessed with your cooperation.

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Mijn promotoren,

Beste Paul,

Je was een geweldige promotor voor mij. Het was bijzonder dat je openstond voor ons idee om het brandwond onderzoek in Tanzania verder te ontwikkelen door expertise en ondersteuning vanuit Nederland te bieden. Je uitgebreide kennis over brandwonden en littekens, je begeleiding van beide promoties en het inzetten van je grote netwerk lieten het onderzoek tot volle wasdom komen. Vanaf het begin stelde je me gerust, liet je mij excelleren waar mogelijk en remde je me af waar nodig. Het organiseren van een duo promotie, ook nog met eens met een tropenarts gestationeerd in Tanzania, is geen sinecure maar je wist dat in perfecte banen te leiden. Dit maakte het voor mij mogelijk om dit proefschrift te kunnen schrijven. Ik heb veel bewondering voor het werk dat jij verzet als hoogleraar brandwonden geneeskunde.

Beste Margriet,

Heel blij was ik met jou als mede promotor. Aan het begin van het traject was je erg betrokken en maakte je je hard voor mij. Toen ik even terug was in Nederland hebben we goede gesprekken gevoerd over hoe ik mij als onderzoeker verder kon ontwikkelen en het traject kon opzetten. Daardoor kon ik beginnen met mijn onderzoek op de afdeling. Je gaf het advies wat ik nodig had en kwam met concrete feedback waar ik verder mee kon. Dank voor de fijne begeleiding.

Mijn copromotoren,

Beste Marianne,

Je was voor mij het baken van deze promotie. Ik was al een aantal maanden onderweg met het onderzoek toen we elkaar leerden kennen. Ik belde je op vanuit Dar Es Salaam. Ik zag door de databomen het onderzoeksbos even niet meer en ik had allerlei vragen en twijfels. Op kalme wijze wist je mij gerust te stellen en wees je me de goede weg. Dit is het gehele traject niet anders geweest en dat gaf mij altijd rust en zekerheid. Tijdens onze uren lange telefoongesprekken heb ik ontzettend veel van je kunnen leren, of het nu ging over onderzoeksmethodes, contracturen, het bewegingsapparaat ansicht of over een cursus onderzoeks-integriteit. Ik heb genoten van onze samenwerking. Ik hoop dat ik in de toekomst met je kan blijven samenwerken en van je kan blijven leren.

Beste Hay,

Ik vind het een eer dat je mijn copromotor bent. Ik ben geïnspireerd door jouw kijk op de chirurgie en de plastische chirurgie in het bijzonder. Je bent een technicus pur sang en een uitermate begaafd chirurg. En daar heb ik een groot respect voor. Tijdens de missie leerde je mij op gedetailleerde wijze over de basis principes van de chirurgie, een goede skin graft en de behandeling van brandwond contracturen. Met eenzelfde precieze voorzag je al mijn stukken van bruikbaar commentaar. Vanaf het begin van het onderzoeksproject ben je intens betrokken bij het project en steunde je ons met volle overgave. Ik ben dankbaar voor het vertrouwen dat je in mij hebt.

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Joost, de master van de data en Castor. Je was 6 maanden in Haydom, je was toen mijn steun en toeverlaat. Je hebt ontzettend veel werk uit handen genomen. Sterker, je hebt het onderzoek in kwaliteit verbeterd. Door jouw aanwezigheid en hulp stelde je me ook in staat om af en toe rust te pakken. Zo kon ik met een gerust hart even weg uit Haydom en had jij in de tussentijd alweer een hele rits aan nieuwe patiënten geïncludeerd. Je bent inmiddels aan het werk als tropenarts in Tanzania. Ik wens je heel veel succes toe!

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yoghurt hielden mijn gewicht op peil!

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Jong geleerd is oud gedaan. Vroeger zat ik uren achter elkaar op mijn kamertje

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About the author

Thom Hendriks was born in Maastricht on November 13th in 1986. He went to high school at the Sint Maartens College in Maastricht. During high school Thom played football and he was a fanatic road cyclist and long-distance runner, which he continues to enjoy until today.

He studied Pharmacy at the University of Utrecht. After one year he was admitted at the to medical school in Amsterdam at the VU University. Since his medical studies, Thom had a special interest in Surgery and Global Surgery. He has been involved in several activities in this area, such as organizing the symposium 'Surgery in low resource settings' in 2014. He was also an active member of the G4 Alliance, which advocates for improving access to basic surgical care for all people worldwide.

After obtaining his MD degree, he specialized in Global Health at the Royal Tropical Institute Amsterdam from 2015-2017. During his training he worked as medical doctor under supervision of surgical consultant E. Staal at the Slingeland Hospital in Doetinchem, and under supervision of gynecology consultant M. Paarlberg at the Gelre Ziekenhuizen in Apeldoorn. Together with colleagues he founded Global Surgery Amsterdam in 2018. This foundation aims to improve access to safe surgical in low-income countries, by training, education and research projects. Thom has a special interest in clinical research and is involved in several studies.

From 2017-2019 he has been working as a surgical resident and researcher at Haydom Lutheran Hospital in Tanzania. This was also the starting point of his PhD-project. In collaboration with the Amsterdam UMC and Haydom and under supervision of prof. dr. P.P.M. van Zuijlen and dr. M.G. Mullender he studies burn care in a resource-limited setting. This includes burn wound care and surgical treatment, contracture release surgery, and the training of healthcare workers during surgical training partnerships.

He is currently working as a surgical resident at the RadboudUMC and his dream is to become a surgical specialist.

Thom lives together with Louise in Amsterdam and they both love to travel, together with their Volkswagen.