TELEMEDICINE AND BURNS: AN OVERVIEW

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SUMMARY. Access to specialized burn care is becoming more difficult and is being restricted by the decreasing number of specialized burn centers. It is also limited by distance and resources for many patients, particularly those living in poverty or in rural medically underserved communities. Telemedicine is a rapidly evolving technology related to the practice of medicine at a distance through rapid access to remote medical expertise by telecommunication and information technologies. Feasibility of telemedicine in burn care has been demonstrated by various centers. Its use facilitates the delivery of care to patients with burn injuries of all sizes. It allows delivery of acute care and can be appropriately used for a substantial portion of the long-term management of patients after a burn by guiding less-experienced surgeons to treat and follow-up patients more appropriately. Most importantly, it allows better effective triage which reduces unnecessary time and resource demanding referrals that might overwhelm system capacities. However, there are still numerous barriers to the implementation of telemedicine, including technical difficulties, legal uncertainties, limited financial support, reimbursement issues, and an inadequate evidence base of its value and efficiency.

Keywords: telemedicine, burn care, digital imaging

Introduction

Telemedicine is a modern rapidly evolving technology related to the practice of medicine at a distance through fast access to remote medical expertise via telecommunication and information technologies. It is emerging as an increasingly popular innovation, with the potential to improve patient care in remote and rural locations.1

Greatly improved survival and enhanced outcomes for patients treated at modern highly-specialized burn centers are undisputed. However, with improving prevention strategies, burn incidence in general has steadily declined in many countries, triggering a decrease in the number of active burn centers. Subsequently, the expertise needed to obtain favorable outcomes has become increasingly centralized within a diminishing number of centers of excellence. Burn centers are covering ever-larger referral areas. They are routinely running at or near capacity, and are facing mounting financial challenges.2,3 In parallel, access to specialized burn care has become more difficult, being restricted by distance and resources for many people known to suffer increased risks of burn injuries and mortality and living in poverty or in rural medically underserved communities.2,5,6 Whenever a burn patient reaches a local hospital, physicians on site may have limited familiarity with burn treatment. Under such circumstances, assessment and treatment in consultation with a remote burn specialist using telemedicine technology becomes highly valuable.2,3,4

The current paper is an overview of telemedicine technology as applied to the management of burn patients, exploring the benefits and the pitfalls of this rapidly evolving technology, in addition to analyzing the current evidence base of its utility and efficacy.

Methods

A literature search of PubMed, Medline and Scopus was conducted; keywords included “telemedicine and burns”, “burns teleconsultation”, “telecommunication and burns”. Only one systematic review of the literature was identified. An additional search with Yahoo and Google uncovered another systematic review. Both have identified a limited number of relevant published papers. The study conducted by Wallace et al.1 in 2011 only identified 24 relevant articles. Dunne and Rawlins7 identified 43 studies in their review conducted in 2013.

Reported evidence of telemedicine benefits in burn care

Outcomes regarding telemedicine feasibility and its effects on triage, follow-up and education, as well as its cost
have been summarized in a recently published systematic review.  

As regards delivery of high quality medical care, irrespective of the geographic location of the treating physician and patient, telemedicine feasibility has been validated by various centers for both acute as well as post-acute follow-up of rehabilitating patients. Instant visual communication together with electronic exchange of interactive video, digital photography, medical information, and electronic health records, extends the expertise of burn centers to peripheral hospitals with limited or no access to specialized burn care. Assessment of transmitted digital images by a specialist may lead to significantly different courses of burn care, including appropriately deferring intubation, significantly changing fluid resuscitation rates, changing the route and timing of referral, and avoiding over-triage and unnecessary transfer of patients over long distances. Similarly, in a military setting, initial resuscitation, consistent triage and timely evacuation of burn patients from remote front-line austere environments to rear-based specialized care centers are facilitated.

Burn triage is becoming a necessity and needs to be expertly implemented to maximize available resources. Based upon acuity and bed availability, the right patient must be sent to the right facility at the right time. Unfortunately, errors in estimation of burn size and severity, particularly by non-specialist inexperienced clinicians, are commonplace; patients are often transferred to burn centers with overestimation of burn size or severity, excessive or inadequate fluid resuscitation, and airway support that at times is deemed inappropriate. Evaluation is becoming even more difficult with the decreasing familiarity of most physicians with burn treatment and the widening gap in expertise between burn centers and many smaller, particularly rural, hospitals. Telemedicine for burn assessment, one of the most important aspects of initial care, has been demonstrated to improve accuracy of triage as well as initial fluid resuscitation, allowing correct evaluation of burn victims by determining the urgency and need for transfer to a specialized burn center and avoiding unnecessary transfers.

At present, local physicians see fewer burns, and of those they do see, more are frequently and needlessly sent to specialized centers for care. Most burns, however, can be treated at local general hospitals, while few require the highly specialized care of a burn center. With fewer burn centers servicing larger catchment areas, unnecessary referrals might not only overwhelm system resources, but are also time and resource demanding. Even though collaboration between a burn center and a rural primary care trauma center is a controversial concept and goes against the dogma of providing burn care only at specialized centers, telemedicine allows less-experienced surgeons to treat and follow-up those patients more appropriately.

By reducing the incidence of over-triage and transporting only those patients who truly require specialized care, resources can be better spent and used when truly needed, which may also reduce costs. Cost analysis studies have also demonstrated savings by decreasing the likelihood of inconvenient and prolonged unnecessary referrals, particularly when aeromedical transport is required. However, economic benefits in smaller nations and for centers with small catchment areas are less clear.

In the outpatient long-term follow-up and burn rehabilitation phase, telemedicine consultation service using digital imaging provides cost-effective valuable advice this is especially the case for patients who live far away after discharge from the burn center, as telemedicine eliminates the inconvenience and costs of frequent and difficult journeys by the patient to the specialized center. It may also be used for consultation and advice about limited burn injuries.

In addition to care administration and distribution, telemedicine is a system for burn education and has the potential to greatly improve early burn management worldwide.

### Adequacy of virtual examination of burn injuries at a distance

When a severely burned patient is taken to a peripheral health care center, the primary care physician usually telephones the physician on duty at the burn center and discusses the case with him. Unfortunately, telephone transmission of information is limited by the competency and expertise of the physician making the call in estimating burn extent, depth and severity. More often it is inaccurate, inadequate, notoriously unreliable, and generally based on guesswork, hindering the burn victim in receiving the optimal care.

Extent and depth of the burn injury are mainly assessed by visual inspection. These factors are very important for selecting the most appropriate type of emergency treatment required, as well as the place and method for the patient’s evacuation. In the absence of a skilled burn specialist, a transmitted picture of the injury is worth a thousand words. Technological advances from analogue to digital images have rendered documentation of the visible external nature of burn injuries appropriate and extremely reliable.

Transmission of digital images for the remote diagnosis of burn injuries has been advocated as early as 1999. Ever since, visual communications with digital technology has progressed tremendously. Today, digital images, whether static or in motion, form a major part of a great variety of modern communication systems. Since digital technology allows near instantaneous transmission of images through an information network from a referring hospital to a remote specialized tertiary center, telemedicine
has emerged as a modality of particular value in conditions for which assessment is primarily a visual skill, such as burns.\(^1,2,6\) To expedite clinical decision-making without reliance on oral descriptions given over the phone, digital images are well suited for evaluation by either synchronous (“interactive”) videoconferencing or asynchronous (“store and forward,” S/F) imagery, with much greater confidence.\(^4,11,12\) Images can be stored, reviewed and accessed from any computer terminal allowing senior input to be obtained for immediate advice on management.\(^11\)

Visual evaluation via image transfer and telemedicine is accurate enough to use in decision-making.\(^4,11,12\) Evaluation of burn injuries by experienced physicians is similar whether relying on transmitted digital telesurgical images or direct patient examination, and is definitely more accurate than estimates of local physicians.\(^5,11\) Diagnostic success rates of image-based assessments are nearly 90% when compared with clinical diagnoses confirmed in-person.\(^20,23\) Likewise, for follow-up burns consultations, the quality of information collected during a videoconference appointment is comparable to that collected during a traditional face-to-face appointment.\(^5,22\)

Image resolution in telemedicine is crucial; claims have been made that clinicians may lose confidence in their diagnosis while viewing a series of images of different resolutions when they are unaware of images resolution variations.\(^1,28\) Good agreement with no major differences was, however, demonstrated between diagnoses of burn depth made in person and those made using 3 different digital image file sizes (2.25, 5.5 and 9 MB per image).\(^7\) In fact, the transmission of JPEG images even after compression of up to 50 times of the original file size does not reduce the usefulness of digital images interpretation.\(^7\) The human brain is remarkable at adapting to color changes and blurring of the pixels’ original boundaries resulting from JPEG image compression,\(^27\) making even low-resolution images (average size 37 kByte) satisfactory for diagnosis.\(^29\)

**Telemedicine and burn care in low and middle-income countries**

In a low-and middle-income country with limited burn care facilities and few burn specialists, almost exclusively located in big urban centers, a telemedicine service could be highly valuable and may form an integral part in the centralization plans to improve burn management.\(^1,30\) Such service would enable the main burn center of the country to exercise control from a distance over peripheral hospitals that would be responsible for providing proper and uniform treatment to all burns victims.\(^30\)

Although most studies on telemedicine have been conducted in high-income countries and revolve around delivering care within national borders, there has been much interest recently in expanding telemedicine reach across international boundaries to areas around the world with limited or no access to medical care.\(^13,21\) As 90% of burns occur in developing or underdeveloped nations, with 70% of the patients being children, telemedicine is a valuable tool for international medical assistance. Implementation of health information technology worldwide across national borders could be a promising tool to mitigate the widening healthcare supply and demand gap between developed and low-and middle-income nations.\(^5,19,32\) Telemedicine does not only provide consultative expertise in acute burn and critical care consultation, but also allows better triage for transport of critically ill burn patients from low-and middle-income countries to a tertiary care facility in a developed country for further management. Moreover, it improves support in long-term follow-ups and rehabilitation procedures after the patient has returned to his home country, and allows continuing medical education for health care personnel in low-and middle-income nations.\(^1,19\)

**Limitations of telemedicine**

Telemedicine has already gained acceptance and support from many public funding projects. It is considered user-friendly, almost infinitely adaptable, and cost effective, yet several persistent potential barriers prevent its more widespread adoption; telemedicine has been slower to catch on and less successful than expected.\(^24\) Obstacles to the growth of telemedicine fall into three categories: lack of a solid evidence base, persistent problems in changing the culture of medicine, and technical as well as administrative limitations.\(^2\)

**Lack of solid evidence base**

Despite suggested benefits of telemedicine in a wide variety of medical and surgical specialties, in addition to the various reports on tangible community service regarding burn care that would not be otherwise available, there are still very few high quality randomized controlled studies on the use of this technology and little scientific evidence of its benefits. Literature about outpatient burn care at facilities other than burn centers to support collaborative telemedicine systems is scarce. Research on patients’ perceptions of teleconsultations is still very limited. Current available studies are underpowered and rigorous class I evidence proving the cost-effectiveness and superiority of telemedicine is notoriously lacking.\(^1,2,4,7,11\) Interestingly, more favorable outcomes have been reported with telemedicine in burn care, in particular for burn centers covering very large areas, in comparison to other specialties. However, benefits and cost effectiveness for centers with small catchment areas are less clear.\(^7\)

For a more widespread adoption of this technology, it is imperative that a clear benefit to this evolving technology be demonstrated and that statistically valid evidence
be generated by scientifically and methodologically solid studies. Risks of delayed or further treatment and associated costs must also be explored. Unfortunately, rigorous controlled trials of telemedicine will be extremely difficult to design, ethically troublesome, and hard to conduct.22,24

**Changing the culture of Medicine**

Telemedicine requires committed providers who are accustomed with new technology and willing and able to adapt to new ways of cooperating.2 Unfortunately, many clinicians are still suspicious and fearful of new technology. This fear can be justified considering previous information technology problems.13,16 Many clinicians have difficulty communicating remotely with other providers. Consultation at a distance is perceived as intimidating and a threat to the physician’s prestige. Many believe that use of telecommunication technology threatens traditional clinician-patient relationships and the basic components of medical care. Telemedicine is also considered a tedious task by many, as it requires a significant learning curve. There is also apprehension concerning possible medical-legal challenges related to responsibilities that distant medical intervention, consultation, and diagnosis carry in the event of poor outcomes. This constitutes a major obstacle to many physicians who fail to appreciate the cost-effectiveness or value to patients of telemedicine.11,21

**Technical and administrative limitations**

Practical problems with implementing telemedicine are numerous.2 Telemedicine requires the means to capture images that may seldom be perfect and need to be evaluated in conjunction with an accurate history. It also requires access to dependable telecommunication equipment and a reliable network for rapid transmission of digital images, data and information.20 This may be a major limiting factor in some developing countries and may not be available in certain areas or certain situations, such as during natural disasters or accidents.2 Real-time videoconferencing requires more expensive equipment that can be quite difficult to support in the context of developing countries.14,15 Moreover, it may be necessary to provide training and retraining for clinical staff on how to take digital photographs and how to use the equipment and the communication network to aid in the diagnostic process.11,12,21

Telecommunication technology is cumbersome, often requiring multiple bridging networks.10 Although static images can be transferred by a ‘store and forward’ facility where internet access is limited and communication between the two parties is of intermittent connectivity, videoconferencing requires a dependable broadband service of adequate bandwidth, which is not always available. Video freeze-ups and spontaneous termination of connections in some areas is a major handicap and may require the presence of technical support staff.18,19,23,25,31 Moreover, with the current state of national telecommunication regulations and the restrictions to a limited number of specific network providers, costs can be prohibitive.23

The potential cost of establishing telemedicine services has been mentioned as an obstacle to its implementation and wide acceptance.34 Unfortunately, cost analysis can be bewildering and complex with subtle differences between benefit, savings, consequences and effectiveness.1 Traditional telemedicine equipment is very costly and requires major infrastructure in two locations.33 Not infrequently, inadequate planning and development of infrastructure leads to ineffective and non-compatible equipment and networks, and thus to great increases in expenditure.31 Several studies have stated significant start-up funding requirements of US $ 50,000.1 The cost of one portable telemedicine “studio” is between US $ 15,000 and US $ 20,000. This, however, is approximately the cost of one acute aeromedical transport from any remotely located hospital to a burn unit.2 Telemedicine expenditures may be justified in large countries such as Australia or the USA where hospital-to-hospital aeromedical transfer of patients is common practice. It may not be so when other methods of transfer in smaller nations exist or where helicopter transfer is primarily reserved to take victims directly from the accident scene to the specialist center.15 In such situations, in order to enhance triage, establishment of a wireless, secure means for ambulance crews to send images to specialist burns teams may be more justified despite the higher set-up costs compared to a hospital-based telemedicine system due to the extra hardware required. The impact of this system on reducing helicopter transfers may be great but the net savings need to be evaluated from another perspective.33

Establishing a successful and functional telemedicine system needs to be part of the very fabric of care in a specialist unit. In that context, maintenance and support of the system may be more important than the initial implementation of the technology. Maintenance costs and how these costs may impact on the day-to-day expenses of running a specialized burn unit become critical in determining the cost effectiveness of the telemedicine system.23

Recent advances in technology and expansion of burn care networking make avoidance of apparently large start-up costs potentially possible. Alternatives to standard telemedicine include email or computer-based data transmission. Even though such a system of communications is certainly more cost effective than establishing a formal telemedicine link, it still requires significant infrastructure at both ends. Images need to be captured with a digital camera then transferred onto a personal computer. Images are subsequently compressed before being sent by e-mail to the burn specialist who will view them and send back his recommendation by e-mail.18,34 However, this process requires time to be completed and cannot support real time
teleconferencing. Surprisingly, use of e-mails to transmit patients’ images and medical information has not been associated with any significant problems so far. Patient confidentiality has been maintained and burn center consultation has been timely. E-mail communication linking patients directly to the specialist also requires investment in equipment, albeit a modest one. It may require training and support but has great potential as a low-cost telemedicine service in burns follow-up.  

Alternatively, routine “real-time” teleconferencing between individuals using personal computers or smartphones, or even a cell-phone based multimedia messaging service, have widened the reach of telemedicine, making care more accessible. With mobile phones image capture, transmission and receipt can be done very quickly without loss of image resolution and without major infrastructure at either end. Cell-phone based transmission, within range of a mobile phone signal, enables the primary care provider to immediately send clinical images and videos to the cell phone of a recipient burn consultant wherever he may be. However, confidentiality and data protection issues currently limit the use of cellular telephones and personal computer-based systems such as Skype™; these rapidly developing popular forms of telecommunications have been prohibited by some government offices and other entities. Image transfer of burns by a personal mobile phone or via an unsecure network is not allowed in certain countries such as Denmark.  

For the integration of this useful tool into clinical practice, it is essential that the medico-legal and confidentiality issues related to image capture and data transfer be addressed in a less defensive but constructive way.  

Another commonly expressed concern is that reimbursement mechanisms for telemedicine are still underdeveloped. At present, it is difficult for health care providers to consistently recover the costs of telemedicine even though in some countries, like the USA, this issue has been partly resolved through specific legislations. It remains very difficult, however, to provide appropriate reimbursement for non-physician professionals like nurses and therapists who are critical in providing state-of-the-art burn care. In fact, financial losses involved with some telemedicine programs are common and may jeopardize the expansion or even the continuation of telemedicine.  

A common obstacle voiced by clinicians is the licensure and credentialing required by various states and hospitals for them to be able to evaluate patients at multiple sites. USA regulations require that each provider be licensed in the state of each affiliated telemedicine site. Moreover, he must be credentialed at each individual health care facility involved. This regulatory hurdle, probably unique to North America, may deter some providers from practicing telemedicine because of the associated bureaucracy and costs. Similar concerns have not been voiced in Europe where state boundaries are dissolving, nor in low and middle-income countries where such issues are not a real concern.  

Legal liability of the specialist evaluating a burn patient from a distance is yet another major issue to be considered. Medical malpractice liability laws are unclear when it comes to telemedicine. Should there be litigation, jurisdiction of cases in interstate practice of medicine has not yet been comprehensively addressed. However, as experienced by many, consultative expertise may be provided from a distance while the responsibility to deliver care to patients remains that of the primary provider.  

Protection of privacy and patient confidentiality issues also remain real concerns. Patient consent for telemedicine consultation may be required; telemedicine communication networks must be secure. Provisions for secure, long-term storage of photos and videos are also required and systems need strong authentication, data encryption, non-repudiation services, a common security policy, and controlled contracts between partners. Fortunately, appropriate and secure physician-to-physician contact can be established easily, whereas the ability to develop secure patient to physician data transfer is more problematic. Healthcare institutions also need to address the potential for abuses and construct appropriate safeguards. In addition, when implementing the system between two countries, multiple other difficulties need to be overcome, including time zone differences, language barriers, and different approaches to patient care.  

Telemedicine also has many burn care specific limitations. Although burn consultations via telemedicine are cost-effective for the patient, they are more time-consuming for the physician and therapist. Burn scar management requires manual palpation to evaluate scar thickness and firmness. Transparent facemasks, splints and compression garments need face-to-face consultation for measurements and readjustments. It is also not permissible for certain medications, such as narcotics, to be prescribed to patients in distant locations by phone orders to pharmacists. Prescriptions need to be mailed, often leading to delays in delivery of medication. Even when a certain medication can be delivered by a telephone order, long distance call charges incurred cannot be reimbursed. Even though telemedicine equipment is available in a large number of regional primary care hospitals, it is rarely used efficiently. Many do not have personnel to operate the facilities during off-hours. Additionally, some switching sites may be available only during regular weekday working hours.  

**Conclusion**  

Practice of medicine from a distance is a relatively new modality developed initially to improve trauma management. Expert opinion has suggested its benefits and
it is widely felt that telemedicine has the potential to improve patient care within health care systems, as well as providing cost savings and time efficiency in patient care. Published studies suggest that telemedicine for burn care is feasible, can be at least as good as face-to-face assessment, and may improve clinical decision-making. Unfortunately, as there are no comparative published studies on providing cost savings and time efficiency in patient care.

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