5 Telemedicine for Trauma and Intensive Care: Changing the Paradigm of Telepresence

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Introduction

While principles of the surgical sciences and practice have remained the same over centuries, the way in which surgery is conducted has changed dramatically in the past 50 years. A key element of these changes is technological advances during this time period, with rapid advances in techniques such as laparoscopy, robotic surgery, and internet and remote presence introduction in the last two to three decades. Telemedicine and telepresence are not new phenomena and have been promoted and practiced by a number of surgeons over the last few decades. While few surgeons, such as Michael E. DeBakey and Ronald C. Merrell, were pioneers of telemedicine [1, 2], only in the last few years have telemedicine and telepresence been routinely accepted and practiced by a greater number of surgeons across multiple subspecialties. Yet, this number is very small compared to the overall number of surgeons worldwide and, in particular, in developed countries. Telemedicine offers great promise, specifically for people living in rural and remote areas because it reduces time and cost as well as provides specialists who are unavailable within those areas. It has also successfully been used from simple surgical consultations with low bandwidth [2] for a consulting second opinion, to intraoperative interventions, to transatlantic spectacular surgical interventions [3], to disaster response scenarios. Because of its potential uses with vulnerable populations, the World Health Organization (WHO) formulated the e-Health strategy in 2005. Within this e-Health strategy, several initiatives to foster development of telemedicine centers in member states began [4].

Recent technological advances have made possible telemedicine application in the management of trauma and emergency care and in the intensive care setting especially in remote areas and isolated communities. The biggest promise of teletrauma, teleresuscitation, and tele-ICU is the transformation of "Golden Hour" into "now care" and the stabilization of the patient and safe transport to trauma center when indicated. The initial experience with teletrauma in saving lives—managing critically ill and injured trauma patients at the rural site or safely transferring them when needed—reducing the overall cost of trauma care has been rewarding and very successful. The acceptance by trauma surgeons, referring physicians, nurses, and other providers, as well as patients, has been excellent. Other clinical specialties are making preparations and creating protocols to use the system as well. The telepresence of the trauma surgeon, through the teletrauma system, is being used to identify

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knowledge gaps and the needs for instituting new outreach educational programs. As technology is becoming friendlier and cheaper, the concepts of teletrauma, telepresence, and teleresuscitation are evolving and will become an integral part of modern care of trauma and emergency care in rural settings, where there is a lack of specialists and other expertise.

Global advances in cellular telephony have made telemedicine even more readily available for poor and remote regions of the world. Agencies such as the National Institutes of Health are inviting proposals to facilitate the use of these technologies in low (LICs) and low middle income countries (LMICs) [5]; however, the use of these technologies for surgical practices still has been less than would be anticipated and is most likely reflective of being in the early phases of development.

Recent activities within the American College of Surgeons have increased the visibility of telemedicine for surgeons by having dedicated courses for surgeons as well as by creating a subcommittee on telemedicine within the Health Information Technology committee [6].

The primary benefit of telemedicine is the ability to provide medical care from and at the distance [7–14]. No other field of clinical telemedicine has proven more beneficial, has reduced mortality and morbidity, and has become more popular, in particular in organized major health systems, than telemedicine for intensive care. Variously known as “virtual e-ICU,” “e-ICU,” or “tele-ICU,” all have the same meaning, however, and that means that an intensivist (surgeon, anesthesiologist, or an intensivist) manages a number of patients, often in a number of intensive care units in wide geographical areas, at the same time. Throughout this chapter, we will refer to telemedicine for intensive care units (ICU) as “tele-ICU,” and to telemedicine for trauma and emergencies as “teletrauma.”

Due to the growing demand of intensive care and the rising elderly population, it is expected that these numbers will continue to grow. On the other hand, there is a major shortage of intensivists caring for these patients, and telemedicine has been promoted as one solution to this major shortage of intensivists, in particular in a large healthcare system [7–15]. Patients are monitored live from a command and control center using audio and video connectivity, assisted with major set of evidence-based medicine guidelines and protocols.

While implementation of tele-ICU has expanded dramatically, there are a number of challenges to implement tele-ICU, both in developing countries and developed countries. These challenges include financial, economic, legislative, attitudinal, and cultural. Despite these barriers with the advancing of technological options, and as technology becomes cheaper, the use of tele-ICU will also grow. However, the benefits of tele-ICU programs outweigh the risks associated with them, and the barriers need to be overcome to allow for successful establishment and integration of tele-ICU services in the overall platform of healthcare system. For tele-ICU, geography and distance are meaningless, as is a case with any form of telemedicine. This chapter reviews the successful tele-ICU and teletrauma programs and discusses the challenges associated with implementing tele-ICU programs.

Prevalence of Tele-ICU and Models of Operations

Tele-ICU is becoming more and more prevalent. A recent review found that formal ICU telemedicine programs now support around 11 % of nonfederal hospital critically ill adult patients and have demonstrated lower ICU and hospital mortality and shorter ICU and hospital length of stay [14]. There is an expected annual growth rate of 1 % per year [11], indicating that critical care delivery models that include telemedicine will continue to grow [11, 15]. In addition to the continuous telemedicine care model, episodic care models continue to grow [15, 16]. In early 2013, there were 175 active robotic devices, 56 of which are known to be supporting ICU patients in 25 North American ICUs, that have been activated more than 10,000 times [15].

There are a couple of models of tele-ICU about which there have been reports. The most common one is Centralized Monitoring Model (CMM), usually applied in major healthcare systems, while the second one, Virtual Consultant Model (VCM), provides care to individual ICUs using a number of off-the-shelf technologies. This technology, especially for CMMs, is very expensive to set up and to maintain; in a most recent study [11], the capital cost of the tele-ICU was $1,186,220. The annual operational cost is $1,250,112, or $23,150 per monitored ICU bed [16].

A recent literature review of 91 studies on tele-ICU found that 46 of these studies assessed clinical outcomes, 36 assessed workload and staff acceptance, and nine assessed cost and financial indicators [17–19]. When these two models were studied side-by-side, it was found that CMMs showed better outcomes [19]. Of 46 studies reported, a reduced LOS and decrease in mortality were noted in all but six of the studies [18]. A review of 25 tele-ICU in the United States found that implementation of tele-ICU programs favorably affected morbidity rates and length of stay. Other studies also have shown decreased LOS and decrease in mortality when tele-ICU was applied [7, 11, 20, 21].

However, many argue against the cost-effectiveness of tele-ICU programs. Others [22] found that, while costs increased with the implementation of a tele-ICU, mortality rates decreased, but only among the sickest population. These authors reviewed the cost per bed for patients before and after the implementation of a tele-ICU in five hospitals within a large nonprofit group. The cost per bed for patients included software and hardware implementation. Costs per patient increased 28 %. Hospital cost per case increased 43 %. Because the sickest of the patients had lower mortality and length of stay, these authors suggest cautious implementation of tele-ICU programs [22] and possibly for the sickest of patients only. Additionally, a meta-analysis on studies that published results from tele-ICU implementation reported that mortality rates and LOS were reduced [23, 24], but the optimal tailoring of tele-ICU programs remains unclear [17]. Specifically, the best benefit to cost ratio has not been defined. Others have suggested further financial analysis [25]. Overall, however, the majority of studies do provide evidence for a reduction in mortality rates and a reduction in length of stay.

In addition, other important benefits come from using tele-ICU. It has been demonstrated that the experience of physicians in training with telemedicine intensivists is positive and that there is increased patient safety [14]. Numerous studies have been conducted on staff perception, usability, and satisfaction with tele-intensive care units. For example, physicians expressed that they were extremely satisfied [26]. Others found that there was an increase in satisfaction among nursing team members, particularly during nighttime hours [27]. Physicians felt they could manage critically ill patients better, were more equipped to communicate with bedside care teams, and were better able to provide reassurance to families [28]. Tele-ICU implementation was associated with improvement in nursing perceptions of working conditions and communications [29]. In one study, 93 % of clinicians felt that telemedicine was clinically useful in neonatal examinations [30]; others found that the use of telemedicine technology by nurses was affected by their perceived usefulness [31].

Overall, the majority of studies that included quantitative and qualitative data provide support for the use of telemedicine in intensive care settings, although in one study it was found that some nurses felt that the transition from bedside caregiver to information manager can be difficult [32]. Fewer studies that provide evidence for patient satisfaction are available. Evidence suggests that patients report higher satisfaction with tele-ICUs; however, vigilance of staff and nurses in the use of these services plays a role in patient satisfaction [33, 34]. Early studies suggest that implementation of ICU telemedicine programs has been associated with lower numbers of malpractice claims and costs. The requirements for Medicare reimbursement and states with legislation addressing providing professional services by telemedicine should be known by all providers involved in this exciting field [14]. A number of new directions and future uses of tele-ICU are being explored, including caring for the increasing geriatric population [35].

Tele-ICU protocols and procedures are based on the institutional policies and the setup. Most practices require 12–24 h telepresence of a critical care specialist. Providers such as physician assistants, nurse practitioners, or residents, in addition to bed site critical care nurses, are usually involved in the site where patients are present. Scheduled bedside rounds and rounds on demand are done. The main point is the fact that the critical care specialist has visual as well as audio access, and access to all the data and medical records as well. In addition, most of the tele-ICU models use guidelines, protocols, and algorithms to manage certain critical conditions.

Teletrauma and Emergency Management

Approximately 10 % of the world's deaths, or 5.8 million, are due to injuries each year. More than 90 % of deaths due to injuries occur in LICs and LMICs. It has been estimated that 40 % of deaths could be preventable in the United States if access to trauma care was uniform throughout the country. It has been postulated by a number of authors that adding telemedicine for trauma (teletrauma) will improve overall trauma care. To this end, a number of programs have been successfully designed and implemented [36].

The first attempt to simulate the use of telemedicine in trauma resuscitation in real time was recorded in 1978 by Dr. R. Adams Cowley, who staged a disaster exercise at Friendship Airport in an aged DC-6 aircraft, using old cumbersome satellite technology. Following the reports by Rogers et al. [37] on their use of a teletrauma, a number of other investigators established telemedicine services for trauma and emergencies, mostly for the management of injuries in rural settings. This certainly has major implications on the cost of transferring these patients to major medical centers, increased utilization of local healthcare facilities, and other social and financial issues of treating these patients away from their families. The clinical accuracy of telemedicine in evaluating other trauma patients also has been assessed and demonstrated. In order to fully implement remote trauma resuscitation, the remote trauma surgeons and referring healthcare providers must feel comfortable and confident in their ability to supervise and manage trauma resuscitation in the remote site from a central location.

While there are several studies that document the effectiveness of telemedicine in trauma, there were no reported randomized controlled trials. The benefits of teletrauma have been well documented and span from reduction of unneeded transfers, reduction in mortality, reduction of cost, to improvements in patients satisfaction. For example, a study comparing telemedicine consultations for a rural pediatric care facility found a high satisfaction rate among providers and patients [38]. Other studies evaluated 841 patients over a 5 years period in Mississippi and found that telemedicine significantly improved acute trauma management. Severely injured patients were more readily identified and transferred when necessary [39]. Several other studies have reported high clinical accuracy as well [40].

In a retrospective analysis of 59 teleconsults between five rural hospitals and a Level I trauma center, we reported the initial experience with 59 trauma and general surgery patients [41, 42]. Of those, 35 (59 %) were trauma patients, and 24 (41 %) were general surgery patients. Fifty patients (85 %) were from the first hospital at which teletrauma was established. For six patients, the teletrauma consults were considered potentially lifesaving; 17 patients (29 %) were kept in the rural hospitals (8 trauma and 9 general surgery patients). Treating patients in the rural hospitals avoided transfers, saving an average of $19,698 per air transport or $2,055 per ground transport. The authors concluded that the telepresence of a trauma surgeon aids in the initial evaluation, treatment, and care of patients, improving outcomes and reducing the costs of trauma care [42]. Others have recently published cumulative results for telemedicine in acute phase injury [43].

The use of telemedicine for wound and burn care has been extensive, and is one of the most common applications of telemedicine practices in surgeries. Burn centers in particular have documented the usefulness of telemedicine in burn and wound care [44–50].

Summary

There are numerous benefits and, as with anything, some limitations to the implementation and use of telemedicine for trauma and intensive care. The reduction in travel costs is significant; however, the initial capital costs for ICU and trauma units need to be balanced out by the benefits seen in the long term.

Successful telemedicine programs have been implemented and provide excellent examples for others, but the adoption of technology, programs, and systems has not happened as readily as expected. Of the successful programs that do exist, many have not spread to large-scale applications. These few successful programs typically have champions who facilitate program funding with government and private sector connections or who have successful grants. By continuing the mission of adopting technology and publishing results of the use of these technologies, empirical evidence supporting the effectiveness of these technologies will contribute to wider acceptance by patients and physicians, which will lead to the establishment of additional clinical telemedicine programs. This adoption will, in turn, contribute to saving lives. Despite the initial high cost of establishing tele-ICUs and teletrauma, the evidence for the effectiveness is unquestionable, and these services will continue to grow. While the technology is rapidly advancing and getting less expensive, the cost of setting it up may also eventually be reduced.

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