Tele-ICU: Remote Critical Care Telemedicine

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Objectives
1. Understand the driving forces behind the development of tele-ICU.
2. Define tele-ICU.
3. Understand the practical aspects of implementing tele-ICU.
5. Introduce the future directions of tele-ICU.

Key words: critical care; information technology; intensivist; tele-ICU; telemedicine

Abbreviations: IT = information technology; ITS = information technology services; LOS = length of stay; tele-ICU = remote critical care telemedicine

High-intensity ICU staffing, ie, intensivist management or comanagement of all patients in an ICU, is a practice model associated with improved patient outcomes.1 Pronovost and colleagues,2 in a metaanalysis including 156 ICUs, reported a 29% reduction in relative risk of mortality with high-intensity staffing compared with low-intensity staffing. Many institutions, however, lack financial resources or available specialist physicians to accommodate the high-intensity model. There is an increasing shortage of critical care physicians in the United States, especially in underserved, rural, or geographically remote communities with limited resources.3 Similarly, the number of experienced critical care nurses is insufficient to meet bedside needs, and this shortage is also projected to persist over time.4 Remote critical care telemedicine (tele-ICU) is a means of leveraging scarce critical care clinician resources, while using information technology (IT) and novel approaches to communication and workflow to provide population-based care to patients in geographically disparate ICUs. This review will outline the key principles of tele-ICU, including its history, barriers and keys to success, evidence for efficacy, and future directions.

Driving Forces Behind the Development of Tele-ICU

In the past 3 decades, the demand for ICU services in the United States has risen. Average life expectancy has increased, with estimates predicting that the US population above age 65 will increase by 50% in 2020, and 100% in 2030. As the average age of the population increases and the complexity of chronic illness progresses, the demand for critical care services is expected to grow proportionally over the next several decades.5,6

In 2008, The Leapfrog Group—a US health-care advisory board of Fortune 500 organizations that regulates annual purchasing standards worth $59 billion—identified evidence-based recommendations for improving health-care quality, decreasing mortality, and reducing expenditures.6,7 Key recommendations included application of computerized physician order entry systems and an increase in ICU physician staffing. ICU mortality rates approach 10% to 20%, accounting for more than 500,000 deaths annually in the United States. The Leapfrog Group estimated that 53,000 lives could be saved annually if a higher standard of ICU physician staffing was adopted.8,9 Personnel shortages have made implementation of Leapfrog standards challenging, with approximately 10,000 practicing intensivists, only 30% of US ICUs are able to meet full adherence to Leapfrog physician staffing standards.6 Tele-ICU provides an opportunity to leverage state-of-the-art technology to deliver the scarce resource of intensivist and nurse expertise to underserved facilities.

Tele-ICU was initially described in 1982 by Grundy and colleagues,10 with telemedicine introduced as an on-demand means of networking critical care consultants with facilities lacking intensivists.11 Tele-ICU has since evolved into the use of continuous monitoring and sharing of information between the bedside and a monitoring center, with two-way interactive audio-video technology to link remote critical care practitioners and patients in geographically separated ICUs. There are multiple providers of tele-ICU technology, including Philips-VISICU (Andover, MA). Philips-VISICU currently supplies tele-ICU technology infrastructure to 42 health systems, which cover 5,900 beds (range 28 to 406 beds). This demographic represents approximately 10% of the ICU beds in the United States.12 As of 2009, more than 1 million patients have been cared for by tele-ICU systems.11

Staffing and Workflow

Although variations in organizational and staffing structure exist between tele-ICU centers, the basic structure consists of a central communication center, or “command center,” with high-speed, stable connections to multiple remote ICUs. The command center is staffed by critical care physicians, physician extenders, critical care nurses, and/or administrative support personnel. At some tele-ICU centers, a critical care pharmacist provides remote ICU pharmacy support.13 The number of remotely located physicians, physician extenders, and nurses depends on the quantity of critical care beds covered by the tele-ICU. Smaller networks (<70 beds) may be covered by one physician and one nurse. Additional staff is added when more than 70 beds are monitored. Most tele-ICUs provide 24/7 nursing coverage.11 Physician coverage is variable, ranging from overnight presence only to 24/7 coverage.

Each tele-ICU workstation consists of multiple monitor screens, allowing clinicians access to real-time data, including bedside monitor data, laboratory studies, radiographic imaging, nursing and respiratory therapy flow sheets, ventilator parameters, physician documentation, and vital signs.6,11 Through continuous rounding, tele-ICU clinicians promote “best practice” care, assess for early signs of clinical decompensation, and assist with the carrying out of care plans as defined by the bedside providers. Additional consultation and management is provided to augment bedside care, such as reviewing and assisting with new admissions, supervising procedures, responding to questions or emergencies, providing education to house staff and less-experienced clinicians, and supporting bedside documentation in real-time.13 Tele-ICU rounding is prioritized based on level of acuity, with highest acuity patients assessed at least hourly, and lower acuity patients reviewed less frequently.5 Audiovisual tools are merged with decision support resources,
including real-time automatic alert systems that highlight abnormalities and trends in laboratory studies and physiologic parameters (e.g., vital signs, urine output, renal function). The alerts are reviewed by the tele-ICU clinical staff, with further investigation, communication with the bedside providers, and resultant action. The clinical record is accessible to both the tele-ICU staff and the hospital care team. In the most integrated programs, a single electronic health record utilized at the bedside and the tele-ICU. Many programs, however, utilize multiple documentation systems (including paper records), and, thereby, rely on fax transmissions and other means of sharing of information. Tele-ICU and hospital clinicians contribute to electronic documentation, entering and reviewing orders and updating progress notes, flow sheets, and care plans. A basic tenet of tele-ICU is that routine rounding and attention paid to acknowledged "best practice" care may help prevent deterioration in the condition of at-risk patients, as well as ICU complications.

The level of involvement of the tele-ICU in an individual patient’s management is dictated by the patient’s level of acuity, level of hospital staff caring for the patient, and the discretion of the hospital-based clinical team. Bedside physicians may opt to allow the tele-ICU to intervene prior to direct communication only in an emergency, or to act as needed, with appropriate documentation of care and consultation after the event. Experience has suggested that outcomes related to tele-ICU are better in patients whose bedside physicians accept a higher level of input and management from the tele-ICU. Tele-ICU is not designed as a replacement for bedside patient care. Bedside providers remain essential—not all interventions can be delivered remotely, such as medication administration or placement of endotracheal tubes or intravenous catheters, and other life-saving procedures. Tele-ICU is designed as an adjunct tool for improving patient safety and contributing to better and more cost-effective population-based and individualized care to patients in the ICU.

Evidence of the Effect of Tele-ICU on Outcomes

A study by Rosenfeld and colleagues, published in 2000, reviewed the outcomes of patients in a 10-bed surgical ICU after implementation of a remote intensivist monitoring program. The authors noted a 45% reduction in severity-adjusted ICU mortality, 30% reduction in hospital mortality and length of stay (LOS), and a 16% reduction in cost. A follow-up study conducted in two affiliated hospitals of Sentara Healthcare was published in 2004. The Sentara study evaluated the use of tele-ICU in both medical and surgical ICUs, comparing outcomes between 1,396 patients in the baseline period and 744 patients in the intervention period, after implementation of tele-ICU. Hospital mortality decreased by 26.4% (relative risk of 0.73; 95% CI, 0.55-0.95), average ICU LOS decreased by 16%, and variable costs decreased by 24.6%. Overall hospital LOS was unchanged.

Tele-ICU was introduced to a rural community within the Avera Health System in 2004, with outcomes data published in 2011. Study hospitals included a large tertiary care facility, three rural regional hospitals, two community hospitals, and 9 critical access hospitals covering 5,146 patients. In small and critical access tele-ICUs, contributed to a 37.5% decrease in patient transfers (to facilities providing a higher level of care), with an estimated savings of $1.25 million. In regional hospitals, mortality rates were unchanged in two hospitals and reduced by 4.5% in a third hospital. Severity-adjusted LOS was reduced in all three tertiary facilities. Within the tertiary care facility, tele-ICU was associated with a reduction in severity-adjusted ICU mortality (odds ratio, 0.35; P = .07), decreased ICU LOS (3.79 vs 2.6 days; P = .001), and reduced hospital LOS (10.0 days vs 7.81 days; P = .001). When combining results from the community hospitals and the tertiary hospital, tele-ICU implementation was associated with a reduction in LOS of 6,825 ICU days and 821 hospital days.

The University of Pennsylvania Health System implemented tele-ICU in an academic surgical ICU, with 2,811 patients managed over a 3-year period. Tele-ICU was associated with a 3.3-mortality reduction from 8.4% to 5.1% (P < .0003), and hospital mortality reduction from 11.1% to 6.0% (P = .01). ICU LOS was reduced by a mean of 3.75 days (P = .007), and hospital LOS was reduced by a mean of 4.43 days (P = .04) after tele-ICU implementation.

Two recently published studies failed to demonstrate significant outcome effects of tele-ICU implementation within early-adopting health systems in Texas and Illinois. Integration of tele-ICU into bedside care was poor in both studies—based on bedside clinician preference, the tele-ICU system was restricted from providing care (outside of life-threatening emergency situations) for 66% and 79% of patients, respectively. The Texas study did suggest improved mortality outcomes after tele-ICU intervention for patients with more severe illness, yet it is unclear if these patients were permitted a higher level of tele-ICU involvement. Together, these studies suggest that tele-ICU monitoring alone—without program acceptance and comprehensive integration with bedside care—is unlikely to be cost-effective. Further studies evaluating the impact of tele-ICU care are expected and are necessary to determine the potential benefit of this complex model.

Practical Aspects of Implementing Tele-ICU

As might be expected with the introduction of an "external" entity into existing care paradigms, there are numerous challenges in establishing and maintaining collegial and effective collaboration from all participants. Careful planning and extensive preimplementation communication with all personnel impacted in any way by the introduction of the tele-ICU are critical. Effective and engaged tele-ICU leadership is essential, at executive, clinical, administrative, and information services levels. Identification and involvement of "local champions" from various disciplines at each associated hospital can have great value in initial acceptance and ongoing success of a program, as can regular provision of outcome data and feedback to bedside clinicians and administrators.

Many of the tele-ICU programs in the United States are affiliated with large health-care organizations. Small hospitals may lack financial or technological resources to develop and manage their own programs. Networking smaller institutions with large hospitals promotes centralized operations of a tele-ICU program, thereby defining organization structure for administrative purposes, program surveillance, review of health-care practices, and financial considerations. System-based tele-ICUs have started to investigate and establish "outreach" to nonaffiliated institutions. It is important to recognize the complexity of introducing a significant number of new practitioners to such institutions; a streamlined and uniform approach to telemedicine privileging can greatly improve efficiency and reduce waste.

The initiation and maintenance of an effective tele-ICU program require an unprecedented partnership between clinicians and information technology services (ITS), including dedicated program-focused personnel, hospital-based ITS collaboration, and 24-h centralized technical support. All tele-ICU audio/video communications are nonrecordable, and strict standards for patient privacy are maintained for all tele-ICU systems.

The cost of implementing tele-ICU technology varies, based on choice of technology and scope. For the most commonly used technology, start-up costs range from approximately $30,000 to $50,000 per ICU bed. Annual operating costs to cover overhead, maintenance, and staffing are estimated at approximately 20% of start-up costs. There is currently no mechanism for patient/insurance billing and reimbursement for tele-ICU physician services, although it is anticipated that this model will change as the role of telemedicine further expands and matures. The costs associated with tele-ICU personnel are, therefore, assumed by the affiliated hospitals and/or health systems. Physicians, physician extenders, and nurses are generally reimbursed on an hourly rate; however, full-time remote tele-ICU providers may be salaried employees.

The operational and start-up costs of a tele-ICU program are recouped primarily by health-care cost savings. As discussed previously, Breslow and colleagues, in the Sentara Healthcare study, demonstrated a 24.6% reduction in variable costs after implementation of a tele-ICU program, translated to $1.3 million saved over a 6-month period. In a more recent study by Zawada and Herr, it is acknowledged that $650,000 per tele-ICU affiliate within their system, $1,202,379 was saved in the first 2.5 years after implementation by reducing the need for transfers from rural hospitals to affiliated tertiary care facilities. In a University of Massachusetts study of 6,400 patients, $5,000 per patient was identified after implementation of a tele-ICU. Tele-ICU implementation at the University of Pennsylvania surgical ICU was associated with a 10% reduction in ICU LOS and...
20% reduction in hospital LOS—an estimated savings of $706,272 to $941,697 for the ICU and $2,134,339 to $2,842,940 for the hospital. Increased revenue has also been suggested, as in the University of Pennsylvania program that reported a significant increase in billable physician services after tele-ICU implementation. This outcome was felt to be primarily related to the role of the electronic health record in capturing patient acuity/complexity and physician activity.

Future Directions for Tele-ICU

The scope of tele-ICU continues to evolve. Several programs have demonstrated improved outcomes using tele-ICU in monitoring and implementing specific “best practice” guidelines. The Sutter Health System has used a tele-ICU as a means of screening for severe sepsis and monitoring and facilitating compliance with the Surviving Sepsis Campaign “bundles.” In a Sutter study, 266 patients were admitted to the ICU with a diagnosis of sepsis, and patient management was shared between hospital practitioners and tele-ICU clinicians. After tele-ICU incorporation, antibiotic administration within 2 h increased from 51% to 79% (P < .001), lactate measurement increased from 49% to 55% (P = .07), frequency of baseline laboratory blood draws increased from 78% to 84% (P = .003), and frequency of blood cultures drawn before antibiotic administration increased from 63% to 74% (P < .001). Such improvements in processes of care are likely associated with the previous observation, from the same institution, that tele-ICU implementation was associated with a 21.2% reduction in ICU mortality resulting from sepsis, with an estimated 56 lives saved.

A pilot program at Baptist Health in Little Rock, AR, utilized tele-ICU to identify patients ready for ICU discharge and facilitate the transfer process. When compared with baseline data, program implementation was associated with a 30% reduction in ICU LOS, with an estimated cost savings of nearly $3 million. Tele-ICU systems have been incorporated into other programs of standardized “best practice” care, including sedation/analgesia/delirium practice and blood transfusion policy. Such innovative programs demonstrate the potential role of a coordinated tele-ICU in systematic process improvement for large populations of patients in ICUs at multiple sites.

Tele-ICU is also beginning to extend to microsystems beyond the ICU, such as EDs, rapid response teams, high-risk labor and delivery units, and long-term acute care hospitals. The model will likely be implemented in intermediate care/step-down and postanesthesia care units, as these departments house patients with higher levels of acuity that often require ICU services or level of care. Extension of tele-ICU technology to other areas will facilitate early communication and early detection of clinical deterioration, which may improve outcomes and mortality rates. Telemedicine has further been expanded to “e-hospitals.” One example is the International Virtual e-Hospital (IVeH) program, which has incorporated telemedicine and e-health education within the public health infrastructure of developing countries, such as Kosovo.

Tele-ICU may influence outcomes in public health emergencies, such as epidemics or mass casualty. The Inova Health System, for example, completed a simulation exercise for the tele-ICU response to mass casualty. The tele-ICU framework was optimal for networking tele-ICU intensivists and trauma surgeons to bedside and on-site providers and triaging and stabilizing patients from a remote site outside of the direct area of emergency impact. Effective tele-ICU disaster response offers potential for “surge management” across multiple sites within a large geographic area. Tele-ICU also has a potential role in syndromic surveillance or prospective early identification of pandemics or toxidromes.

The technology is also well suited toward applications such as tele-pharmacy and tele-stroke programs. Further experience and study regarding the extension of tele-ICU into these areas and others are warranted.

Tele-ICU programs are being incorporated into critical care fellowship training programs, nursing education, and simulation-based education programs. As the use of the tele-ICU model becomes more widespread, it will be advantageous to have well-educated clinicians with familiarity with the role of tele-ICU from “both sides of the camera.”

Conclusions

Tele-ICU is an expanding resource for utilizing technology to improve population-based critical care health-care delivery in the face of increasing provider shortages. This specialized technology has the potential to improve clinical outcomes, optimize provider efficiency, and reduce health-care costs.

Posttest Questions

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Related Terms: Critical Care ICU Management CME PCCSU PCCSU Volume 24 Resources