Robotic Telepresence in a Medical Intensive Care Unit—Clinicians' Perceptions

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Abstract

Background: Robotic telepresence has been used for outsourcing of healthcare services for more than a decade; however, its use within an academic medical department is not yet widespread. Intensive care unit (ICU) robots can be used to increase access to off-site supervising physicians and other specialists, reducing possible wait time for difficult admissions and procedures.

Objective: To study the use of ICU robots through a pilot program in an academic hospital and examine provider attitudes toward the usability and effectiveness of an ICU robot.

Materials and Methods: The study was done as a postinterventional cross-sectional seven-question survey in a medical ICU in an urban academic hospital. Participants were attending physicians, fellows, residents, nurses, and respiratory therapists.

Results: Users of the ICU robot reported satisfaction with communication, and improved patient care. They also reported perceived improved quality of care with the use of the robot.

Conclusions: Findings show the importance of a whole-team approach to the installation and implementation of an ICU robot. The ICU robot is an effective tool when it is used to visualize and communicate with patients, bedside staff, and families. However, a number of providers are still not trained or have not been shown how to use the ICU robot, which affects the overall utilization rate.

Keywords: robotic telepresence, ICU, health informatics, telemedicine, telehealth

Introduction

Early experiments with telemedicine technologies in intensive care unit (ICU) settings found that the audiovisual technologies were adequate, but too expensive, for consultations in patient care.[1] Since then, ICU telemedicine has continued to grow and evolve, with the first formalized program developing in 2000.[2–4] Today, numerous ICU telemedicine programs are in use across the United States, utilizing different technologies (fixed, portable, or mHealth), employing different care models (continuous, preemptive/scheduled, or reactive) in a centralized or decentralized tele-ICU.[5] A PubMed search of "robotics and telepresence and intensive care units" yielded five journal articles.[6–10] One of the main observations of the differences between traditional videoconferencing systems in healthcare and robotic telepresence is that users tend to "interact with the robot as if it is a person."[11] Even though the growth of ICU telemedicine seems to be remarkable, many barriers to implementation and adoption remain—from medical liability, reimbursement, high costs, and provider resistance to widespread disagreement about appropriate application.[12–14] Although telemedicine and robotic telepresence have shown great potential in emergency medicine and ICU settings, they are still being underutilized because of the healthcare

community's reluctance to use the new technologies because of feasibility concerns, scientific evidence, finances, and so forth.[15] Patients in general accept telemedicine technologies quickly, most likely because of their personal use of at-home videoconferencing.[16] On the contrary, providers are slow adopters because of legal and regulatory concerns.[17] In addition, studies have reported that physicians' hesitation to adopt new technologies is one of the main barriers to implementation.[18] These issues, however, are expected to diminish as technology becomes a part of everyday medical practice and more tech-savvy younger providers enter the practice.[19]

Robotic telepresence in the ICU is used primarily to provide ICU physician coverage to rural and remote hospitals affected by the shortage of specialists. In 2010, 25 ICUs in North America were using robotic telepresence, with a total of 56 robot endpoints, almost 50 percent of which were in academic institutions.[20] In other words, each robot represents one endpoint, so 25 ICUs have an average of two robots each. The ICU robots are used as a vehicle that enables fast face-to-face communication between providers when some of them are not present in the ICU.[21] The robots are used instead of old-fashioned telephonic communication.[22] Providers located remotely can also observe patients' vital signs, examine medical charts, and communicate with bedside staff. The robots are also used to allow providers to communicate with patients and families when they are away from the ICU. Reynolds et al. (2012) showed great provider satisfaction in this model, with 100 percent of respondents reporting that both patient care and patient satisfaction were improved by using a robot.[23]

At the University of Missouri Hospital, the ICU robot is used to enable attending physicians to connect to the ICU for patient rounds, resident and fellow supervision, and respiratory therapists' consults when the physicians are not physically present in the ICU. The aim of this pilot study was to assess user attitudes and perceptions of usefulness and effectiveness of the ICU robot. The study was conducted to find out if these attitudes may influence the actual usage of the ICU robot. In this pilot project, we use the term *provider* to refer to a medical provider of services "who furnishes, bills, or is paid for healthcare in the normal course of business," as described by the Social Security Act.[24]

Materials and Methods

Design, Setting, and Sample

This pilot study was initiated to evaluate actual usage and provider attitudes toward an ICU robot used internally instead of to outsource services. The study was a postinterventional, cross-sectional survey. It was conducted at a medical ICU (MICU) of an academic hospital, the University of Missouri Hospital and Clinics (UMHC). The MICU is an 18-bed closed intensive care unit. It represents one of four types of intensive care units at UMHC, but it is the only one currently utilizing the ICU robot.

The UMHC MICU is divided into two pods, staffed by the Division of Pulmonary, Critical Care, and Environmental Medicine. These two pods are mirror images of each other: beds 1–9 are in pod 1, and beds 10–18 are in pod 2. The two MICU pods are bridged by the unit clerk's desk. The healthcare team consists of physicians (attendings, fellows, and residents), medical students, nurses, respiratory therapists, pharmacists, dieticians, and support staff (speech pathologists, physical and occupational therapists, unit clerks, housekeeping, etc.). The ICU robot is used by pulmonary faculty to provide patient care and consultations with colleagues, fellows, residents, nurses, and respiratory therapists when the faculty are not physically present in the MICU. The remote physicians accessed an iPad app to connect to the robot from different locations—home, administrative offices, clinics, or even the ICU floor. Engaging the robot was a physician-driven process: the physicians would connect to the robot to check on a patient's status on the basis of their previous knowledge about a critically ill patient being admitted or treated in the MICU. During the connection via the robot, the physicians usually speak with the nursing staff and sometimes with respiratory therapists. They would also communicate with residents and fellows if they were present. The study respondents were 29 physicians (attending physicians, residents, and fellows), nurses, and respiratory therapists. (See Table 1.) The study was approved by the University of Missouri Health Sciences Institutional Review Board.

Survey Instrument and Survey Administration

An evaluation was conducted to determine if MICU providers currently use the ICU robot, their satisfaction with it, and if they find it useful and effective. During the study design process, literature and websites were utilized to identify best practices for survey design and deployment. The survey tool included seven specific questions that addressed the providers' job title, use, and satisfaction with the ICU robot. Table 2 shows the seven questions from the survey.

Data were collected from October to December 2013 through an online survey via Research Electronic Data Capture (REDCap). REDCap is a secure web application for creating and managing online surveys and databases. REDCap provides audit trails for tracking data manipulation and user activity, as well as automated export procedures for seamless data downloads to Excel, PDF, and SPSS Statistics.[25] Participants received one initial invitation and up to three reminders to complete the survey, each at about two-week intervals after the initial e-mail was sent out.

Data Analysis

Quantitative analysis was applied to examine the providers' use of and attitude toward the ICU robot using SPSS statistical software. We compared the scores for providers who have used the ICU robot with the scores for providers who have not used the ICU robot by computing a Mann-Whitney *U* statistic for ordinal data. Average scores, standard deviations, ranges, and differences for each of the items along with the respective levels of significance were calculated.

Results

A total of 29 physicians, nurses, and respiratory therapists responded to the survey for a response rate of 48 percent (see Table 1). The ICU robot was used for a total of 72 minutes from October 26 to December 20, 2013, and only on Monday through Thursday, not on Fridays or weekends. It was used in a total of eight sessions, with the average of nine minutes per session. All sessions were performed at different times of the day, between 10 a.m. and 5:30 p.m. A total of five respondents (17 percent) replied having used the ICU robot. Of those, three (60 percent) were attending physicians and two (40 percent) were respiratory therapists. Nurses and fellows who responded to the survey all reported never having used the ICU robot. Four respondents who indicated never having used the ICU robot did not complete the remainder of the survey. The robot was used for patient rounds, to communicate with respiratory therapists when they were caring for a patient and had additional questions for attending physicians, and, in one instance, to discuss the patient with the patient's family members when the attending physician was not present in the ICU.

There were significant differences between users and nonusers of the ICU robot (see Table 2). All of the ICU robot users (100 percent) felt more confident caring for the patient with the supervising physician observing the visit via the ICU robot, compared to only 10 percent of the nonusers. The remainder of the nonusers (90 percent) reported neutral opinions. Likewise, there were significant differences in the opinions of providers that have used the ICU robot, who reported that it improved the quality of care, compared to those who have not, who were more likely to have neutral opinions. However, the two groups had little difference in their opinions regarding having to wait for a physician to be physically present in the ICU. Although there was no significant difference between users and nonusers on the question related to waiting for the supervising physician to be present in order to perform a procedure or dispense medication, 25 percent of the ICU robot users felt they could do these tasks more quickly by connecting via the ICU robot, compared to 5.2 percent of the nonusers.

Discussion and Conclusion

We identified only five actual users of the ICU robot. These five providers reported greater satisfaction, confidence in improved patient care, and ease of use than those who have not used the ICU robot. The self-identified users likely represent the actual users, and to the best of our knowledge these five providers are the only ones who have utilized the robot. Previous studies on user satisfaction with ICU robotics suggest that satisfaction increases with familiarity with the robot and with continuous usage,

regardless of the length of training time.[26] The low user number may be attributed to the lack of buy-in and support from bedside staff that may be seen if remote monitoring technology is introduced in an ICU with no clear plan or purpose for how the technology will be used.[27, 28] In this case, a half-day training session was provided for nursing staff and physicians, with attendance depending on their individual availability. The training was hands-on, and attendees used the iPad app to engage the robot. A clear plan and protocol describing why and how the remote monitoring should be used may need to be integrated into the hands-on training to maximize the utilization. Lily and Thomas (2009) observed that the integration and acceptance of remote monitoring in an ICU is greater when there are established standards and collaborative rounding models and agreements between providers.[29] The providers who used the robot were self-selected; those who indicated during the hands-on training that they wanted to have an iPad app to control the robot are the ones that continued to use it.

This pilot study emphasized the importance of the following factors identified as essential for staff acceptance of ICU robotics: (1) detailed training and orientation; (2) identification of roles, responsibilities, and expectations; (3) needs assessment; and (4) administrative support and organization.[30] In other words, if these four factors are not appropriately addressed, they are likely to create barriers for implementation and adoption.[31]

Robotic telepresence in the UMHC MICU does not seem to be used to its full potential. A very small number of physicians are currently using the robot, and they use it minimally. One of the challenges to telemedicine in any setting is getting buy-in from providers and clerical staff. However, those who have used it most often perceive it as a useful tool that increases efficiency and patient care. Providers who used the ICU robot show high confidence in caring for patients with attending physicians observing via the ICU robot. Not surprisingly, providers who have not used the ICU robot have opposite views, reporting report less confidence in caring for patients with attending providers observing the visit from a remote location. In general, the findings suggest a dichotomy in provider attitudes, which may be related to lack of preparation and training. The difference in attitudes toward the ICU robot is based on the providers' inclusion in the implementation of the ICU robot, which ultimately affects their usage of it. The low usage by current users may also be attributed to the exclusion of the robot from the everyday MICU practice.

Preparation of ICU robot protocols and training that includes all bedside staff and essential clerical personnel might promote more acceptance and use. We also suggest identifying a provider champion on all care and administrative levels who would assist with staff buy-in to maximize the usage of the ICU robot.

Our study had several limitations. Having a small number of users of the ICU robot may not have given us an accurate picture of the users' perceptions. We conducted the study in the MICU of an academic medical center. Our results may not be applicable to other ICU units, different clinical departments, or nonacademic medical centers.

Future studies should include the ways in which the suggestions provided above could affect implementation, acceptance, usage, and provider satisfaction with ICU robotics. The studies also could include other departments that may be using the ICO robot internally and compare the results. We propose surveying and interviewing providers regarding their choice to use the robot or not. These studies may assist in predicting future usage and how it can be improved.

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Notes

1. Grundy, B. L., P. Crawford, P. K. Jones, M. L. Kiley, A. Reisman, Y. H. Pao, E. L. Wilkerson, and J. S. Gravenstein. "Telemedicine in Critical Care: An Experiment in Health Care Delivery." *JACEP* 6, no. 10 (1977): 439–44.
2. Breslow, M. J., B. A. Rosenfeld, M. Doerfler, G. Burke, G. Yates, D. J. Stone, P. Tomaszewicz, R. Hochman, and D. W. Plocher. "Effect of a Multiple-Site Intensive Care Unit Telemedicine Program on Clinical and Economic Outcomes: An Alternative Paradigm for Intensivist Staffing." *Critical Care Medicine* 32, no. 1 (2004): 31–38.
3. Reynolds, H. N., H. Rogove, J. Bander, M. McCambridge, E. Cowboy, and M. Niemeier. "A Working Lexicon for the Tele-Intensive Care Unit: We Need to Define Tele-Intensive Care Unit to Grow and Understand It." *Telemedicine and e-Health* 17, no. 10 (2011): 773–83.
4. Rosenfeld, B. A., T. Dorman, M. J. Breslow, P. Pronovost, M. Jenckes, N. Zhang, G. Anderson, and H. Rubin. "Intensive Care Unit Telemedicine: Alternate Paradigm for Providing Continuous Intensivist Care." *Critical Care Medicine* 28, no. 12 (2000): 3925–31.
5. Reynolds, H. N., H. Rogove, J. Bander, M. McCambridge, E. Cowboy, and M. Niemeier. "A Working Lexicon for the Tele-Intensive Care Unit: We Need to Define Tele-Intensive Care Unit to Grow and Understand It."
6. Vespa, P. "Robotic Telepresence in the Intensive Care Unit." *Critical Care* 9, no. 4 (2005): 319–20.
7. Mendez, I., M. Jong, D. Keays-White, and G. Turner. "The Use of Remote Presence for Health Care Delivery in a Northern Inuit Community: A Feasibility Study." *International Journal of Circumpolar Health* 72 (2013).
8. Masia, L., H. I. Krebs, P. Cappa, and N. Hogan. "Design and Characterization of Hand Module for Whole-Arm Rehabilitation Following Stroke." *IEEE/ASME Transactions on Mechatronics* 12, no. 4 (2007): 399–407.
9. Gao, X. "The Anatomy of Teleneurosurgery in China." *International Journal of Telemedicine and Applications* (2011). doi:10.1155/2011/353405.
10. Marttos, A. C., F. M. Kuchkarian, P. Abreu-Reis, B. M. Pereira, F. S. Collet-Silva, and G. P. Fraga. "Enhancing Trauma Education Worldwide through Telemedicine." *World Journal of Emergency Surgery* 7, suppl. 1 (2012): S4. doi:10.1186/1749-7922-7-S1-S4.
11. Vespa, P. "Robotic Telepresence in the Intensive Care Unit."
12. Mendez, I., M. Jong, D. Keays-White, and G. Turner. "The Use of Remote Presence for Health Care Delivery in a Northern Inuit Community: A Feasibility Study."
13. Berenson, R., J. Grossman, and E. November. "Does Telemonitoring of Patients—the eICU—Improve Intensive Care?" *Health Affairs* 28, no. 5 (2009): w937–w947.
14. Kahn, J. M., B. D. Cicero, D. J. Wallace, and T. J. Iwashyna. "Adoption of ICU Telemedicine in the United States." *Critical Care Medicine* 42, no. 2 (2014): 362–68.
15. Rogove, H. J., D. McArthur, B. M. Demaerschalk, and P. M. Vespa. "Barriers to Telemedicine: Survey of Current Users in Acute Care Units." *Telemedicine and e-Health* 18, no. 1 (2012): 1–6.
16. Ibid.
17. Ibid.
18. Charles, K., M. Cannon, R. Hall, and A. Coustasse. "Can Utilizing a Computerized Provider Order Entry (CPOE) System Prevent Hospital Medical Errors and Adverse Drug Events?" *Perspectives in Health Information Management* (2014).

19. Rogove, H. J., D. McArthur, B. M. Demaerschalk, and P. M. Vespa. "Barriers to Telemedicine: Survey of Current Users in Acute Care Units."
20. Reynolds, E. M., A. Grujovski, T. Wright, M. Foster, and H. N. Reynolds. "Utilization of Robotic 'Remote Presence' Technology within North American Intensive Care Units." *Telemedicine and e-Health* 18, no. 7 (2012): 507–15.
21. Rincon, F., M. Vibbert, V. Childs, D. Caliguri, J. Urtecho, R. Rosenwasser, and J. Jallo. "Implementation of a Model of Robotic Tele-presence (RTP) in the Neuro-ICU: Effect on Critical Care Nursing Team Satisfaction." *Neurocritical Care* 17, no. 1 (2012): 97–101.
22. Ibid.
23. Reynolds, E. M., A. Grujovski, T. Wright, M. Foster, and H. N. Reynolds. "Utilization of Robotic 'Remote Presence' Technology within North American Intensive Care Units."
24. US Social Security Administration. "Compilation of the Social Security Laws: Part E—Miscellaneous Provisions. Definitions of Services, Institutions, Etc." Available at http://www.ssa.gov/OP_Home/ssact/title18/1861.htm (accessed December 8, 2014).
25. University of Missouri Institute for Clinical and Translational Science. "REDCap (Research Electronic Data Capture)." Available at http://icats.missouri.edu/portal/redcap.php (accessed July 25, 2014).
26. McNelis, J., G. J. Schwall, and J. F. Collins. "Robotic Remote Presence Technology in the Surgical Intensive Care Unit." *Journal of Trauma and Acute Care Surgery* 72, no. 2 (2011): 527–30.
27. Venditti, A., C. Ronk, T. Kopenhaver, and S. Fetterman. "Tele-ICU: 'Myth Busters.'" *AACN Advanced Critical Care* 23, no. 3 (2012): 302–11.
28. Moeckli, J., P. Cram, C. Cunningham, and H. S. Reisinger. "Staff Acceptance of a Telemedicine Intensive Care Unit Program: A Qualitative Study." *Journal of Critical Care* 28, no. 6 (2013): 890–901.
29. Lily, C. M., and E. J. Thomas. "Tele-ICU: Experience to Date." *Journal of Intensive Care Medicine* 25, no. 1 (2010): 16–22.
30. Moeckli, J., P. Cram, C. Cunningham, and H. S. Reisinger. "Staff Acceptance of a Telemedicine Intensive Care Unit Program: A Qualitative Study."
31. Ibid.

Table 1

Survey Respondents

Clinical Specialty	Invited	Participated	Participation Rate
Attending physicians	10	6	60%
Residents or fellows	9	2	22%
Nurses	12	6	50%
Respiratory therapists	30	15	50%
Total	**61**	**29**	**48%**

Table 2

Provider Attitudes Toward the ICU Robot

Survey Item	**Providers Who Have Used the ICU Robot**	**Providers Who Have Not Used the ICU Robot**		
Have you used the ICU Robot?	Yes (*n* = 5)	No (*n* = 20)		
	Mean ± SD (Range)	**Mean ± SD (Range)**	**Difference**	***p***
It was easy to use the ICU Robot.	1.6 ± 0.9 (1–3)	3.0 ± 0.2 (2–3)	1.4	< .001
The ICU Robot enhanced the visit with the patient by allowing visual contact.	1.8 ± 1.1 (1–3)	3.0 ± 0.3 (2–3)	1.2	.003
I felt more confident caring for the patient with the supervising physician observing through the ICU Robot.	1.6 ± 0.5 (1–2)	3.0 ± 0.5 (2–4)	1.4	< .001
With the use of the ICU Robot, I do not have to wait for the physician to be physically present in the ICU to perform a procedure or dispense medication.	2.8 ± 1.3 (1–4)	3.1 ± 0.5 (2–5)	0.3	.902
The ICU Robot improves the quality of our care.	1.8 ± 0.8 (1–3)	3.1 ± 0.4 (2–4)	1.3	.001
Comments	None	None		

Note: 1 = strongly agree, 2 = agree, 3 = neutral, 4 = disagree, 5 = strongly disagree.