2-1-2017

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Recommended Citation

Collins, Tara Ann; Robertson, Matthew P.; Sicoutris, Corinna P.; Pisa, Michael A.; Holena, Daniel N.; Reilly, Patrick M.; and Kohl, Benjamin A., "Telemedicine coverage for post-operative ICU patients." (2017). *Department of Anesthesiology Faculty Papers.* Paper 39.
https://jdc.jefferson.edu/anfp/39

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J Telemed Telecare. Author manuscript; available in PMC 2018 March 13.

Published in final edited form as:
J Telemed Telecare. 2017 February ; 23(2): 360–364. doi:10.1177/1357633X16631846.

Telemedicine coverage for post-operative ICU patients

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Abstract

Introduction—There is an increased demand for intensive care unit (ICU) beds. We sought to determine if we could create a safe surge capacity model to increase ICU capacity by treating ICU patients in the post-anaesthesia care unit (PACU) utilizing a collaborative model between an ICU service and a telemedicine service during peak ICU bed demand.

Methods—We evaluated patients managed by the surgical critical care service in the surgical intensive care unit (SICU) compared to patients managed in the virtual intensive care unit (VICU) located within the PACU. A retrospective review of all patients seen by the surgical critical care service from January 1st 2008 to July 31st 2011 was conducted at an urban, academic, tertiary centre and level I trauma centre.

Results—Compared to the SICU group ($n = 6652$), patients in the VICU group ($n = 1037$) were slightly older (median age 60 (IQR 47–69) versus 58 (IQR 44–70) years, $p = 0.002$) and had lower acute physiology and chronic health evaluation (APACHE) II scores (median 10 (IQR 7–14) versus 15 (IQR 11–21), $p < 0.001$). The average amount of time patients spent in the VICU was 13.7 +/−9.6 hours. In the VICU group, 750 (72%) of patients were able to be transferred directly to the floor; 287 (28%) required subsequent admission to the surgical intensive care unit. All patients in the VICU group were alive upon transfer out of the PACU while mortality in the surgical intensive unit cohort was 5.5%.

Discussion—A collaborative care model between a surgical critical care service and a telemedicine ICU service may safely provide surge capacity during peak periods of ICU bed

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Declaration of Conflicting Interests
The authors declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

demand. The specific patient populations for which this approach is most appropriate merits further investigation.

Keywords

ICU surge capacity; post-anaesthesia care unit; advanced practitioners; nurse practitioner

Introduction

The number of intensive care unit (ICU) patients is increasing disproportionally to the number of ICU beds.[1–3] As a result, intensivists frequently must arbitrate the allocation of ICU beds to the most acutely ill patients, leaving little room for those less sick. Patients who are refused admission to the ICU have an increased risk of mortality and those patients transferred out of the ICU before their ICU needs have resolved have increased readmission rates to the ICU and increased mortality.[4–11]

Numerous studies and two meta-analyses have revealed that telemedicine has been shown to positively impact the management and outcome of ICU patients, with effects including decreased hospital acquired infections, decreased mortality and decreased length of stay in the ICU.[12–17] Reasons for this are myriad but include increased compliance with guidelines and protocols, rapid response to alerts and having an intensivist available 24 hours per day.[12–17] Telemedicine literature has also discussed monitoring patients outside of the conventional ICU, including use of the post-anaesthesia care unit (PACU), emergency department or on the floors for a rapid response or medical assistance response.[18,19] The telemedicine system has also been used to increase scalability and increase capacity to utilize existing intensivists over a larger population or geographic area,[18–21] thus allowing hospitals to increase volume and capacity.[20]

The University of Pennsylvania is an urban, academic, tertiary and level 1 trauma centre. Faced with an increasing demand for surgical ICU beds, a novel paradigm was implemented in order to effectively increase capacity. The surgical critical care service (SCCS) oversees a 24-bed ICU and is managed by two teams, both of which include intensivists, fellows, residents and nurse practitioners. In 2004 a telemedicine ICU service was initiated to provide additional oversight of patients. The SCCS census on average WAS 30 patients; therefore, many patients WERE admitted into other ICUs within the hospital. We sought to determine if we could create a safe surge capacity model to increase ICU capacity by treating ICU patients in the PACU utilizing telemedicine service and nurse practitioners during peak ICU bed demand.

Methods

We created a four-bed virtual ICU (VICU) within our 36-bed PACU. We outfitted these four beds for full telemedicine capabilities by installing cameras (AXIS, Sweden), bedside computer work stations and the hospital electronic medical record (Allscripts, Chicago, IL). The nursing ratio for these patients was made comparable to the surgical intensive care unit (SICU) with critical care trained nurses at a ratio of two patients per nurse.

The VICU patients were managed jointly by the SCCS and the telemedicine ICU service. Our telemedicine ICU service, which includes two ICU registered nurses during the day (7am–7pm) and a physician intensivist and nurse at night (7pm–7am), covers 80 beds at three hospitals within our health system. The ICUs covered by the telemedicine team include a surgical ICU in an urban, academic, tertiary and level 1 trauma centre; a combined medical/surgical ICU; a medical ICU and a surgical ICU at two intercity community teaching hospitals. A long term acute care hospital is also covered by the same telemedicine team.

From 7am to 7pm an in-house SCCS nurse practitioner and intensivist were responsible for managing the patients in the VICU. From 7pm to 7am a telemedicine intensivist would assume primary care of these patients. The SCCS nurse practitioner would sign out to the telemedicine intensivist at 7pm and the telemedicine intensivist would sign out to the SCCS nurse practitioner at 7am. In addition, from 7pm to 7am an in-house chief surgical resident was available for any emergencies that required a bedside physician. Each weekday morning, if it was deemed that ICU capacity would not meet demand, patients with lower-intensity post-operative needs were preferentially identified to be boarded in the VICU. These patients remained in the VICU until either a SICU bed became available or their critical care needs resolved (at which point they would be discharged to a general floor bed). Patients would not stay in the VICU for more than 24 hours, per policy. Patients did not have to consent to be in the VICU as this was considered standard care. Patients in the SICU and VICU did require consent for video monitoring, which was included in the ICU consent form.

A retrospective review of all patients seen by the SCCS from January 1st 2008 to July 31st 2011 was conducted utilizing an existing SCCS database. The SCCS database utilizes concurrent data entry of all patients upon admission to the SCCS by nurse practitioners and is updated daily. The VICU coverage model started in January 2008. Patients were divided into two groups: those admitted directly to the SICU versus those admitted directly to the VICU. The primary outcome measurement was mortality. Other outcomes included length of stay and ICU discharge disposition. Prior to analysis, continuous variables were examined for normality using the Shapiro–Wilk test and by visual inspection of histograms. Normally distributed continuous outcomes between groups were compared using a *t*-test, while non-normally distributed variables were compared using a Kruskal–Wallis test. Categorical outcomes were assessed using chi-squared tests as appropriate. Using a chi-squared test of two independent proportions on the outcome of mortality, with a sample size of ~1000 in the VICU group and 6000 in the SICU group, an alpha of 0.05 and a beta of 0.8, this study was adequately powered to detect an absolute effect size of 1.3%. All statistical testing was performed using Stata v13.0 (College Station, TX). The study was approved by the University of Pennsylvania Internal Review Board.

Results

A total of 7689 patients were treated by the SCCS during the study time period. Of these, 6652 patients were directly admitted to the SICU and 1037 were admitted to the VICU. Of those admitted to the VICU, 28% transitioned to the SICU (as a result of ongoing critical care needs) and 72% transitioned directly to the floor (Figure 1). Demographics for the SICU and VICU groups are depicted in Table 1. Significant differences were noted in age, APACHE II scores, gender and race. Differences in volume regarding composition by surgical service between SICU and VICU groups are shown in Figure 2, with more in neurosurgical, trauma, vascular, emergency surgery and transplant volume in the SICU compared to VICU.

The average daily census was 0.8, the range was zero to eight patients per day. Average length of stay in the VICU was 13.7 hours. Patients who ultimately were transferred to the SICU after the VICU had an average combined VICU and SICU length of stay of 3.2 days. There were no deaths while patients boarded in the VICU. There were two deaths in patients who were managed in the VICU then transferred to the SICU, giving a mortality rate of 0.2%. These deaths occurred an average of 10 days into their ICU course. This compares to the SICU average mortality of 5.5% (Table 2). Patients who transitioned to the floor from the VICU had an ICU readmission rate excluding neurosurgery patients of 0.9% at 72 hours post-VICU discharge.

VICU patients who transferred to the floor had a median age of 59, whereas patients who transitioned to the SICU had a median age of 62 ($p = 0.001$). VICU patients who transferred to the floor had a median APACHE II score of 9, whereas patients who transitioned to the SICU had a median APACHE II score of 13 ($p < 0.001$).

During the study period, total (SICU plus VICU) SCCS volume increased 13%, from 1993 to 2284 patients. The number of patients treated in the conventional SICU also increased during the study period. During the study period, the inpatient operating room (OR) volume increased by 15% (Table 3). The VICU volume did not increase significantly and was noted to be episodic.

Discussion

By implementing a novel surge capacity paradigm in conjunction with our existing telemedicine service, we were able to safely and effectively manage 14% of our critical care population in a non-traditional setting. Furthermore, the vast majority of these patients (n = 750, 72%) were able to be transferred from the VICU directly to the floor, bypassing the conventional ICU.

Our aim was to ensure that higher acuity patients would be managed in the conventional SICU and lower acuity patients would be managed in the VICU, which is reflected in APACHE II scores. Additionally, composition by surgical service was also noted to differ with increased trauma, vascular, emergency surgery, thoracic and transplant volume in the SICU compared to the VICU. This was deliberate as these patient populations have a perceived higher acuity. Differences were also noted in neurosurgery volume as these patients were generally managed by the SCCS in the VICU but, if neurosurgical ICU beds were available, these patients were managed in that unit under the care of the neurosurgical critical care team.

VICU patients had significantly lower APACHE II scores compared to SICU patients and low ICU readmission rates, which raises the question of whether or not this patient population even needed ICU care in the first place. However, our institution does not have a step down unit and therefore the services often requested ICU monitoring in lieu of floor beds. Patients who were ultimately transferred to the SICU from VICU had a higher APACHE II score and were slightly older compared with those who eventually went to the floor. Total ICU length of stay (including time in the VICU) was 3.2 days for this group. Further research is needed to determine the best disposition for this patient population using identifiers or risk factors that led to a need for ongoing critical care.

There were limitations to our study. The study objective was to describe this novel coverage model and not to demonstrate that VICU services improve outcomes. We were unable to provide adjusted mortality. Neurosurgical readmission rates were excluded as a result of limited data registry. With neurosurgical volume being highest, this poses an issue. We were also unable to quantify the interventions by the telemedicine ICU team, including the number of notes and orders written, labs reviewed, etc.; we are currently working on capturing and standardizing the efforts of the telemedicine nurses and physicians. In addition, the data is a few years old. Due to increased ICU bed demand, the hospital and health system have increased the number of physical ICU beds in the past three years, which has led to a drastic decrease in the number of VICU patients.

Several challenges were noted with the development and implementation of this model. First, the PACU nursing staff needed education regarding pathway and protocols for ICU patients. Additionally, nursing staff had to configure how to adjust nurse–patient ratios in the presence of VICU patients. The VICU intensivist was off site but in charge of the VICU patients; this created confusion and scepticism for the surgical teams. Historically in our hospital, the telemedicine intensivist was a consultant service for the ICU team. After education and encounters with the telemedicine attending in the VICU, the surgical teams understood the role and involved them in the care of the patient. The patient flow with the OR team and bed management required close monitoring to ensure less acute patients would be slotted for VICU beds despite time of day or other cases.

Other studies have looked at ICU overflow and boarding ICU patients in remote locations. Ziser et al.[21] performed a prospective study looking at patient overflow to the PACU from the OR and emergency department. A total of 400 patients were managed in the PACU, with 70% of patients being ICU patients, and the mortality rate for these patients was 4.5%. Issues identified included surgical services managing these ICU/PACU patients as opposed to a designated ICU service, and sub-optimal nurse to patient ratios.[21] For our study, nurse to patient ratios were appropriate for the ICU and we had ICU providers managing patients as opposed to surgical teams.

Sidlow and Aggarwal[22] looked at ICU overflow as well; however, they looked at medical intensive care unit (MICU) patients boarding in the coronary care unit (CCU). MICU patients who boarded in the CCU were managed by the CCU team, with mandatory ICU consultation.

A retrospective analysis noted no difference in length of stay, mortality or readmission between the MICU group and MICU patients boarded in the CCU.[22]

We were able to effectively incorporate telemedicine into our VICU model and were able to safely accommodate an increase in our volume.

Conclusion

Over the four year time period we were able to safely and effectively expand our ICU coverage with a select patient population. During this time frame we were also able to manage an increased elective OR volume as well as increased SICU volume without creating any new physical beds. Further work is needed to determine if this could be applied to higher acuity patient populations.

Acknowledgments

Funding

The authors received no financial support for the research, authorship, and/or publication of this article.

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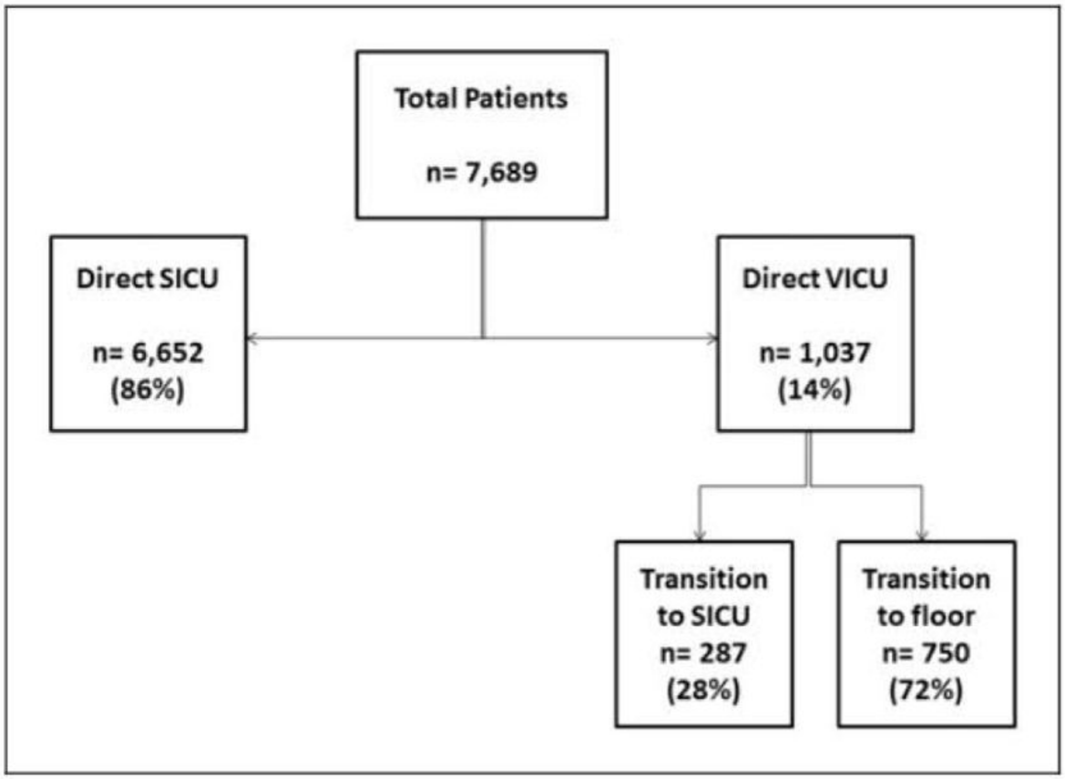

Figure 1.

Patients managed by the surgical critical care service.

SICU: surgical intensive care unit; VICU: virtual intensive care unit

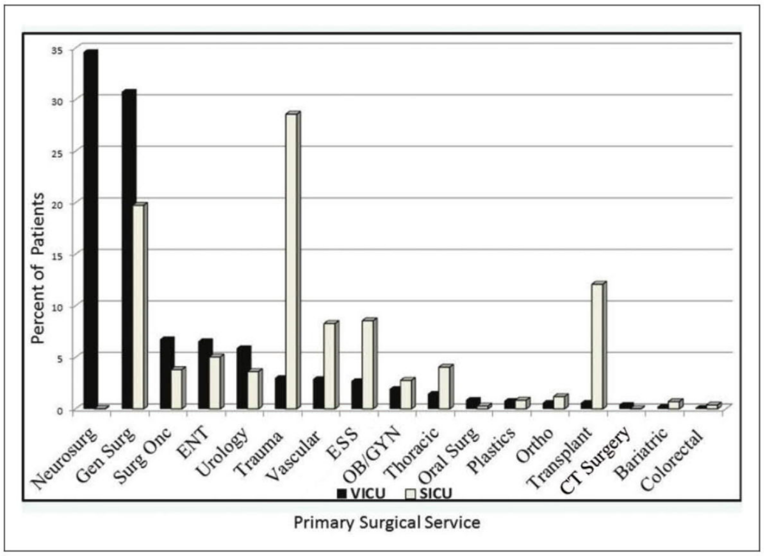

Figure 2.

Primary surgical service in the virtual intensive care unit cohort compared to the surgical intensive care unit cohort.

SICU: surgical intensive care unit; VICU: virtual intensive care unit; ENT: ear, nose and throat, ESS: Emergency Surgery Service, CT: cardiothoracic.

Table 1

Demographics of Virtual Intensive Care Unit cohort compared to Surgical Intensive Care Unit cohort VICU, Virtual Intensive Care Unit; SICU, Surgical Intensive Care Unit.

	VICU (n = 1,037)	SICU (n = 6,652)	p
Age, median (IQR)	60 (47–69)	58 (44–70)	0.002
APACHE II, median (IQR)	10 (7–14)	15 (11–21)	<0.001
Gender, M (%)	518 (50)	4235 (61)	<0.001
Race, n (%)			
Caucasian	841 (81)	4624 (60)	<0.001
African American	168 (16)	1733 (26)	
Asian	10 (1)	89 (1)	
Other	18 (2)	206 (3)	

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Table 2

Comparison of virtual intensive care unit to floor, virtual intensive care unit to surgical intensive care unit and surgical intensive care unit cohorts VICU, Virtual Intensive Care Unit; SICU, Surgical Intensive Care Unit.

	VICU to Floor (n = 750)	**VICU to SICU (n = 287)**	**SICU (n = 6,652)**
Age, median (IQR)	59 (47–68)[+]	62 (52–72)[+,*]	58 (44–70)[*]
APACHE II, median (IQR)	9 (6–13)[†,‡]	13 (9–18)[†,#]	15 (11–21)[‡,#]
ICU Mortality, n, %	0, 0%[$,&]	3, 1.0%[$,^]	364, 5.5%[&,^]

[+]Significantly different p = 0.008;

[*,†,‡,#]Significantly different p = 0.000;

[$,&,^]each subscript noted a subset of categories whose column proportions do differ significantly from each other.

Table 3

Volume of patients over time FY, fiscal year; VICU, Virtual intensive Care Unit; SICU, Surgical Intensive Care Unit; PACU, Post Anesthesia Care Unit; OR, Operating Room.

	FY 08*	FY 09	FY 10	FY 11
# Patients in SICU	1802	2116	1935	2055
# Patients in VICU	191	300	306	229
# Patients Total	1993	2146	2241	2284
# Inpatient OR Cases	7,055	7,105	7,271	8,283

*PACU/VICU Coverage began Jan 2008