Implementation of Evidence-Based Protocols Improves Survival:

A 15-year Surgical ICU Experience in 10,172 Patients

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Introduction

Mortality rates are higher in the intensive care unit (ICU) than in other hospital areas owing to the high severity of patient illness and the need for sophisticated interventions. Due to the complexity of care in the ICU, medical errors are more likely to occur, leaving patients more susceptible to experiencing adverse outcomes (1, 2).

Variation in patient case-types, severity of illness and transfer rates unfortunately complicate using a raw mortality rate to compare performance amongst hospital ICUs (3). The standardized mortality ratio (SMR) is a simple statistical comparison of the observed mortality to the predicted mortality (observed /predicted mortality). A SMR greater than one reflects higher than expected mortality, whereas a SMR less than one reflects lower than expected mortality. The SMR was first described in the critical care literature over 15 years ago, yet it has been reported infrequently, and little is known about the sufficiency of this measure as a comparative outcome metric (4).

We hypothesized that the introduction of protocolized processes of care in an iterative manner to improve outcomes would be accompanied by a decrease in SMR for our surgical ICU (SICU) patients. To test this hypothesis, we measured outcomes in the most recent 2-year cohort of patients admitted to our SICU and also analyzed the SMR over the last 15 years as a consequence of these interventions.

Materials and Methods

Tufts Medical Center is a 415-bed, level I trauma and tertiary-care medical center in Boston, Massachusetts. The Tufts Medical Center SICU is a 10-bed unit that accepts a diverse cohort of noncardiac surgical patients, including general surgery, vascular surgery, otorhinolaryngology, orthopedics, neurosurgery, trauma, thoracic surgery, oncologic surgery, and high-risk obstetrical emergencies.

The practice in the SICU over the past 2 decades has evolved with increasing reliance on protocolized processes of care, beginning in 1996 with the introduction of protocols for electrolyte replacement and weaning from mechanical ventilation.

All SICU patients are screened and the data are entered into an ICU database, which has been in place since 1997; this tool is used to catalog admissions and benchmark outcomes in intensive care units around the United States.

From 1997 until 2009, Project IMPACT, a database developed by the Society of Critical Care Medicine, was used. Severity of illness was quantified using the Simplified Acute Physiology Score (SAPS) II (5). From March 2010 until the present, a new semi-automated database, ICUTracker® by Alere™ Informatics Solutions, (Charlottesville, VA; USA), was installed with the Acute Physiology and Chronic Health Evaluation (APACHE) IV score used to quantify severity of illness (6).

The primary cohort consisted of patients admitted to the SICU from March 2010 through February 2012. A longitudinal cohort of all ICU admissions, from 1997 to 2011, was assembled to measure changes in standardized mortality during the most recent 15-year period.

Results

The primary cohort consisted of 1903 admissions to the SICU from March 2010 to February 2012; 1799 patients had complete recorded data by which to calculate APACHE IV scores; SMR scores were calculated and determined from this latter cohort. The patient demographics of the primary cohort are listed in Table 1 patients had a mean APACHE IV score of 49.7 ± 26.7.

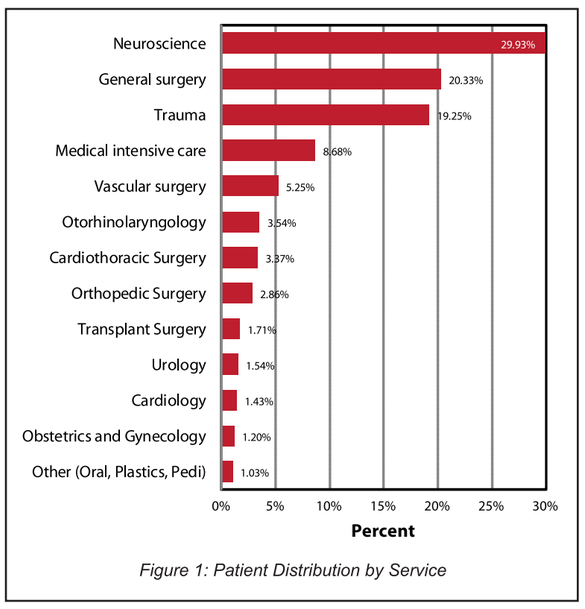

Figure 1: Patient Distribution by Service

Of the patients admitted to the SICU in the primary cohort, 56.6% were admitted for medical management including sepsis, 25.9% underwent elective surgical procedures, and 17.6% underwent emergent surgical procedures. Figure 1 displays the primary admission services with the geographic source of admissions listed in Table 2 for the primary cohort.

From the SICU, 69.1% were transferred to the inpatient wards; 12.9% were transferred to another ICU within the same institution; 6.2% were discharged home; 5.3% died; 3.6% were discharged to a rehabilitation facility or nursing home; and 1.5% went to the operating room.

Table 3 illustrates discharge information in the primary cohort by showing the destination of discharged patients from the medical center. Institution of evidence-based protocols and the evolution of these programs is illustrated in Figure 2 .

Primary cohort outcomes from several of these processes of care are shown in Table 4, including time on mechanical ventilation, venous thromboembolism prevention and glycemic control.

The observed in hospital mortality of the primary cohort was 8.4% with an APACHE IV predicted hospital mortality of 14.5%, yielding an SMR of 0.58 (95% confidence interval 0.49-0.65).

Figure 3 compares the primary cohort SMR with SMRs reported from other ICUs in the literature.

Table 1: Patient Demographics

Age, mean; years	59.6
Female/male, % (n)	44/56; 786/1013
APACHE II, mean (SD)	13.8 (7.55)
APACHE IV, mean (SD)	49.7 (26.6)
Mechanically ventilated, % (n)	35.0 (667)
ICU mortality, %	5.3
Hospital mortality, %	8.4
Predicted hospital mortality, %	14.5
Standardized Mortality Ratio	0.58
ICU LOS, days; mean (SD)	3.50 (5.24)
Predicted ICU LOS; days	4.33
Standardized ICU LOS Ratio	0.81

Table 2: Source of admission to ICU

Another Tufts ICU, % (n)	6.3 (113)
Tufts inpatient wards, % (n)	9.4 (170)
Outside hospital transfer or direct transport, % (n)	8.4 (151)
Emergency Department, % (n)	34.8 (625)
Operating Room or Procedural Area, % (n)	40.5 (729)
Other, % (n)	0.3 (5)

Table 3: Destination after discharge from hospital

Home with or without services, % (n)	48.0 (863)
Rehabilitation facility or nursing home, % (n)	38.2 (688)
Transfer to tertiary hospital, state facility, department of corrections, % (n)	2.7 (51)
Hospice care, % (n)	1.0 (20)
Psychiatry unit, % (n)	0.84 (16)
Death, % (n)	8.4 (151)

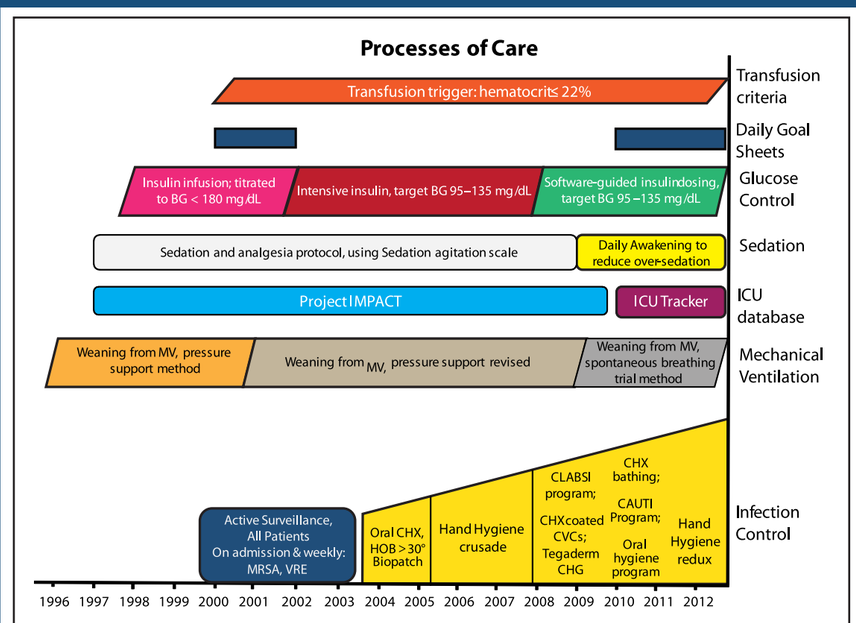

Figure 2: Changes in Delivery of Care by Protocol

The LOS in the SICU was 3.5 days while the predicted ICU LOS was 4.3 days, yielding a standardized LOS ratio of 0.81. Patients admitted with sepsis or diagnosed with sepsis during their hospital stay constituted 16.6% of admissions.

For the subset of patients with sepsis, the SMR was 0.90 (95% confidence interval 0.71-1.11) and the mean SICU LOS was 7.9 days with a LOS ratio of 1.17. Seventy-five percent of septic patients were mechanically ventilated and 45.3% required vasopressor therapy on admission.

The longitudinal cohort was comprised of 10,172 admissions to the SICU during the period from 1997 to 2011. The SMR decreased by 20%, from 0.73 to 0.58, an absolute one percent decrease per year (p = 0.039; CI -.02 to -.002) during this 15 year period. We estimate an additional 562 lives were saved with the decline in standardized mortality, Figure 4.

In the years 2007 and 2008, for example, crude hospital mortality was 10.3% in each year, yet the respective SMR was 0.73 and 0.57; this illustrates that crude mortality and standardized mortality do not necessarily change in parallel.

Figure 5 shows the change in duration of mechanical ventilation. The combination of spontaneous breathing trial (SBT) coupled with a daily awakening (DA) in 2009 led to a decrease in duration of mechanical ventilation that was both steeper and more sustained. From 1997-2008, the average ventilator duration was 5.6 days, in contrast to 2009-2011 after rollout of the SBT/DA, when it was 4.4 days (depicted in horizontal lines).

Table 4: Results from practice protocols

Mechanical ventilation, days; mean(±SD)	4.3±6.4
Reintubation, %	1.0
Unplanned extubation, %	2.4
Deep venous thrombosis prophylaxis, a %	94.3
Blood glucose, mg/dL; mean(±SD)	132±48
Frequency of blood glucose < 70 mg/dL, %	1.3
Blood glucose when < 70 mg/dL; mean(±SD)	56±14

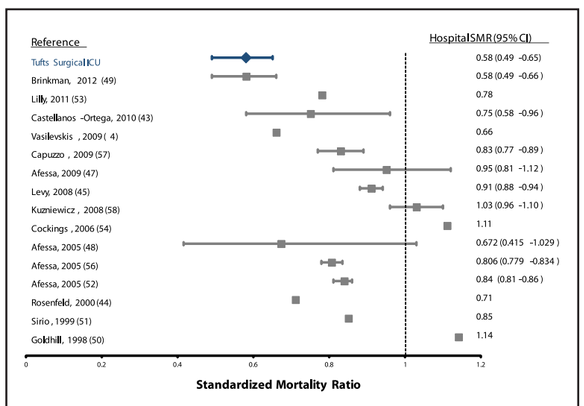

Figure 3: Comparison of the primary cohort SMR with SMRs reported from other ICUs in the literature

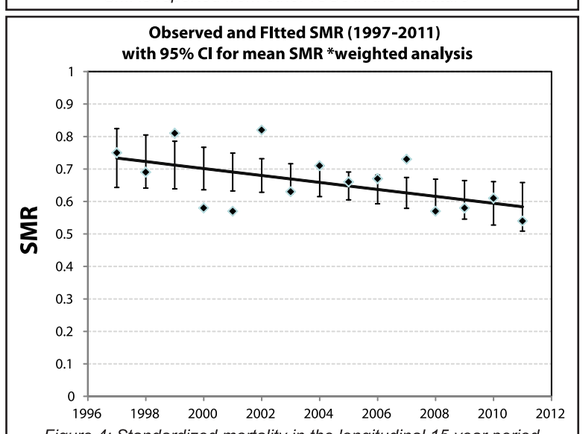

Figure 4: Standardized mortality in the longitudinal 15 year period.

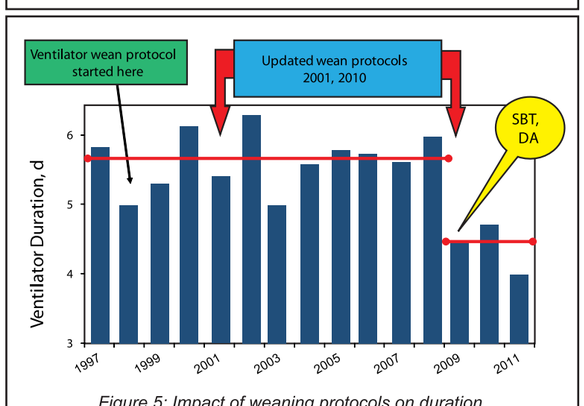

Figure 5: Impact of weaning protocols on duration of mechanical ventilation.

Conclusion

Standardized mortality in an academic SICU was much less than predicted, and declined in response to a systematic approach using a continuous stream of protocolized practice changes aimed at improving care, improving communication and decreasing hospital acquired infections (7). We believe this systematic approach decreased preventable harm to patients. The SMR can be used to track success when changes in the delivery of care are made. The ratio should be reported to review performance; however, it must contain a confidence interval, include a report of the patient case mix and include an analysis of discharge practices in order to correct for concerns with reporting the statistic.

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