

Preventability of death in a medical intensive care unit at a university hospital in a developing country

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Abstract

Objective: To determine the incidence and characteristics of preventable in-ICU deaths. **Materials and Methods:** A one-year observational study was conducted in a medical ICU of a teaching hospital. All patients who died in medical ICU beyond 24 h were analyzed and reviewed during daily medical meeting. A death was considered preventable when it would not have occurred if the patient had received ordinary standards of care appropriate for the time of study. Preventability of death was classified by using a 1-6 point preventability scale. The types of medical errors causing preventable in-ICU deaths and the contributory factors to deaths were identified. **Results:** 120 deaths (47 ± 19 years, 57 months-63 weeks) were analyzed (mortality: 23%; 95% confidence interval (CI): 15-31%). At admission, Acute Physiology and Chronic Health Evaluation (APACHE) II score was 18 ± 7.6 and Charlson comorbidity index was 1.3 ± 1.6. The main diagnosis was infectious disease (57%) and respiratory disease (23%). The median period between the ICU admission and death was 5 days. The rate of preventable in-ICU deaths was 14.1% (17/120). The most common medical errors related to occurrence of preventable in-ICU deaths were therapeutic error (52.9%) and inappropriate technical procedure (23.5%). The preventable in-ICU deaths were associated with inadequate training or supervision of clinical staff (58.8%), no protocol (47.1%), inadequate functioning of hospital departments (29.4%), unavailable equipment (23.5%), and inadequate communication (17.6%). **Conclusion:** According to our study, one to two in-ICU deaths would be preventable per month. Our results suggest that the implementation of supervision and protocols could improve outcomes for critically ill patients.

Keywords: Adverse events, intensive care unit, medical errors, patient safety, preventable mortality

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Introduction

The morbidity-mortality conferences (MMC) are a meetings of care providers to evaluate and improve care management through the discussion of cases with adverse events (AEs).^[1] AE is usually defined as an unintended injury resulting in temporary or permanent disability or death and caused by healthcare management rather than by the patient's underlying disease process.^[2] MMCs are effective in reducing future

error in healthcare management.^[1] In fact, the purposes of MMCs are to assess the preventability of the event, to identify its causes (human, material, and organizational), to prevent recurrence, and to improve the quality of care. The complexity of healthcare management is the main characteristic of intensive care units (ICUs) that are associated with significant risks for AEs and serious errors. Indeed, several factors may increase risk of error and compromise patient safety: Severity and instability of illness, patient's preexisting medical conditions, frequent need for high-risk interventions and medications, and decision making by inexperienced practitioners.^[3,4]

Even though MMCs are considered a tool for evaluating and improving medical skills and practices, they lack a precise format and goals specifically tailored to the

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ICU.^[5] Therefore, there is a paucity of data concerning the preventable mortality in critical care.^[6]

The aim of this study was to analyze the deaths occurring on a medical ICU and to determine the incidence and characteristics of preventable in-ICU deaths. In fact, in this viewpoint, our medical team has established a particular mortality conference to assess preventability of deaths observed in our context. Secondary objectives were to analyze: (1) Contributing factors to deaths, (2) medical errors resulting in deaths, (3) predictive factors for preventable in-ICU deaths, and (4) corrective actions that could be recommended.

Materials and Methods

Study design and setting

This observational study was conducted in a 12-bed medical ICU of a 1,200-bed tertiary care academic hospital from January to December 2008.

The hospital is a major referral center for the northwestern region of the country. Annually, the medical ICU admits approximately 600 adult patients from emergency department essentially (90%). The medical ICU is staffed with four senior physicians (practicing in the ICU for more than 10 years) and 10 junior physicians (practicing in the ICU for <2 years). The nurse team involves 17 nurses, seven nurse's aides, and one physiotherapist. The study method was approved by the local ethic committee of our university.

Patients

All adult patients (>16 years) who died in medical ICU beyond 24 h were included in the study and evaluated. Early deaths occurring in the first 24 h after ICU admission were excluded.

Review process

Within the first 24 h after death, physicians reviewed the deceased patient record during the daily medical meeting from Monday to Friday. If death occurred during a weekend, the medical record was evaluated on the following Monday. The medical staff consisted of the head of department, three seniors, and 10 juniors. Review team was made up of experienced senior doctors with safety patient background.^[2] After training established that the physicians understood the goals of this study and the review instrument, the first death was included. To insure confidentiality, all participants were required to keep patient's personal information and staff's conclusion in confidence.

During the daily medical meeting, the physicians involved in patient care presented the cases. Several aspects of the diagnosis process and patient management were considered using a review tools adopted from those used in EMRO/AFRO study.^[2]

For each case, we discussed the preventability of death, the types of error causing death, the clinical context for the death, the contributory factors to death, and the measures that should be taken to prevent reoccurrence in the future.^[2]

Definitions

Preventability is defined as an event (death) that would not have occurred if the patient had received ordinary standards of care appropriate for the time of study.^[6,7] Ordinary standards of care implied an accepted practice that was taken to be the current expected level of performance for the average practitioner who treats the condition in question.^[2,5,8] A death was considered preventable if the discussion of the physicians led to the consensus conclusion that it could have been averted with different management or treatment using a 1-6 point preventability scale [Table 1].^[2,5] To be counted as a preventable death, the preventability score needed to be >3.^[2,7]

The types of error causing death were categorized as: A diagnosis error (failure to make a diagnosis), an inappropriate technical procedure, a drug error (error occurring in the medication process: Prescribing, administering, and monitoring), or a therapeutic error (diagnosis has been made but an appropriate therapeutic was not delivered).

To specify the clinical context for the death, the following data were examined: Comorbidity, clinical complexity of cases, consensus on healthcare management, and degree of deviation from the accepted norms for care.^[2] Patients with chronic disease often have comorbid illness that presents challenges to achieve optimal care and those with greater clinical complexity were more likely to receive the most aggressive management.

Contributory factors to death were classified according to preestablished items: Defective or unavailable

Table 1: Scale for preventability of death

Confidence in the evidence of preventability	Point
Virtually no evidence of preventability	1
Slight to modest evidence of preventability	2
Preventability not quite likely (less than 50/50)	3
Preventability more than likely (more than 50/50)	4
Strong evidence of preventability	5
Virtually certain evidence of preventability	6

equipment, inadequate communication or notification, inadequate training or supervision of clinical staff, delay in investigations (laboratory tests, X-ray, etc.), inadequate staffing, inadequate functioning of hospital departments, no protocol, or failure to implement a protocol.^[2]

Data collection

After the case presentation and discussion were complete, the following data were recorded at the time of ICU admission: Baseline demographic data, Charlson comorbidity index, Acute Physiology and Chronic Health Evaluation (APACHE) II, Logistic Organ Dysfunction System (LODS) score, diagnosis, date, and time of occurrence of death.

Statistical analysis

Data are presented as mean \pm standard deviation (SD) for variables with a normal distribution, median, and interquartile range for variables with skewed distributions, and percentage for categorical variables. Comparisons between preventable deaths and non-preventable deaths were made with the Mann-Whitney test and the Fisher's exact test. Analyses were performed with Statistical Package for Social Sciences (SPSS) version 13.0 (SPSS Inc., Chicago IL, USA). A two-tailed $P < 0.05$ was considered significant.

Results

During the study period, there were 523 admissions to our medical ICU with a total of 120 deaths corresponding to an ICU mortality rate of 23% (95% confidence interval (CI): 15-31%). All deaths have been included in this mortality review. The mean age of the study patient was 47 ± 19 years and 63 (52.5%) were female. The mean APACHE II score was 18 ± 7.6 , mean Charlson comorbidity index was 1.3 ± 1.6 , and mean LODS score was 5.4 ± 4.3 . Eighty-seven patients (73%) were admitted from emergency department with a median delay of 12 h (range, 4–35 h). The median period between the ICU admission and the death was 5 days (range, 3-10 days). We observed that 31.7% of the deaths occurred in the morning period, 19.2% in the afternoon period and 49.2% in the evening period.

Concerning the causes of ICU admission, 57.7% were infectious disease, 23.3% were respiratory disease, 9.2% were neurological disease, 5.8% were acute intoxication, and 5% metabolic disease. More data of the in-ICU deaths are summarized in Table 2. Refractory septic shock was the primary cause of death (47; 39.2%) and 29 patients (24.2%) had one or several hospital-acquired infections (HAI).

Preventability of in-ICU deaths

Seventeen in-ICU deaths (14.1%) were judged to have a high preventability score (4 or more) [Table 3].

Types of error causing preventable in-ICU deaths

The medical error categories resulting in preventable in-ICU deaths were:

- Diagnostic error (11.8%): Inadequate actions after test results (two)
- Inappropriate technical procedure (23.5%): Extubation failure (two), catheter-related bloodstream infection (one), and tracheoesophageal fistula (one)
- Therapeutic error (52.9%): Delay in initiating dialysis (two), delay in initiating intubation (one), inadequate treatment of ventricular tachycardia (one), inadequate monitoring of patient vital signs (one), delay to treat nosocomial urinary tract infection (one), no surgery for bowel obstruction (one), delay to treat hypotension caused by anesthetic drugs and post-obstructive diuresis (one), and finally delay to realize pericardiocentesis for cardiac tamponade.(1)
- Drug error (11.8%) cases concerning prescription of insulin (one) and anticoagulants (one).

Clinical context for preventable in-ICU deaths

Evaluation of comorbidity revealed that patients were judged moderately ill in 12 cases (70.6%) and very ill in two cases (11.8%). The management and treatment of the preventable in-ICU deaths were moderately complex in 15 cases (88.2%) and no complex in two cases (11.8%). Likewise, the consensus on diagnosis and treatment was large in 14 cases (82.3%), medium in one case (5.9%) and low in two cases (11.8%). The degree of deviation from the accepted norms for care was severe in 13 cases (76.5%) and small for four cases (23.5%).

Contributory factors to preventable in-ICU deaths

The major factor contributing to preventable in-ICU death was inadequate training or supervision of clinical staff (58.8%) followed by absence of protocol noted (47.1%), inadequate functioning of hospital departments (29.4%), and unavailable equipment (23.5%) [Figure 1].

Risk factors associated with preventable in-ICU deaths

The factors significantly associated in univariate analysis with the preventable in-ICU deaths are noted in Table 4.

Table 2: Characteristics of deaths at admission and day of death (N=120)

Variables	Admission, mean±SD or N	Extremes or %	Day of death, mean±SD or N	Extremes or %
Temperature (°C)	37.6±1.2	34.6-40.6	37.8±1.6	32-41.5
Respiratory rate (breaths/min)	26.9±7	16-48	27.8±8.3	12-50
Heart rate (beats/min)	109±20	40-160	129.2±19.7	40-140
Systolic blood pressure (mmHg)	120±30.3	50-230	86.1±27.9	0-170
Diastolic blood pressure (mmHg)	69.2±20.9	40-140	49±22.2	0-100
Shock	15	12.5	78	65.3
Urinary output (ml/day)	1467±720	0-3,000	1128±773	0-3500
Natremia (mmol/l)	136.5±10.5	110-168	140.7±1.3	116-166
Kalemia (mmol/l)	4.5±3	1.6-29	4.4±1.2	2.5-8
HCO ₃ ⁻ (mmol/l)	23.4±7.6	5-40	23±7	5-40
Urea (mmol/l)	16.6±18.3	1.7-91.3	1.2±18.3	1.7-91.3
Creatinine (mmol/l)	223.5±422.4	11.4-3172	245.5±342	11.4-2,270
Glycemia (mmol/l)	8.8±5.5	0.88-33.6	9.4±6.1	0.83-31.9
Protides (m/l)	58.2±10.9	27-84	50.3±11	24-71
Hemoglobin (g%)	11.2±2.5	2.9-16	9.8±2	5.1-14
Hematocrit (%)	34±7.1	18-52	29.5±5.9	18-45
White blood cell (10 ³ /mm ³)	14.8±8.5	1-42.8	15.1±9.9	1.9-49.2
Platelets (10 ³ /mm ³)	222.8±133.6	7-656	192.3±131.8	7-593
Prothrombin rate (%)	67.4±19.1	8-100	58.1±26.2	15-100
Electrocardiogram abnormalities	18	15	15	12.5
Abnormal chest X-ray	68	56.7	71	59.2
Treatment				
Central venous catheter	8	6.7	45	37.5
Mechanical ventilation	33	27.5	90	75
Vasoactive drugs	24	20	91	75.8
Sedation	25	20.8	74	61.7
Hospital-acquired infections				
Ventilator-associated pneumonia	-	-	24	42.9
Urinary tract infections	-	-	14	25.9
Resuscitation of cardiocirculatory arrest	-	-	93	77.5

SD: Standard deviation

Table 3: Preventability of deaths

Evidence of preventability	N	%
No evidence	86	71.7
Slight to modest evidence	11	9.2
less than 50/50	6	5
More than 50/50	10	8.3
Strong evidence	7	5.8
Certain evidence	0	0

Preventing recurrence of preventable in-ICU deaths

The main prevention strategies identified were training (75%), supervision (62.5%) and application of protocols (56.3%) [Figure 2].

Discussion

In our study during 1 year period, there were a total of 120 in-ICU deaths corresponding to an ICU mortality rate of 23%. Seventeen in-ICU deaths (14.1%) were judged preventable. To our knowledge, this study is the first prospective study that investigated preventable in-ICU death in a developing country.

In previous studies, preventable in-ICU death rates were ranged between 6.1 and 21%.^[5,9-11] Reasons for this widely variation in the incidence of preventable mortality may include different patient populations,

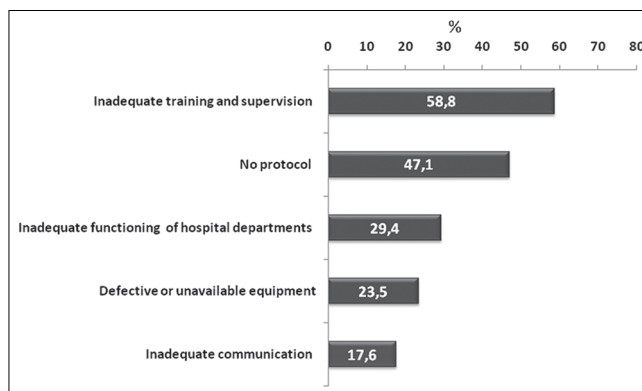


Figure 1: Factors contributing to death

lack of uniformity of definitions, methods of review (most studies used patient records as the source of data), and variation of patient safety culture in the different centers. Although we used a different data collection methodology than several of the studies mentioned above, our result has remained within the literature findings. In the future, some critical care safety studies could be reported fewer preventable deaths but it will be difficult to exceed, in the ICU environment with the high risk for errors, an uncompressible threshold corresponding to human error.^[12,13] It is important to recognize that human

Table 4: Characteristics of patients with preventable versus non-preventable deaths

Variables	Non-preventable deaths, mean±SD or N (%) N= 103	Preventable deaths, mean±SD or N (%) N= 17	P value
Age (years)	47±20	47±15	NS
Sex (women/men)	58/45	5/12	0.054
Charlson comorbidity index	1.3±1.7	0.9±0.9	NS
APACHE II score	18±7.7	17.8±7.3	NS
Logistic organ dysfunction System score	5.4±4.2	5.8±4.9	NS
Length of stay (h)	7.7±7.5	7.6±7.1	NS
Electrical abnormalities on the death day	10 (9.7)	5 (29.4)	0.04
Blood urea at admission (g/l)	0.95±1	1.7±1.5	0.014
Serum creatinine at admission (mg/l)	20.5±32.7	54.8±96.6	0.015
Resuscitation of cardiocirculatory arrest	76 (73.8)	17 (100)	0.012
Comorbidity			
Very ill	33 (32)	2 (11.8)	NS
Moderately ill	51 (49.5)	12 (70.6)	
Healthy	19 (18.5)	3 (17.6)	
Complexity of case			
Very	5 (4.9)	0	NS
Moderately	82 (79.6)	15 (88.2)	
No	16 (15.5)	2 (11.8)	
Consensus on diagnosis and treatment			
Large	95 (92.2)	14 (82.3)	0.004
Moderate	7 (6.8)	1 (5.9)	
Low	1 (1)	2 (11.8)	
Deviation of the care from accepted norm			
Severe	12 (11.6)	13 (76.5)	<0.001
Moderate	5 (4.9)	-	
Little	86 (83.5)	4 (23.5)	
Type of errors			
Diagnosis error	1 (1)	2 (11.8)	0.052
Inappropriate procedure	2 (1.9)	4 (23.5)	0.004
Drug error	2 (1.9)	2 (11.8)	NS
Therapeutic error	7 (6.8)	9 (52.9)	<0.003

SD: Standard deviation; APACHE: Acute physiology and chronic health evaluation

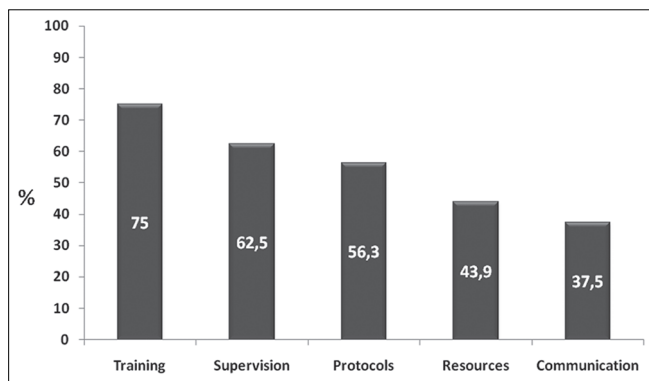


Figure 2: Improvement actions to prevent recurrence

error is inevitable for even the best-trained and best-qualified healthcare providers.

For estimating AE rates, the retrospective method of data collection by review of medical records is as effective as the prospective method based on data gathering during ICU stay.^[14] However because all the studies used different methods, it is difficult to compare them: A direct-observation studies reveal much higher levels of preventable AEs compared with studies that use chart reviews.^[15-17]

In our study, we analyzed each in-ICU death immediately after its occurrence during routine medical meetings because we believe that this direct-observation method allows the best effectiveness for identifying preventable in-ICU death. In our context, this method would ensure greater reliability of our judgment and good appreciation of chain of events and their consequences.^[14] Furthermore, it would reduce measurement errors due to lack of availability of data in the medical record. Indeed, many errors may not be documented in the medical record nor identified through chart review.^[18-20]

The relationships among severity of illness, exposure to medical procedures, risk of medical injury, and mortality are complex.^[21] In ICU, these complicated relationships present difficulty to researchers and clinicians to determine preventability of AEs and to distinguish between what we could have avoided and what appears to be uncontrollable. Accuracy of estimation and preventability of AEs are highly dependent on the reviewer’s judgment and may vary according to reviewer training, adequacy of medical records, and degree of confidence expressed by the clinical reviewers.^[17,22]

The reliability of reviewers is not always good and illustrates the difficulty and the limitations of estimating preventability.^[16,23-25]

This preventability is still more difficult to assess in elderly patients (20% of our study) because it could be assumed that poorer outcomes were more likely to occur because their age and the complexity of their condition.^[26] This point does not imply that death of elderly patients resulting from medical error is unimportant.^[26]

This study has several limitations. First, more objective discussion could be provided with inclusion of nurses and outside auditors in the medical meeting. Discrepant attitudes exist between ICU nurses and physicians about teamwork experiences.^[27] So, interdisciplinary discussion could contribute to improving reliability and usefulness of the results. Second, our survey was conducted in a single-center and can be reflects only our activity. Our findings may not be generalizable to ICU with different staffing models and different patient types. Third, comparison of our results is limited by the methodology that we used, but no reference method exists for identifying preventable deaths. Indeed, there is a lack of standardization in preventable death evaluation system. Fourth, the time period prior to ICU admission was long and events occurred during this period were not analyzed in our study. The demand for ICU beds exceeded widely the supply of beds and the quality of care on emergency department prior to admission to intensive care could be affected subsequent outcome. Fifth, a quarter of deceased patients in our study had an HAI and assessment of the preventability was difficult in this situation. HAIs were especially hazardous, but it is often impossible to identify a specific error responsible for a death.^[27] There is no definite way to attribute a death to an HAI because patient deaths frequently have multiple causes and the role of infection may not always be clear.^[28] Sixth, our mortality review can be considering time consuming and could extend the time of daily meetings but its duration was perceived as acceptable in most cases by the medical staff.

Conclusion

The present study demonstrated that the preventable in-ICU deaths are a serious problem occurring in 14.1% of all deaths observed in our ICU. In other words, one to two deaths would be preventable per month. Some simple measures identified in this study must be implemented by the healthcare team to improve patient safety and secure system. In fact, efforts should be focused on detection, reduction, and prevention of medical errors using training, supervision, and implementation of protocols.

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