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Determinants of Outcome in Patients Admitted to a Surgical Intensive Care Unit

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Introduction: Outcome in intensive care may be categorized as mortality or morbidity related. Mortality is an insufficient measure of Intensive Care Unit (ICU) outcome when measured alone and length of stay may be seen as an indirect measure of morbidity related outcome. Length of stay may be seen as a surrogate marker for adverse outcome and increased resource use following surgery. The aim of the present study was to evaluate case fatality rates and the determinants of death and length of stay in patients admitted to a surgical ICU.
Methods: The study was observational and prospective in a surgical ICU and all consecutive adult patients admitted between October 2004 and April 2005, who underwent noncardiac surgery, were enrolled. Patients were categorized according age, gender, body mass index, ASA physical status, type and magnitude of surgical procedure, type and duration of anesthesia, core temperature at admission, Length of stay (LOS) in the ICU and in the hospital, and mortality in the ICU and in the hospital. The Simplified Acute Physiology Score II (SAPS II) was calculated. Postoperative prolonged ICU stay was defined as intensive care lasting for seven days and longer.
Results: The mean ICU LOS was 4.22 ± 8.76 days. Significant risk factors for staying longer in ICU were SAPS II (OR 1.08; 95% CI: 1.06-1.11, $p < 0.001$), ASA physical status (OR 3.00; 95% CI: 1.49-6.07, $p = 0.002$ for ASA III/IV patients) and emergency surgery (OR 6.56; 95% CI: 1.89-12.44, $p < 0.001$ for emergency surgery). Forty two (11.2%) patients died during hospitalization. Mortality was significantly associated with ASA physical status (OR 3.04; 95% CI: 1.41-6.56, $p = 0.005$ for ASA III/IV patients), emergency surgery (OR 5.40; 95% CI: 2.74-10.64, $p < 0.001$), SAPS II scores (OR 1.09; 95% CI: 1.07-1.20, $p < 0.001$) and longer stay in ICU (OR 8.05; 95% CI: 3.95-37.18, $p < 0.001$).
Conclusions: Severity of disease and emergency surgery resulted in prolonged ICU stay and higher mortality. Staying longer in ICU is also a determinant of hospital mortality.
Key-words: intensive care; outcome; postoperative period; hospital mortality; length of stay.

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INTRODUCTION

Outcome in intensive care have primarily been focused on hospital survival and resource utilisation adjusted for severity of illness. Many outcome prediction systems for Intensive care unit (ICU) patients have been developed (1-4)and are routinely used in many ICU all over the world measuring severity of illness as mortality prediction models. They have been widely used and their performance well studied in large international data set (5). Predicted outcomes may also be used both for clinical decision making in individual patients and for assessing quality of care. Severity of illness in the ICU setting is typically quantified using models relating risk of death to physiologic variables within 24 hours of admission to the ICU. Such models include the Acute Physiology and Chronic Health Evaluation (APACHE) II (6), APACHE III (7), the Mortality Probability Models (4), and the SAPS (8). Scoring systems can be used to quantify the risk.

Over the last three decades, outcome prediction and quantization of the severity of illness have become an irreplaceable tool for the estimation of effectiveness and quality of intensive care as a supplement to structural, procedural, and outcome measurement methods, such as technology availability, staffing patterns, and patient procedures (9). In addition to predict death, investigators want to evaluate the performance of individual intensive care unit (ICU) relative to international standards (10). A scoring system defines the severity scores of illness that could be used for the prediction of hospital mortality risk by applying logistic regression equations. One of the most widely used scoring system for the general severity of illness and prognosis is the Simplified Acute Physiology Score (SAPS) system. The second version of this scoring system was developed and validated for a large group of ICU patients on the basis of an analysis of a large database of physiologic data from critically ill medical and surgical patients (8). The SAPS II scoring system has been shown to accurately stratify risk of death in a wide range of disease states and clinical settings (11-14). This experience has resulted in the widespread use of the SAPS II scoring system as a tool for ICU audit.

Even simple, subjective measures such as the ASA score can be used to stratify patients by surgical risk (15,16). Approximately 50% of surgical deaths are in patients scoring ASA IV or V. Although the case fatality is considerably lower for patients with lower ASA scores, because more operations are performed on these patients they account for most deaths. The ASA physical status score is a rating given to each patient by the anaesthesiologist before anaesthesia. It was designed originally as a standardized way for anaesthesiologists to convey information about the patient's overall health status and allow outcomes to be stratified by a global assessment of their severity of illness. However, the score is frequently used to estimate operative risk and it correlates well with surgical mortality (17).

The type of surgical procedure can also be used to stratify patients according to cardiac risk and cardiac complications, such as myocardial infarction or congestive heart failure, represent the single most common cause of death in postoperative patients (18). A number of studies have identified an elevated cardiac risk in certain surgical types such as vascular surgery (19-21). Eagle KA have identified particular types of noncardiac surgery that appear to be associated with a heightened risk of perioperative death or myocardial infarction.

Cost analysis studies have found that ICU cost per day per patient is remarkably consistent across most diagnoses (22) and therefore, ICU length of stay (LOS) has been also used as a measure of resource utilisation in the ICU (23,24).

Despite refinements in perioperative management, prolonged intensive care unit stay is still associated with poor patient outcome and increased costs (25-27) and consumption of a considerable amount of ICU resources (28,29).

Although length of stay in ICU may be affected by discharge policies, variable practice patterns and bed management (30) prolonged ICU stay can adversely affect the health status by increasing the risk of infection, complications, and, possibly, mortality (31). These have also impact upon bed availability and could result in cancellation of elective surgeries, leading to long waiting times and time spent on the ward before ICU admission.

The likely length of stay of a patient may also influence therapeutic decisions. Several recent studies have indicated that some therapeutic strategies that impact on patient outcome may only have an effect on patients with longer ICU stays (32,33).

There is no generally accepted definition of the term 'long-term intensive care'. Because of the markedly skewed distribution of LOS-ICU, no obvious cut-off exists and time periods of ≥7 days up to >30 days have been used to define prolonged ICU stay (10,28,34). For the present study, 'long-term intensive care' was defined as an ICU stay of more than 7 days.

The aim of the present study was to evaluate case fatality rates and the determinants of death and length of stay in patients admitted to a surgical ICU.

METHODS

The protocol was approved by our institutional review board. This prospective study was performed between October 2004 and July 2005. All postoperative adult patients (> 18 years old) who underwent scheduled or emergency noncardiac surgery, admitted to a nine bed surgical ICU of a tertiary care hospital, were eligible for the study.

The following clinical variables were recorded on admission to the ICU: age, gender, body mass index, preoperative body temperature, ASA physical status, emergency or scheduled surgery, magnitude of surgical procedure as described by Kongsayreepong S [35] and classified in major, medium (surgery in which body cavities are exposed to a lesser degree such as appendectomy), and minor surgery (superficial surgery), anaesthesia technique and duration of the anaesthesia. Tympanic membrane core temperature (Tc) was determined on arrival and patients classified as hypothermic (Tc≤35ºC) or normothermic (Tc>35ºC). The type of operation was further defined as higher or lower risk on the basis of a post hoc analysis of the combined myocardial infarction and/or death rate as described by Eagle KA (36) and included in the practice guidelines of the American College of Cardiology/American Heart Association (ACC/AHA) on Perioperative Cardiovascular Evaluation for Noncardiac Surgery) (37).

For all patients we also recorded the ICU and hospital LOS and mortality. The Simplified Acute Physiology Score II (SAPS II) was calculated using standard methods (8).

Postoperative prolonged ICU stay was defined as intensive care lasting for seven days or longer. Two groups of patients were created: patients with prolonged ICU stay and patients with no prolonged ICU stay. For mortality analysis we also created two groups of patients: patients who died during their stay in the hospital and patients who survived.

Groups were compared to assess the relationship between each clinical variable and long ICU stay or mortality using univariate analysis performed by simple binary logistic regression with an odds ratio (OR) and its 95% CI and independent samples t test, $\chi2$ test or Fisher's exact test.

A multiple binary logistic regression model with forward conditional elimination of variables was used to examine covariate effects of each factor on ICU LOS and hospital mortality and to calculate OR and their 95% CI. Covariates with a univariate $p < 0.1$ in the respective univariate analysis were entered in these models. A two-sided significance level of 0.05 was used for all analyses.

Quantitative variables are presented as mean ± standard deviation (SD). All analyses were performed using SPSS for Windows (version 13.0, Chicago, IL).

RESULTS

The primary patient's characteristics are described in table 1 and the total patient sample size by surgical service is listed in table 2 whereas in table 3 surgical procedures are listed by cardiac risk stratification. Three hundred seventy five patients were studied. The mean age was 64.11 ± 13.6 (median: 66 years; range: 23 - 94) being 64 % male patients. The majority of patients (57%) was ASA III or ASA IV, and mainly submitted to elective surgery (82%). One hundred thirty-seven patients (36.7%) were submitted to high risk surgery. The majority (54%) were major surgeries and almost all patients (85%) were submitted to general anaesthesia. The mean duration of anaesthesia was 258 minutes. The mean admission core temperature was 34.8°C ± 1.1°C (range, 30.2ºC–38.2°C, first quartile, 34.1°C, and third quartile 35.5ºC). Prevalence

Table 1 - **Patient baseline characteristics (n=375).**

Variable	mean ± SD or number / total number (%)
Age (years)	64.11 ± 13.60
≥ 65	201 (53.6)
Male (n / %)	240 (64.0)
Body mass index (Kg / m^2)	25.51 ± 5.92
Cardiac risk	
High risk surgery	137 (36.5)
ASA Physical status	
I	22 (5.9)
II	138 (36.5)
III	178 (47.5)
IV	37 (9.9)
Type of surgery	
Emergency surgery	68 (18.1)
Elective surgery	307 (81.9)
Magnitude of surgery	
Minor	28 (7.5)
Medium	145 (38.7)
Major	202 (53.5)
Type of anaesthesia	
General anaesthesia	318 (84.8)
Regional anaesthesia	33 (8.8)
Combined anaesthesia	24 (6.4)
Duration of anaesthesia	258 ± 122
> 180 min.	183 (48.8)
Temperature at admission	34.79 ± 1.14
≤ 35ºC	216 (57.6)
Score of Acute Physiologic system (SAPS II)	27.74 ± 14.60

SD - Standard deviation; ASA - American Society of Anesthesiologists.

Table 2 - **Distribuition of patients by surgical service.**

Surgical service	Number of patients	Percent of sample
General Surgery	203	54.1
Vascular Surgery	86	23.0
Urology	32	8.5
Plastic Surgery	13	3.5
Orthopaedics	12	3.2
Otorrinolaringology	10	2.7
Obstetrics/Gynaecology	10	2.7
Neurosurgery	6	1.6
Ophthalmology	3	0.8

Table 3 - **Surgical procedures stratified by cardiac risk.**

	Number of patients	Percent of sample
High Risk	**134**	**35.7**
Emergent major operations, particularly in the elderly	13	3.5
Aortic and other major vascular surgery	28	7.5
Peripheral vascular surgery	30	8.0
Prolonged surgical procedures with large fluid shifts	63	16.0
Intermediate Risk	**238**	**64.5**
Carotid endarterectomy	19	5.1
Head and neck surgery	35	9.3
Intraperitoneal and intrathoracic surgery	160	42.7
Orthopedic surgery	19	5.1
Prostate surgery	5	1.3
Low Risk	**3**	**0.8**
Breast surgery	3	0.8

of core hypothermia on ICU admission was 57.6 % (95% CI, 54.2%-61.6%).

The LOS in the ICU varied from 1 to 82 days with a mean ± SD of 4.22 ± 8.76 days. The percentage of patients who stayed in ICU longer than 7 days was 13.3% (n= 50).

According to univariate analysis (Table 4), age, gender, BMI, magnitude of surgery, duration of anaesthesia, temperature at admission in ICU and high risk type of surgery were not associated risk factors for staying longer in the ICU.

According to univariate analysis (Table 4) significant risk factors for staying longer in ICU were SAPS II (OR 1.1; 95% CI: 1.06-1.11, p < 0.001, for each SAPS point), ASA physical status (OR 3.0; 95% CI: 1.49-6.07, p=0.002 for ASA III/IV patients) and emergency surgery (OR 6.6; 95% CI: 1.89-12.44, p< 0.001).

Patients who stayed longer in ICU had a significantly higher mortality in the ICU (OR 11.1; 95% CI: 4.69 – 26.28, p < 0.001) and in the hospital (OR 8.1; 95% CI: 3.95 – 16.89, p < 0.001).

Multiple binary logistic regression with forward conditional elimination to examine all covariate effects of each factor showed that significant factors predicting longer staying in the ICU were higher SAPS scores (OR 1.1; 95% CI: 1.05-1.10, p < 0.001, for each SAPS point) and emergency surgery (OR 2.7; 95% CI: 1.28 - 5.68, p = 0.009).

Twenty five (6.70%) patients died in ICU and 42 (11.2%) died during their hospitalization.

According to univariate analysis (Table 5), age, gender, BMI, magnitude of surgery, duration of anaesthesia, temperature at admission in ICU and high risk type of surgery were not associated risk factors for mortality in the hospital. Significant risk factors for mortality in the hospital were SAPS II (OR 1.1; 95% CI: 1.07-1.20, p < 0.001), ASA physical status (OR 3.0; 95% CI: 1.41-6.56, p=0.005 for ASA III/IV patients), emergency surgery (OR

Table 4 - **Univariate analysis of categorical and continuous predictors of length of stay.**

Variable	ICU Stay ≥ 7 days	ICU Stay <7 days	Odds ratio (95% CI)	p-value
Age (years)	65.9 ± 14.6	63.8 ± 13.4		
< 65	20	154	1	
≥ 65	30	171	1.35 (0.74-2.48)	0.331
Gender				
Female	16	119	1	
Male	34	206	1.23 (0.65-2.32)	0.815
BMI (Kg / m²)	24.2 ± 4.1	25.8 ± 6.1	0.95 (0.89-1.01)	0.945
High risk surgery	21	113	1.36 (0.74-2.49)	0.322
ASA Physical status				
I/II	11	149	1	
III/IV	39	176	3.00 (1.49-6.07)	0.002
Emergency / elective surgery				
Emergency surgery	25	43	6.56 (1.89-12.44)	<0.001
Elective surgery	25	282	1	
Magnitude of surgery				
Minor	1	27	1	
Medium	15	130	5.46 (0.72-41.59)	0.101
Major	34	168	3.12 (0.40-24.60)	0.281
Duration of anaesthesia	228 ± 122	231 ± 121		
≥ 180 min.	28	164	1	
> 180 min.	22	161	1.25 (0.69-2.28)	0.466
Temperature at admission	34.84 ± 1.47	34.79 ± 1.08	1.04 (0.80-1.35)	0.790
SAPS II	41.42 ± 14.79	22.17 ± 12.77	1.08 (1.06-1.11)	<0.001

ICU - Intensive care unit; ASA - American Society of Anesthesiologists; SAPS - Simplified Acute Physiology Score.

Table 5 - **Univariate analysis of categorical and continuous predictors of mortality in the hospital.**

Variable	Nonsurvivors	Survivors	Odds ratio (95% CI)	p-value
Age (years)	63.71 ± 13.39	67.29 ± 14.85		
< 65	19	155	1	
≥ 65	23	178	1.05 (0.55-2.01)	0.949
Gender				
Female	14	121	1	
Male	28	212	0.88 (0.44-1.73)	0.876
BMI (Kg / m^2)	25.72 ± 6.30	24.07 ± 6.62	0.94 (0.88-1.01)	0.943
High risk surgery	12	122	1.45 (0.71-2.93)	0.306
ASA Physical status				
I/II	9	151	1	
III/IV	33	182	3.04 (1.41-6.56)	0.005
Emergency / elective surgery				
Emergency surgery	20	48	5.40 (2.74-10.64)	<0.001
Elective surgery	22	285	1	
Magnitude of surgery				
Minor	1	27	1	
Medium	13	132	4.35 (0.57-33.26)	0.157
Major	28	174	2.66 (0.33-21.19)	0.356
Duration of anaesthesia	220 ± 119	232 ± 122	1	
≥ 180 min.	25	167	1.29 (0.80-1.13)	0.950
> 180 min.	17	166	1.25 (0.69-2.28)	0.466
Temperature at admission	34.82 ± 1.33	34.79 ± 1.11	1.02 (0.77-1.36)	0.254
SAPS II	44.45 ± 17.73	22.25 ± 12.07	1.09 (1.07-1.20)	<0.001
Length of ICU stay (days)	12.91 ± 17.48	13 ± 6.17		
< 7 days	23	302	1	
≥ 7 days	19	31	8.05 (3.95-16.39)	<0.001

ICU - Intensive care unit; ASA - American Society of Anesthesiologists; SAPS - Simplified Acute Physiology Score.

5.4; 95% CI: 2.74-10.64, p< 0.001), longer stay in ICU (OR 8.1; 95% CI: 3.95 - 16.39, p < 0.001 for LOS longer than 7 days).

The multiple logistic regression analysis showed that significant factors predicting death in the hospital were higher SAPS scores (OR 1.1, 95% CI: 1.06-1.11, p < 0.001) and ICU LOS (OR 2.5; 95% CI 1.09 - 5.86 p=0.030). The analysis showed that these were the factors that more significantly predicted death in the intrahospitalar setting.

DISCUSSION

In this study, severity of illness, as measured by ASA physical status and SAPS II scores was predictor of prolonged stay in ICU and the same was true for patients submitted to emergency surgery. This probably reflects the assumption that more severely ill patients stay longer in ICU.

Studies that have examined long-stay ICU patients have shown that, while they account around 10% of the total ICU patient population, >30% of ICU resources are expended on this group (28,38). In our study 13% stayed longer than 7 days in the ICU. These included almost all patients that had postoperative complications and those who were more severely ill at admission.

Studies that have examined the characteristics of patients with long stay in ICU have primarily been retrospective or focused on homogeneous populations derived from specific populations' within the ICU, such as cardiac (38,39) and trauma (40). The objectives of our study were to examine the characteristics of non cardiac surgical patients considered as a more heterogeneous group of patients and to study their outcome.

Several other studies (29,41,42) have investigated factors associated with prolonged admission to the ICU. Most notably, Higgins et al (29) conducted a multicentered study in 34 ICUs and found thathigher severity of disease, middle age, infection, ventilation,male gender, emergency surgery, trauma, critical care fellows, and longer pre-ICU lengths of hospital stay were associated with longer ICU stays, and that the presence of full-time ICU physicians, do-not-resuscitate orders, and coma were associated with shorter admissions. In contrast, we did not find that gender or age, were independently associated with a prolonged ICU admission. We could confirm the results of this study and, as in others, severity of illness of patients as measured by ASA physical status and SAPS II were predictors of prolonged stays in ICU (43,44).

To reduce mortality following major surgery remains a significant challenge for surgical intensive care units. The British National Confidential Enquiry into Peri-Operative Deaths reports show that the majority of deaths occur in older patients who undergo major surgery and who have severe coexisting disease (45). The few available estimates suggest mortality rates of between 5.8% and 25% for this high-risk surgical population [46-52]. Developments in perioperative care may significantly improve outcome for these patients (53,54). In our study a hospital mortality rate of 6.7% confirms these results and the existence of a population of surgical patients with an important mortality rate. The findings of this study are consistent with current mortality estimates for this population (55,56) and are in the range of what was expected by the correspondent standard mortality ratios observed from SAPS II.

We identified higher severity of illness as measured by SAPS II scores, higher ASA physical status, emergency surgery and prolonged ICU LOS as statistically independent factors for dying during hospital stay.

The ASA classification has established itself as the most widely used patient risk assessment tool in anaesthesia. Although developed in 1941 by Saklad (57) it remains accepted as a standard for assessing preoperative fitness. Although ASA was never intended to be a peri-operative risk score, large studies have suggested that a higher ASA score is one of the best predictors of post-operative morbidity (58,59).

Several retrospective studies have demonstrated a correlation between ASA classification and perioperative mortality (35,44,60,61)and have suggested its usefulness as a predictor of patient outcome (62).

The importance of the type of surgery has been emphasized previously (17,35,60,63). Elective surgery and minor surgery reduce operative risk and there is an effect on poor outcome attributable to emergency surgery.

Although it appears to exist a clear break point among types of procedures, with a combined myocardial infarction and death rate among medically treated patients of ≥4% for patients submitted to higher risk surgery or <4% for those submitted to lower risk as suggested by Eagle (36) our results (39) were not according and indeed we could not found differences in mortality by surgical procedures when we stratified the type of surgery by cardiac risk.

Like we concluded in another study (64), hypothermia at ICU admission was not predictor of staying longer in the ICU and was not an independent risk factor for mortality.

Studies addressing the association of high BMI in patients admitted to the ICU have demonstrated conflicting results. Our study agree with Choban retrospective study (65) but not with other studies published by Finkielman (66), Tremblay and Garrouste-Orgeas (67,68) that have showed that high BMI was not associated with high mortality in post-operative patients.

In conclusion, prolonged ICU stay and mortality are more frequent in more severely ill patients at admission and in patients submitted to emergency surgery. Hospital mortality is more frequent in patients who stayed longer in ICU.

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