Early predictive factors for intensive care unit readmission

Fatores preditores precoces de reinternação em unidade de terapia intensiva

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ABSTRACT

Objective: To predict readmission in intensive care unit analyzing the first 24 hours data after intensive care unit admission.

Methods: The first intensive care unit admission of patients was analyzed from January to May 2009 in a mixed unit. Readmission to the unit was considered those during the same hospital stay or within 3 months after intensive care unit discharge. Deaths during the first admission were excluded. Demographic data, use of mechanical ventilation, and report of stay longer than 3 days were submitted to uni and multivariate analysis for readmission.

Results: Five hundred seventy-seven patients were included (33 excluded deaths). The readmission group had 59 patients, while 518 patients were not readmitted. The lead time between the index admission and readmission was 9 (3-28) days (18 were readmitted in less than 3 days), and 10 died. Patients readmitted at least once to the intensive care unit had the differences below in comparison to the control group: older age: 75 (67-81) *versus* 67 (56-78) years, $P<0.01$; admission for respiratory insufficiency or sepsis: 33 *versus* 13%, $P<0.01$; medical admission: 49 *versus* 32%, $P<0.05$; higher SAPS II score: 27 (21-35) *versus* 23 (18-29) points, $P<0.01$; Charlson index: 2 (1-2) *versus* 1 (0-2) points, $P<0.01$; first ICU stay longer than 3 days: 35 *versus* 23%, $P<0.01$. After logistic regression, higher age, Charlson index and admission for respiratory and sepsis were independently associated to readmissions in intensive care unit.

Conclusion: Age, comorbidities and respiratory- and/or sepsis-related admission are associated with increased readmission risk in the studied sample.

Keywords: Morbidity; Hospitalization; Length of stay; Patient admission; Patient readmission; Quality of health care

INTRODUCTION

Readmissions to the intensive care unit (ICU) within the same hospital stay are usually associated with increased morbidity and mortality.[1,2] Readmission rate across some studies ranges between 2 and 15%.[3] This rate may be useful to evidence the quality of patients' care, and is emphasized for hospital accreditation in several countries.[4] Optimization of ICU resources use in Brazil is a current and relevant issue, as there is lack of beds in hospitals both in the public and private network. Thus, we aimed to analyze the possible causes associated with ICU readmission.

Many factors were already implied as accountable or adjuvant for ICU

readmission: advanced age, urgent medical or surgical hospitalization, acute disease severity, increased organ failure degree (shock, respiratory or renal failure), comorbidities, resolution of the diseases causing hospitalization and biomarkers.[5-7]

The relationship between possible risk factors may be complex, as there are many confounding and/or intrinsically related factors, such as advanced age and acute disease severity scores.[8] We thus developed a prospective observational study aiming to analyze readmission causes and associated factors, based on demographics and severity data collected at the beginning of patients' ICU stay; additionally, we studied early readmissions frequency and characteristics.

METHODS

A prospective study in a general private hospital ICU was conducted from 2009 January to May. All admissions were consecutively included. The main objective was to find data evidencing increased readmission likelihood, which was defined as being readmitted to the ICU during the same hospital stay or within 3 months after the ICU discharge. Patients who died during the first ICU stay were excluded. The readmission rate was calculated as the number of readmissions over the total ICU admissions during the studied period. Data collected on the first ICU stay were chosen. Demographics (age and gender), acute disease severity (Simplified Acute Physiology Score - SAPS II), organ failure degree (Sequential Organ Failure Assessment - SOFA), use of mechanical ventilatorion support and body mass index (BMI). The comorbidities studied were those pointed by the Charlson score, and present some influence on hospital mortality (diabetes mellitus, acute myocardial infarction - AMI, heart failure, peripheral arterial atherosclerotic disease, stroke, dementia, chronic obstructive pulmonary disease - COPD, connective tissue diseases, peptic disease, liver cirrhosis, chronic renal failure, active neoplasm with or without metastasis, lymphoma/leukemia, and acquired immunodeficiency syndrome - AIDS.[9] ICU stay longer than 3 days (above the median ICU stay) was considered prolonged. The admission causes were categorized by different systems (respiratory, cardiovascular, neurological, gastrointestinal, renal or urological, orthopedic, trauma, infection/sepsis and several non-categorized in any other systems), attempting to uniform patients' diagnosis case mix.

The readmissions group was further categorized as early (readmission less than 72 hours after ICU discharge) or late (above 72 hours). The readmission causes were compared to those for the first patients' admission.

Numerical data were described as mean and standard deviation or median and 25-75% interquartile interval, and compared using the Student t test if the data distribution was normal, or with the Mann-Whitney test for non-parametrical data. Categorical variables, as gender and mortality, were expressed as absolute value and percentage and evaluated using the chi-square test. Statistical significance was considered for *P* values below 0.05. The analysis of ICU readmission associated variables in the initial logistic regression comparison identified those independently related with the outcome. The variables analyzed in the logistic regression were selected according to regular comparison between the groups readmission and non-readmission and/or with the possible influence on the outcome. The same variables were dichotomized as categorical with median of the numeric data or by the numeric value with clinical significance (e.g.: BMI > 25 kg/m^2 meaning overweight/obesity).

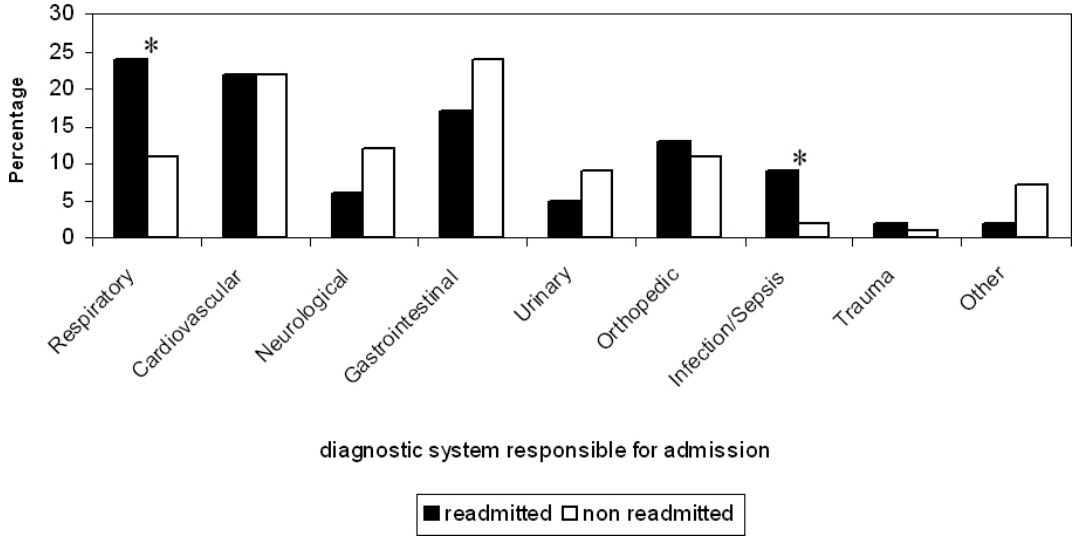
RESULTS

During this period 610 patients had 688 admissions to the ICU. Intensive care unit population was in average 67.5 ± 15.7 years old, with a predominance of the male gender (53%). The average BMI was 25.8 ± 5.1 kg/m^2. Surgical patients prevailed in the studied population (63%), with medium and major abdominal surgery (114), cardiothoracic (95) and orthopedic (65). Any comorbidity by the Charlson score was seen in 63.6% of the population, with at least 1 point attribution. The average ICU stay was 4.1 ± 8.2 days. Sixty-one (10%) patients required mechanical ventilation. The first admission mortality was 5.5% (33 deaths), and these patients were excluded from the analysis.

The ICU readmission rate was 11.5% (78 readmissions of 59 patients). The patients were readmitted to the ICU within 1 to 101 days (median 9, inter-quartile interval 3-28 days) after the first admission. Five hundred and eighteen patients were not readmitted to the ICU in this period, and were compared to the readmitted group (Table 1). Readmitted patients were older, 75 (67-81) versus 67 (56-78) years, *P*>0.01. Medical diseases admissions prevailed in the readmitted subgroup, compared to non-readmitted (49 versus

32%; *P*<0.01). Respiratory or infectious/sepsis issues admissions were also more prevalent in the readmitted subgroup (*P*<0.01) (Figure 1). The admission cardiovascular, orthopedic, gastrointestinal and urologic causes were similarly frequent in both groups. The acute disease severity (SAPS II) was higher in the readmitted subgroup, 27 (21-35) versus 23 (18-29) points, *P*=0.001, however organ dysfunction degree by the SOFA score was not different, 1 (0.5-3) versus 1 (0-2) points. Comorbidities frequency (Charlson score) was higher in the readmitted subgroup, 2 (1-2) versus 1 (0-2) points, *P*=0.01. Even with this data, no comorbidity was strictly associated with increased readmission likelihood. Diabetes mellitus (n=138; 24%) and active neoplasm (n=168; 28%) were the most common comorbidities in the overall population, with similar frequency both in with and without ICU readmission groups. The length of stay during the first ICU admission was also significantly longer in the readmission group, 2 (1-5) versus 2 (1-2) days, *P*<0.01. Length of stay longer than 3 days was more common in the readmitted group than in those not readmitted, 35 versus 23%, *P*<0.01.

Eighteen (30%) patients had early (less than 72 hours) readmissions. No significant differences were found regarding demographics or acute and chronic diseases severity in patients early or late readmitted. Readmission causes were different from the primary



*p < 0.05; ANOVA

Figure 1 – Causes of admission, per system, among patients either readmitted or non-readmitted to the intensive care unit.

Table 1 – Comparison between intensive care unit readmitted and non-readmitted patients

	Readmitted patients N = 59	Non-readmitted patients N = 518	P value
Age (years)	75 (67-81)	67 (56-78)	0.002
Male (%)	27 (43)	278 (54)	0.16
BMI (kg/m^2)	25 (21-30)	25 (23-29)	0.59
Medical admission (%)	29 (49)	162 (32)	0.003
SAPS II (points)	27 (21-35)	23 (18-29)	0.001
Day 1 SOFA (points)	1 (0.5-3)	1 (0-2)	0.48
Charlson (points)	2 (1-2)	1 (0-2)	0.01
MV use (%)	4 (7)	34 (7)	0.98
1st ICU admission stay (days)	2 (1-5)	2 (1-2)	0.002
ICU stay > 3 days	22 (35)	117 (23)	0.005

BMI – body mass index; SAPS – Simplified Acute Physiology Score; SOFA – Seqüencial Organ Failure Assessment; ICU – intensive care unit; MV – mechanic ventilation. Results expressed as median and inter-quartile 25-75%, absolute figures and percentages. Numerical variables were compared by Student t test or Mann-Whitney, depending on the distribution normality. Categorical variables were compared by Chi-square.

Table 2 – Analysis of intensive care patients' readmission-associated factors

	Odds ratio (CI 95%) (univariate analysis)	Odds ratio (CI 95%) (multivariate analysis)	P value
Age > 75 years	2.16 (1.25-3.71)	1.02 (1.00-1.04)	0.03
Male	1.45 (0.86-2.46)	-	0.69
BMI > 25	1.02 (0.59-1.75)	-	0.88
Type of admission (medical)	2.31 (1.35-3.96)	-	0.44
Respiratory or sepsis admission	3.53 (1.99-6.29)	2.78 (1.47-5.28)	0.002
Charlson score > 1 point	2.43 (1.32-4.47)	1.18 (1.02-1.37)	0.02
SAPS II > 30 points	4.40 (2.29-8.46)	-	0.78
ICU stay > 3 days	2.34 (1.35-4.04)	1.06 (0.99-1.14)	0.07

BMI – body mass index; SAPS – Simplified Acute Physiology Score; ICU – intensive care unit; CI (95%) – 95% confidence interval; Results expressed as median and inter-quartile 25-75% interval. Student t test or Mann-Whitney depending on normal distribution.

causes in 22 (37%) of the patients; the most common readmission causes were respiratory decompensation in 26 patients (pneumonia, aspiration pneumonitis, pulmonary thromboembolism, cardiogenic pulmonary edema), nosocomial infection with our without sepsis (13), cardiac arrhythmia (5) and gastrointestinal bleeding (3), among several others.

Logistic regression was conducted to identify independent associated factors for ICU readmissions. Age, male gender, BMI, medical causes admission (mainly respiratory system or infection/sepsis), Charlson score, SAPS II and ICU length of stay longer than 3 days were analyzed together (Table 2). Independent risk factors for readmissions were age (odds ratio 1.02, CI 95% 1.00-1.04), admission for respiratory diseases and/or sepsis (odds ratio 2.78, CI 95% 1.47-5.28) and Charlson score (odds ratio 1.18, CI 95% 1.02-1.37). The first ICU length of stay was also associated to ICU readmission, although at a lesser degree as compared to the previously mentioned factors (CI 95% 0.99 to 1.14).

DISCUSSION

ICU readmission increases patients severity and mortality, and may be used as a quality criterion to be controlled by ICU leaders and managers.[1,4] Our readmission rate was 11.5%, while in other studies it ranged from 2.8 to 14.5%.[1,3,7,10-12] We analyzed early predictors of patient readmission, based on collected data at the onset of ICU stay. Advanced age, respiratory and/or severe infections with sepsis admissions, and comorbidities were independently associated with increased ICU readmission likelihood in this population.

Other studies evaluated ICU readmissions.[1,5,6,10,11,13,14] Most analyzed the readmission causes, always trying to associate the underlying disease, mainly without definitive resolution, with increased readmission occurrence. In most studies, data regarding the end of the ICU stay were analyzed, as nosocomial infections and organ failure degree (SOFA and Logistic Organ Dysfuncion Score – LODS).[11] The criteria evaluated by the discharge timepoint are widely variable, e.g. discharge during the night shift, which can contribute for increased readmissions, or even hospital mortality rate.[13,15]

Some factors are directly related to ICU readmission. The lack of ameneable or resolved clinical picture accountable for the first admission increases, in a relatively anticipated way, the likelihood for patient readmission.[16] However, this can only be predicted by the end of the ICU stay, sometimes shortened due to discharge requested by patients or family members, or even by their responsible physicians. This is also related to the lack of objective variables and predictive models for this specific outcome.[3]

We can speculate that the readmissions studies should be performed independently in each unit, because risks and variables may be heterogeneous in different ICUs and hospitals. Metnitz et al. evaluated a large ICU patients cohort in Austria, where the readmission rate was 5%.[11] An increased ICU readmission risk was seen in patients with larger organ supports use, as evaluated by the SOFA and TISS (Therapeutic Intervention Scoring System) scores. Some degree of reliance on hemodynamic, ventilatory or renal support was larger within readmitted patients. Residual organ dysfunctions may account for eventual intensive care readmissions, and may be calculated by objective scores. However, reducing organ failures, mainly if the support may be offered out of the ICU, is not always possible, such as for patients remaining with proxy renal support for weeks after renal failure. Our study population consisted mostly of elderly and surgical patients, and

with short length of stay, so the contribution of the organ failure (SOFA) score wasn't useful, and the disease severity and acute disease probably lost its power comparison after the logistic regression. However, we still don't have a way to analyze the SOFA or TISS scores by the ICU discharge time, which were important in the Austrian study.

Another trial evidenced advanced age, increased hospital stay before ICU admission (at a ward or room), Acute Physiology and Chronic Health Evaluation II (APACHE II) score, and discharge to a high dependency patients unit, as readmission risk factors.[10] Patients from the ward are acknowledged as having increased ICU morbi-mortality risk, perhaps due to the lack of their underlying disease resolution before reaching the ICU,[8,16] but in our study, surgical population had shorter hospital length of stay before surgery leading to the ICU. Another important factor was advanced age, which is an acknowledged risk factor, because the elderly physiology who recovers from organ injuries at a slower rate,[17] and perhaps increased comorbidities rate.[18] Prognostic scores are useful for hospital mortality prediction in ICU populations, and were also associated with increased readmission likelihood.[4,10] However the points calculation is usually made with high weight for the variable age, mainly in the above 65 years old group. In APACHE II, for instance, an older than 75 years patient is given additional 6 points. It is therefore difficult to identify how much scores like APACHE II and SAPS II influence the multivariate analysis results, mainly if one reanalyze data as age, comorbidities and some organ dysfunctions. In our observation, patients readmitted had higher SAPS II score than those not readmitted, however minor points differences are not clinically relevant. Additionally, the age difference between the groups was 6 to 7 years, which could explain the 3-4 points difference in the SAPS II scores; this points out to similar partial scores in both groups, if we remove the age factor from the score. In the logistic regression analysis this was corroborated by the absence of SAPS II score, which was not included in the final predictive model.

The increased Charlson score in the readmitted patients highlights the importance of comorbidities. One single comorbidity included in the Charlson score was also a ICU readmission-associated factor. Another trial also associated this comorbidities score to ICU readmissions,[14] indicating that it can better predict late than early readmission. It was also observed that comorbidities didn't change the readmitted patients' mortality, but this couldn't be demonstrated in the current study.

Early readmission may be defined as readmission to the ICU within 48 to 72 hours, and are seen as lack of complications prediction by the ICU discharge time, as if discharge was anticipated. We couldn't find differences in the patients' characteristics either with or without early readmission, although there was a trend to older age and higher Charlson score. Ho et al. identified that comorbidities influence mostly the late patient readmission, while the early readmission is mainly related to the primary admission cause.[14] We couldn't find associations, mainly because the small sample size and subgroup analysis, which reduced the power of any comparison.

CONCLUSION

Age, comorbidities and admission for specific causes or systems (respiratory diagnosis and infection and/or sepsis) may help predicting ICU readmission. Logistic regression analysis showed that hospitalizations for respiratory diseases and/or sepsis lead to an almost three-fold increase of ICU readmission risk, while comorbidities and age increased this risk at a lesser extent.

It was pointed out the relevance of studying these features at each individual unit, as there are differences in the predictive models described in the several different studies. Finally, the detailed study of the outcome 'readmission' may improve the care for patients borderline to ICU readmission, and help developing mechanisms for preventing this event, as the creation of predictive scores, prophylactic transference to lower complexity units, or post-ICU discharge visits for increased readmission risk patients.

RESUMO

Objetivos: Prever reinternação na unidade de terapia intensiva, analisando as primeiras 24 horas de pacientes após admissão em unidade de terapia intensiva.

Métodos: A primeira internação de pacientes de janeiro a maio de 2009 em UTI geral foi estudada. Considerou-se reinternação em unidade de terapia intensiva na mesma permanência hospitalar ou retorno em até 3 meses após alta da unidade. Pacientes que faleceram na 1ª admissão foram excluídos. Fatores demográficos, uso de assistência ventilatória e permanência na unidade de terapia intensiva por mais de 3 dias foram analisadas de forma uni e multivariada de acordo com desfecho reinternação.

Resultados: Quinhentos e setenta e sete pacientes foram incluídos (33 óbitos excluídos). O grupo de reinternação foi 59 pacientes, e 518 não reinternados. O tempo entre admissão índice e reinternação foi 9 (3-28) dias (18 foram readmitidos com menos de 3 dias) e 10 faleceram. Os pacientes reinternados pelo menos 1 vez na unidade de terapia intensiva apresentaram as seguintes diferenças em relação ao grupo controle: maior idade: 75 (67-81) *versus* 67 (56-78) anos, p<0,01; admissão por insuficiência respiratória e/ou sepse: 33 *versus* 13%, p<0,01; admissão clínica: 49 *versus* 32%, p<0,05; maior SAPS II: 27 (21-35) *versus* 23 (18-29) pontos, p<0,01; Charlson: 2 (1-2) *versus* 1 (0-2) pontos, p<0,01 e permanência maior que 3 dias na unidade de terapia intensiva na 1ª admissão (35 *versus* 23%, p<0,01). Após regressão logística, idade, índice de Charlson e admissão por causas respiratórias ou sepse foram independentemente associados às reinternações em unidade de terapia intensiva.

Conclusão: Idade, comorbidades e admissão por insuficiência respiratória e/ou sepse estão precocemente associadas a maior risco de reinternações na unidade de terapia intensiva estudada.

Descritores: Morbidade; Hospitalização; Tempo de internação; Admissão do paciente; Readmissão do paciente; Qualidade de cuidados em saúde

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