European Journal of Internal Medicine 20 (2009) 636–639

Contents lists available at ScienceDirect

European Journal of Internal Medicine

journal homepage: www.elsevier.com/locate/ejim

Original article

Ability of physiological parameters versus clinical categories to predict mortality on admission to an internal medicine ward

Esther Francia [a], Olga Torres [a], Ana Laiz [a], Domingo Ruiz [a], Ignasi Gich [b], Jordi Casademont [a,*]

[a] Internal Medicine Department, Hospital de la Santa Creu i Sant Pau. Universitat Autònoma de Barcelona, Barcelona, Spain
[b] Epidemiological Unit, Hospital de la Santa Creu i Sant Pau. Universitat Autònoma de Barcelona, Barcelona, Spain

ARTICLE INFO

Article history:
Received 20 April 2009
Received in revised form 25 June 2009
Accepted 27 June 2009
Available online 24 July 2009

Keywords:
Mortality
Internal medicine
Health care
End-of-life care

ABSTRACT

Background: The prediction of mortality in internal medicine departments may help in taking diagnostic and therapeutic decisions. We analyzed the usefulness of two mortality prediction models, one physiological and the other mainly clinical, and determined whether one approach is better than the other to predict mortality at admission.

Methods: This is a prospective observational cohort study in patients admitted to an acute internal medicine ward in a tertiary care, urban, university teaching hospital in Spain. Five hundred consecutive patients either electively admitted or coming from the emergency department from May to December 2008 were analyzed. Medical history, physical examination and routine clinical laboratory tests were performed on admission. At discharge, diagnosis and dead or survived status was recorded. Logistic regression analyses were used to test variables that emerged as independent predictors of mortality. The area under the curve was used to determine which model best predicted mortality.

Results: Mortality in the ward was 13.0%. Age, chronic respiratory failure, creatinine, mean arterial pressure, respiratory rate and Glasgow coma scale independently predicted mortality. ROC curves showed that the physiological model was superior to the clinical model, but differences were not statistically significant. The predictive capacity improved when the two models were combined but the improvement was not significant.

Conclusions: Both models are satisfactory predictors of in-hospital mortality for management purposes but neither proved to be a useful tool for individual predictions. Complementary approaches need to be considered.

1. Introduction

Mortality analysis is frequently used to evaluate hospital effectiveness, quality of care and benchmarking. It is usually based on administrative and clinical data obtained during hospital admission and documented in discharge medical records [1]. While generally considered a good quality measure for individuals with acute illness who are not expected to die, there are concerns about the usefulness of such analysis in patients with multiple chronic diseases who are near the end of life [2].

A major challenge in mortality analysis is to distinguish patients who are not supposed to die from those dying of advanced chronic illnesses. Depending on hospital type, the availability of palliative-care beds, hospice facilities in the surrounding area and cultural characteristics of the population, inpatient mortality rates may vary widely between institutions. A reliable prediction of mortality at admission would be of great interest, allowing a distinction between expected and unexpected deaths. Such information would probably reflect the quality of care given more accurately than the actual rate of mortality, even if risk-adjusted.

Mortality prediction models have been widely developed for patients admitted to intensive care units (ICU) [3] and for those with specific diagnosis such as sepsis [4], acute renal failure [5], pulmonary embolism [6], pneumonia [7], and others. Fewer models are available, however, for non-surgical patients admitted to general internal medicine wards, and those that exist differ greatly. Some have been derived from ICU models using physiological data [8,9], while others have been developed using mainly clinical [10] or laboratory parameters [11,12], or a combination of these [9,11,13–15]. Comparisons between these different models are lacking and, as a result, there is no general agreement on which type of variables better predict mortality in internal medicine departments at the time of admission.

The present study first analyzed whether the variables that had demonstrated an independent ability to predict mortality in two previous studies reproduced their usefulness in a cohort of general internal medicine patients in a tertiary, university teaching hospital. The two models were chosen because they use completely different

* Corresponding author. Hospital de la Santa Creu i Sant Pau, Universitat Autònoma de Barcelona, Sant Antoni M. Claret 167. 08025 Barcelona, Spain. Tel.: +34 935565609; fax: +34 935565938.
E-mail address: jcasademont@santpau.cat (J. Casademont).

0953-6205/$ – see front matter
doi:10.1016/j.ejim.2009.06.008

approaches: one is mainly based on physiological measurements [8] and the other on prior health status data [10]. Additionally, this later model was undertaken in a single centre and needs to be confirmed in other settings. Both studies had demonstrated a good discrimination capacity, measured by an area under the curve (AUC) of the receiver-operating characteristic (ROC) curves higher than 0.85 [8,10]. We aimed to determine which of the two better predicted mortality in our setting and evaluated whether a model combining the two offered any advantage.

2. Methods

Our centre is a tertiary, university teaching hospital which covers an urban area of about 420,000 inhabitants, and has all the subspecialties of internal medicine. Patients without a defined organ or system disease and those with multiple disorders are admitted to one of the three general internal medicine wards. One of these is a short-stay unit, another mainly specializes in post-acute care and the third could be considered a classical acute general internal medicine ward.

We evaluated five hundred consecutive patients who were admitted to this third internal medicine ward from May to December 2008. All patients came directly form the emergency or outpatient services. Patients coming from other hospital departments, such as the ICU, were excluded from the study. In all cases, a complete medical history, physical examination and routine clinical laboratory tests were performed on admission.

Two previously published predictive models of mortality were applied to all patients. The Rapid Emergency Medicine Score (REMS) is mainly based on physiological measurements taken in the emergency department in non-surgical patients who are subsequently admitted to the hospital [8]. Variables include age, blood pressure, respiratory rate, pulse rate, Glasgow coma scale and peripheral oxygen saturation. The Mortality Probabilistic Model at 24-Hours (MPM_{HOS-24}) is mainly based on prior health status data [10] and includes the diagnoses of chronic heart failure, chronic respiratory failure, chronic liver disease, cancer and dementia, gathered from medical history in accordance with criteria shown in Table 1, as well as age, haemoglobin and creatinine levels. The only difference we introduced in respect to these models was that we did not categorize the quantitative variables in a scoring system (present or absent) but treated them as continuous variables. We refer to the two models as the "physiological model" and the "clinical model". The combined model included in the same logistic regression analysis the variables of both aforementioned models. At discharge, outcome (deceased or alive) and diagnosis-related group (DRG) classification were recorded. No predictions of mortality were made until data from all patients had been collected. The study was approved by the ethics committee at our institution.

Statistics were generated using SPSS (version 15.0). Logistic regression analyses were used to identify independent predictors of mortality reproducing the models already published. The Hosmer–Lemeshow test was used to analyze the goodness-of-fit between the observed and predicted number of cases [16]. ROC curves were constructed and the AUC were compared according to 95% confidence intervals. The Spearman rank correlation method was used to determine the strength of association between the different models.

3. Results

Data were prospectively collected between May and December 2008. The basic characteristics of the consecutive 500 patients constituting the cohort are given in Tables 2–4. All measurements included in the analyses were available for 99.6% of patients.

In-hospital overall mortality for all general internal medicine beds during the period under study was 8.8%, while in the ward specifically analyzed it was 13.0%.

Table 1
Variables included in the MPM_{HOS-24} model analysis [10].

Variable	Definition
Age	Age ≥70 years
Type of admission (Ad)	Admission through emergency department (in contrast to scheduled admission)
Chronic heart failure (CHF)	Medical history of at least one episode of symptomatic heart failure due to a non-reversible cause requiring chronic pharmacologic therapy
Chronic respiratory failure (CRF)	Medical history of a chronic pulmonary disease or basal arterial PO_2 <60 mm Hg taken at least on two occasions breathing at FiO_2 of 0.21 in the absence of an acute decompensation
Chronic liver disease (CLD)	Pathologic diagnosis of chronic hepatitis or cirrhosis. In the absence of a pathological diagnosis, the presence of clinical, analytical and ultrasonographic diagnosis of liver disease for at least six months, together with a decompensation in the form of ascites, encephalopathy or bleeding oesophageal varices was also accepted
Cancer (C)	Pathological diagnosis of malignancy. Diagnosis based on imaging techniques was accepted when the suspicion was a primary tumour in the central nervous system or a metastatic liver disease.
Dementia (D)	Cognitive and emotional decline that interferes with daily activities and quality of life
Haemoglobin (Hb)	Haemoglobin <110 mg/dL
Creatinine (Cr)	Creatinine ≥2 mg/dL

When any of the above conditions was satisfied, 1 was introduced in the logistic regression model. When the condition was not satisfied, 0 was introduced in the model. The model was [10]:

$$\text{Probability} = \frac{e^{Logit}}{1 + e^{Logit}};$$

$$Logit = -5.901 + 1.091*\text{Age} + 1.234*\text{Ad} + 1.157*\text{CHF} + 1.926*\text{CRF} + 1.243*\text{CLD} + 1.580*\text{C} + 1.342*\text{D} + 0.730*\text{Hb} + 1.313*\text{Cr}.$$

From among the variables included in the two prediction models, bivariate analyses disclosed that mortality was associated with age, chronic heart failure, chronic respiratory failure, creatinine levels, mean arterial pressure, respiratory rate, O_2 saturation and Glasgow coma scale (Table 4). Mortality was not associated with type of admission (emergency or scheduled), chronic liver disease, cancer, dementia, haemoglobin levels or heart rate.

Using the clinical model, multivariate analyses showed that only age, chronic respiratory failure and creatinine independently predicted mortality (Table 4). When using the physiological model, age, mean arterial pressure, respiratory rate and Glasgow coma scale emerged as independent predictors of mortality. The Hosmer–Lemeshow test had a good degree of fit for both models: chi-square 6.41, d.f. = 8 ($p = 0.60$)

Table 2
Main characteristics of patients included in the study.

Variables	*N* (%)	Mean (SD)
Patients	500 (100)	
Sex; male/female	219/281 (43.8/56.2)	
Age in years		73.6 (16.8)
Type of admission; emergency/scheduled	440/60 (88/12)	
Chronic heart failure	121 (24.2)	
Chronic respiratory failure	85 (17)	
Chronic liver disease	21 (4.2)	
Cancer	69 (13.8)	
Dementia	151 (30.2)	
Hb in mg/dL		119.2 (22.9)
Creatinine in mg/dL		1.36 (1.12)
Mean arterial pressure in mm Hg		91.9 (18.5)
Heart rate in heartbeats per minute		88.9 (20.5)
Respiratory rate in respirations per minute		22.3 (5.9)
Saturation of O_2 (Sat O_2) in %		93.9 (5.3)
Glasgow coma scale		14 (2)
Status at discharge; dead/survived	65/435 (13/87)	

Categorical variables are expressed in number (*N*) and percentages (%). Continuous variables are expressed as mean and standard deviation (SD).