Chapter 1

Intelligent Management of Sepsis in the Intensive Care Unit

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ABSTRACT

Sepsis is a transversal pathology and one of the main causes of death in the Intensive Care Unit (ICU). It has in fact become the tenth most common cause of death in western societies. Its mortality rates can reach up to 60% for Septic Shock, its most acute manifestation. For these reasons, the prediction of the mortality caused by Sepsis is an open and relevant medical research challenge. This problem requires prediction methods that are robust and accurate, but also readily interpretable. This is paramount if they are to be used in the demanding context of real-time decision making at the ICU. In this brief contribution, three different methods are presented. One is based on a variant of the well-known support vector machine (SVM) model and provides and automated ranking of relevance of the mortality predictors while the other two are based on logistic-regression and logistic regression over latent Factors. The reported results show that the methods presented outperform in terms of accuracy alternative techniques currently in use in clinical settings, while simultaneously assessing the relative impact of individual pathology indicators.

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INTRODUCTION

Sepsis and its associated complications, Septic Shock and Multiorgan Function Syndrome (MODS) are considered the most frequent causes for morbidity and mortality for patients admitted to the Intensive Care Unit (ICU) (Livingston DH, 1995).

Sepsis is characterized by the systemic response to infection and from a clinical point of view it is recognized by a set of clinical signs and symptoms corresponding to the response of the organism to the presence of microorganisms or their toxic products.

The evolution and prognosis of septic patients is variable and unpredictable. Some patients with Sepsis have a fulminant evolution leading, within hours, to death of a refractory Septic Shock. However, other patients survive the hyperacute phase and develop MODS, which also lead to death. Fortunately, other patients present a favorable evolution and successfully recover from Sepsis.

The diagnosis of a Septic Shock is not trivial and it is usually carried out in challenging clinical emergency situations. Early recognition of signs of decreased perfusion before the onset of hypotension, appropriate therapeutic response, and removal of the center of the infection are the keys to survival of patients with Septic Shock. Given the criticality of this pathology, it is of capital importance to have available an early indication of this condition in order to allow doctors to act rapidly at the onset of Sepsis.

Needless to say, the ICU environment can be unforgiving in terms of decision making tasks. Clinicians in general might benefit from at least partially automated computer-based decision support, but those clinicians making real-time executive decisions at ICUs in particular will require methods that are not only reliable, but also, and this is a key issue, readily interpretable. This work aims to address these needs through the design and development of computer-based decision making tools to assist clinicians at the ICU. These developments will focus on the problem of Sepsis in general and, more specifically, on the problem of survival prediction for patients with Severe Sepsis. The tools at the core of Sepsis data analysis will stem from the fields of multivariate statistics, machine learning and computational intelligence.

BACKGROUND

The incidence of Sepsis and its associated complications: Septic Shock and MODS are difficult to establish and their causes are multiple and varied: longevity, associated pathologies (diabetes mellitus, hepatic cyrrhosis, neoplasias, chronic renal insufficiency, and so on), the increased use of invasive techniques, corticoid administration, chemotherapy and immunosuppressants, organ transplants, and so on (Luce J., 1987).

Studies carried out in the eighties probably underestimated the real incidence of Sepsis. In 1990 the US Center for Disease Control (CDC) calculated that between 1979 and 1987 there were 450,000 cases of Sepsis causing the death of 100,000 people. The incidence of Sepsis increased from 73.6 cases/100,000 people in 1979 to 175.9 cases/100,000 people in 1989 (CDC, 1990).

Now it is commonly accepted that the incidence of Sepsis is much higher. Angus et al. (Angus DC., 2001) describes an incidence of 3 cases / 1000 people, which implies that in the US there may appear 750,000 cases of Sepsis per year out which 51.1% will require ICU admission, with a hospital mortality rate of 28.7% (resulting in more than 215,000 deaths/year). These figures are similar to those of secondary deaths of acute myocardial infarction. It is expected that this incidence will increase 1.5% each year due to increased longevity, more aggressive treatment and the increased...