Critical Events in Mechanically Ventilated Patients

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Abstract. Mechanical Ventilation is an artificial way to help a Patient to breathe. This procedure is used to support patients with respiratory diseases however in many cases it can provoke lung damages, Acute Respiratory Diseases or organ failure. With the goal to early detect possible patient breath problems a set of limit values was defined to some variables monitored by the ventilator (Average Ventilation Pressure, Compliance Dynamic, Flow, Peak, Plateau and Support Pressure, Positive end-expiratory pressure, Respiratory Rate) in order to create critical events. A critical event is verified when a patient has a value higher or lower than the normal range defined for a certain period of time. The values were defined after elaborate a literature review and meeting with physicians specialized in the area. This work uses data streaming and intelligent agents to process the values collected in real-time and classify them as critical or not. Real data provided by an Intensive Care Unit were used to design and test the solution. In this study it was possible to understand the importance of introduce critical events for Mechanically Ventilated Patients. In some cases a value is considered critical (can trigger an alarm) however it is a single event (instantaneous) and it has not a clinical significance for the patient. The introduction of critical events which crosses a range of values and a pre-defined duration contributes to improve the decision-making process by decreasing the number of false positives and having a better comprehension of the patient condition.

Keywords. Critical Events, Intensive Care, INTCare, Ventilated Patients, Data Acquisition, Real-Time, Streaming Data, Interoperability.

1 Introduction

The process of ventilating a patient using artificial techniques is complex and it involves a set of concerns. By default a set of variables is defined in the ventilator according to the patient needs. Then the ventilator is prepared to monitoring the patient condition by collecting a set of patient values (e.g. Plateau Pressure, PEEP, Respiratory Rate, others). Typically these data are shown in the ventilator monitor

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and they are partial recorded (only the first value of the hour is considered) in an electronic platform or manual sheet.

To a better decision it is fundamental to have a system able to collect and process the data in real-time. In this sense a data acquisition architecture was designed. The architecture developed uses interoperability, streaming data and intelligent agents to store the patient data in the database. After this process a huge volume of data is available to be consulted by the clinicians in order to make the best decision. However and although the high number of data available, the physicians do not have time to read and understand all the data available in the right moment. In order to support and facilitate this analysis the Critical Events (CE) concept [1] was adopted and it was associated to ventilation variables. The concept was initially applied to vital signs variables [2]. This process was defined using the knowledge obtained through a literature review and after meeting with physicians. The process was tested and it was defined taking in attention the Intensive Care Units (ICUs) particularities.

ICU is a unit where the patients with severe diseases are admitted. In most cases they are needing mechanical ventilation. This work is framed in the INTCare project [3, 4] and it was evaluated using real data provided by the Intensive Care Unit of Centro Hospitalar do Porto, Hospital Santo António. The introduction of critical events [5, 6] has as main goal decreasing the number of false positives and finding an alternative way to avoid the noise alerts presented in the ventilators [7]. Generally the alerts are turned off because they are very noisy and they interfere in the environment. With this new solution an event only is considered serious if a patient has a critical value for a pre-defined period of time. This solution contributes to outwit false positives provided by the ventilator. All the values collected are validated before being used by the agent responsible to categorize the value as critical or not.

As already mentioned all the definition process was based in clinical evidences. The definition of the values was made after meetings with the intensivists and after reading clinical works.

The goal of this work was achieved and as result the critical events concept was defined to mechanically ventilated patients. At same time a platform was developed to show the results and alert the clinicians about the patient condition, i.e., when the patient is with a critical event.

This paper is divided in seven sections. After a brief introduction of the work the concepts are addressed and the project is presented in section 2. Section 3 presents the data acquisition architecture designed. Section 4 presents the critical events ranges and how it is calculated. Then in section 5 a dataset was analysed in terms of critical events and their results are presented. Section 6 makes a conclusion of the work and finally in section 7 there is some points of future work.

2 Background

2.1 Mechanical Ventilation

A patient is connected to a ventilator when he cannot breathing from natural ways. Mechanical ventilation is used to support the patient in their respiratory functions.