Development of a discharge ontology to support postanesthesia discharge decision making

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ABSTRACT

Postanesthesia discharge decision making is a challenging process due to the high complexity and variability of care provided to postoperative patients. We built an ontology-based decision support system that generates discharge recommendations for patients who have undergone surgical procedures. Discharge decisions are made based on patient vitals, symptoms, medical history and details of the surgical procedure. The output recommendations of our system can aid healthcare providers in discharge decision-making and potentially reduce readmissions due to improper discharge. This project demonstrates the potential uses of ontologies in medical decision support systems, especially in areas that use specific scoring guidelines to aid decision-making.

1 INTRODUCTION

Evidence-based discharge decision making and planning is a critical care process that can improve patient outcomes and reduce readmission rates. Inappropriate discharge can cause additional pain and suffering for patients and their families and consume unnecessary hospital resources (Anderson *et al.*, 2011). For surgical procedures, the risks associated with early discharge may be even higher. When planning for discharge, healthcare professionals have to account for multiple variables such as age, vitals, comorbidities, medications and social issues. A tool like the Aldrete scoring system is commonly used to help healthcare professionals determine when patients can be safely discharged (Aldrete, 1995). However, there are no standardized guidelines routinely used by healthcare professionals to assist them in making postoperative discharge decisions. A knowledge-based decision support tool based on standardized procedures can enhance discharge decision making and reduce errors. In Bouamrane *et al.*, 2010, the authors built an ontology to model preoperative domain knowledge. In this paper, we use a similar approach to create a postoperative ontology-based decision support system to assist discharge decision making.

2 METHODS

Our goal is to create an ontology to aid in post-surgery discharge decision-making. Following surgery, patients generally go from phase I postanesthesia care to phase II before being discharged to home. Phase I care immediately follows surgery and involves intensive monitoring of patient status. Phase II care is less intensive and sees the patient recovering well from anesthesia. The goals of our system are (i) to detect patients who may be suitable for discharge, (ii) to determine the appropriate discharge workflow, and (iii) to generate a list of additional recommendations for physicians.

Many clinics have specified their own modified criteria for postanesthesia discharge. We begin by assembling resources published online by various surgical units. Among these resources, many are based on the Aldrete scoring system, with additional modifications tailored to clinic-specific workflow. Criteria from Stanford Hospital and Clinics, Loyola University Medical Center and others are used to construct a global discharge rule set (Stanford Hospital and Clinics, 2010; Brown *et al.*, 2008). The Phillips *et al.*, 2011 systematic review of postanesthesia discharge protocols is also used to determine levels of evidence for various scoring criteria. Scoring guidelines present in all or most resources we studied are included as criteria in our ontology-based decision support system.

Based on the the criteria in these resources, we build a set of SWRL rules, which in turn guides our development of an OWL ontology. We first create a full set of postanesthesia discharge criteria using information from our source documents. We then translate these criteria into SWRL rule syntax to facilitate reasoning. Afterwards, we use these rules to guide the creation of OWL classes, as well as the definition of object and data properties.

The modified Aldrete score, for example, consists of five primary criteria: consciousness, respiration, circulation, movement and pain. Some of these, such as respiration and circulation, can be broken down further. For example, respiration consists of breathing quality, breath rate and oxygen saturation.

Aldrete subscores, along with the total score, are used as criteria for discharge. For each Aldrete subscore, a patient receives a score on a 2 point scale, where 0 means a low functional level and 2 means a normal functional level. We create a data property that corresponds to each primary criteria. The value of this data property is determined using SWRL rules and assigned to a patient based on his/her current status in the system. An example data property *hasAldreteScoreConsciousness* may take on the values of 0, 1 or 2 if the patient is unresponsive, responsive but drowsy, and responsive and fully alert respectively.

Another example is the circulation subscore, where the patient's blood pressure must fall within a pre-specified range from the baseline blood pressure. Within $\pm$ 20 mmHg yields a score of 2, within $\pm$ 20-50 mmHg yields a score of 1, and anything outside of that range yields a score of 0. These specific differences can be automatically calculated by our reasoner, which then assigns a score to the patient. This reduces the need for healthcare workers to perform time-consuming numerical calculations.

An example SWRL rule for oxygen saturation is:

$$Patient(?pt), hasSpO2(?pt, ?SpO2), greaterThan(?SpO2, 95)$$
$$\rightarrow hasAldreteScoreOxygen(?pt, 2)$$

which assigns 2 points to the Aldrete oxygen subscore if a patient's oxygen saturation is greater than 95%. The sum of points

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assigned to all Aldrete criteria is then calculated and used to determine whether a patient fits the basic criteria for discharge. If a patient satisfies this condition, she/he is assigned into the class *DISCHARGE_FROM_PHASE_I_POSTANESTHETIC_CARE*.

Our ontology classifies patients for discharge from phase I to phase II care, as well as from phase II care to home. Additionally, our discharge ontology makes recommendations for healthcare provider actions. For example, a patient receiving a sciatic block may require clutches at discharge (Figure 1), or a patient with high pain levels may require additional pain management. These recommendations can be used by healthcare providers to prioritize patient care and to generate discharge notes.

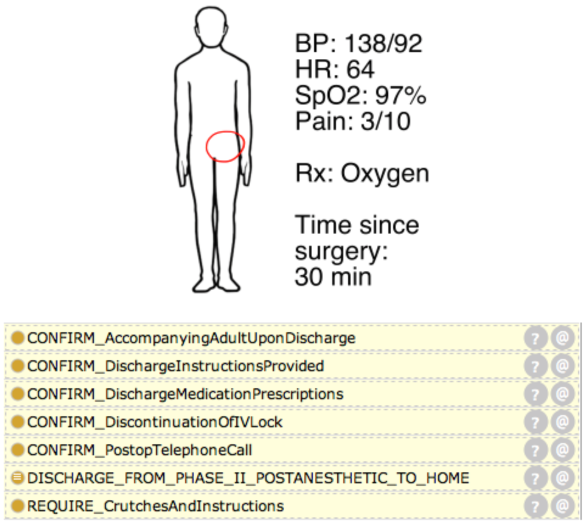

Fig. 1. Example patient who is 30 minutes post surgery with stable vitals. Output classifications based on SWRL rules are given.

3 RESULTS & DISCUSSION

In this project, we demonstrated our work in building a knowledge-based decision support system that generates decision support recommendations to determine patient discharge eligibility after surgical procedures. We were able to model appropriate discharge decision making in several example patients (Figure 1). In addition to making the correct discharge decision, our system also generates a list of recommendations for clinicians which should be followed before the actual discharge.

Our decision support system operated with a number of limitations. First of all, the recommendations and guidelines issued by our system are constrained by the accuracy of the guidelines that we modeled. Therefore, any errors or flaws present in the model guidelines will be systematically replicated by our system. Also, due to the lack of a standard discharge protocol, we could only capture a representative set of criteria. Our ontology, therefore, may need to be modified for use in any specific clinical environment.

Additionally, we should align our system with pre-existing medical ontologies for morbidity classification such as ICD-10 or SNOMED-CT. We believe that such integration is critical for the future interoperability of our system. Future work will also involve extracting information from electronic health records or in-room patient sensors (Figure 2) to increase the accuracy, timeliness and reliability of patient medical data. Some obvious challenges to this work are the semantic plurality of clinical data representation and non-standard data exchange protocols between platforms.

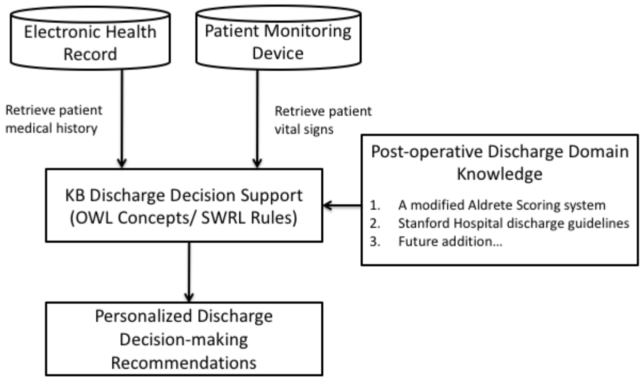

Fig. 2. Integrating information from electronic health records and patient monitoring devices into the decision support ontology.

Another future direction is to expand our system to create automated discharge summary notes to assist in the transition of care. The discharge summary notes can be generated for two groups of users: (1) healthcare professionals, and (2) patients and caregivers. Discharge notes generated for healthcare professionals can be used to facilitate continuity of care. Notes generated for patients and caregivers can contain care instructions specifically tailored to the patient to help guide them through the complex post-discharge care process.

4 CONCLUSION

The discharge decision-making process relies on a set of predefined clinical criteria that must be interpreted correctly to reach the appropriate discharge decision. Our ontology integrates patient vitals, symptoms, and surgical and medical information, and outputs recommendations for discharge and healthcare provider actions. This decision support tool could simplify postanesthesia discharge procedures and may help reduce adverse events based on improper or early discharge.

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