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ORIGINAL ARTICLE

Evaluation of an Electrolyte Replacement Protocol in an adult Intensive Care Unit: A retrospective before and after analysis

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KEYWORDS
Electrolyte replacement;
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Hypokalaemia;
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Summary
Background: Electrolyte imbalances are frequently encountered in the Intensive Care Unit (ICU) and protocol-driven interventions may facilitate more timely and uniform care.
Objective: To compare the effectiveness and timeliness of electrolyte replacement in an adult ICU before and after implementation of an Electrolyte Replacement Protocol (ERP) and to assess nurse and physician satisfaction with the ERP.
Methods: Health records of adult patients who experienced hypokalaemia, hypomagnesaemia, or hypophosphataemia in the ICU during the study periods were retrospectively reviewed. Effectiveness of the ERP was assessed by the number of replacement doses indicated but not given and the number of doses and total dose required to normalise the low electrolyte level. Timeliness was evaluated by the time between the laboratory reporting the low electrolyte level and administration of the replacement dose. Nurse and physician satisfaction with the ERP was assessed through a written survey.
Results: After implementation of the ERP, the number of replacement doses indicated but not given was reduced for magnesium from 60% to 35% ($p = 0.18$) and for phosphate from 100% to 64% ($p = 0.04$). The time to replacement was reduced for potassium from 79 to 60 min ($p = 0.066$) and for magnesium from 307 to 151 min ($p = 0.15$). Nurses and physicians were satisfied with the ERP.
Conclusions: Implementation of an ERP resulted in improvements in the effectiveness and timeliness of electrolyte replacement and nurses and physicians were satisfied with the ERP.

Introduction

Low electrolyte levels are frequently encountered in the critical care setting (Hamill-Ruth and McGory, 1996; Hijazi and Al-Ansari, 2005; Kraft et al., 2005; Sedlacek et al., 2006). The clinical presentation of electrolyte deficien-

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cies can range in severity and often reflects the degree of deficiency (Kraft et al., 2005). Hypokalaemia may produce signs and symptoms such as nausea, vomiting and weakness, as well as more severe consequences such as respiratory failure, cardiac arrhythmias, and sudden death (Gennari, 1998; Kraft et al., 2005; Sedlacek et al., 2006). Hypomagnesaemia may result in symptoms which include tetany, generalised convulsions, muscle weakness and cardiac arrhythmias including life-threatening types such as torsades des pointes (Hamill-Ruth and McGory, 1996; Kraft et al., 2005; Sedlacek et al., 2006). Hypophosphataemia may cause impaired diaphragmatic contractility, reduced myocardial contractility, paresthesias and seizures (Kraft et al., 2005; Taylor et al., 2004).

Protocol-driven interventions are increasingly being used in the critical care setting and have been associated with improved outcomes such as a reduction in mortality and more efficient use of resources (Zimmerman et al., 2003). A prospective study from Saudi Arabia comparing protocol-driven and physician-driven electrolyte replacement of potassium, magnesium, and phosphate in critically ill adult patients reported that protocol-driven replacement was associated with more timely administration of the replacement dose and fewer missed episodes of low levels without any difference in side effects related to the infusions (Hijazi and Al-Ansari, 2005). Although no side effects related to the infusions were found, the types of adverse events and methods of monitoring were not specified. In addition, a small retrospective study evaluating the efficacy of an order form for replacing potassium, magnesium, and phosphate in a medical ICU found that it effectively and safely replenished potassium and magnesium serum concentrations compared to a matched control group (Owen et al., 2008). This study did not evaluate timeliness of replacement with the order form. Neither of the above-mentioned studies evaluated adverse events related to delays in replacement.

Traditionally, a physicians order was required for electrolyte replacement in our Intensive Care Unit (ICU). In September 2007, an Electrolyte Replacement Protocol (ERP) (Appendix A) was implemented. According to this preprinted order form, ICU nurses can administer the specified replacement dose of potassium, magnesium, and phosphate according to the level of deficiency, and order follow-up electrolyte levels to assess the efficacy of the replacement dose. The traditional practice that requires a physician's order, allows for individual assessment, taking into account the severity of electrolyte deficiency, clinical presentation, trends in electrolyte levels and patient's renal function before determining a replacement dose. However, some disadvantages of the traditional approach include differences in physician prescribing practices that may lead to inadequate replacement, less timely administration of the electrolyte replacement dose and lack of nursing autonomy.

The primary objective of this study was to compare the effectiveness and timeliness of electrolyte replacement for hypokalaemia, hypomagnesaemia, and hypophosphataemia before and after implementation of the ERP in our ICU. A secondary objective was to assess nurse and physician satisfaction with the ERP.

Methodology

We conducted a retrospective review of the health records of adult patients ($\geq$18 years of age) who experienced an episode of hypokalaemia ($K < 3.5$ mmol/L), hypomagnesaemia ($Mg < 0.7$ mmol/L), or hypophosphataemia ($PO_4 < 0.8$ mmol/L) during admission to the nine bed medical—surgical ICU in our community acute care hospital. We excluded patients with impaired renal function on admission to ICU (defined as a serum creatinine (SCr) > 150 μmol/L and/or a urine output < 0.5 mL/kg/h), diabetic ketoacidosis, chronic malnutrition, without a central line for potassium replacement and without a signed ERP on file during the post-protocol phase. Patients were also excluded if their chart was inaccessible.

All episodes of hypokalaemia, hypomagnesaemia and hypophosphataemia experienced by each patient throughout their ICU stay were evaluated. Some low levels of potassium, magnesium or phosphate from patients included into the study were excluded from the analysis for the following reasons: the patient had renal dysfunction or did not have a central line for potassium replacement at the time of the electrolyte deficiency, the replacement dose was not administered as per the ERP in the post-protocol phase, an alternate method of electrolyte replacement was given in response to the low level (e.g. oral replacement), follow-up levels were not done to assess the efficacy of the replacement dose given or there was insufficient information in the patient chart (e.g. medication administration record documenting administration of replacement dose was missing from a patient's chart).

The primary objective of the study was to compare the effectiveness and timeliness of electrolyte replacement before and after implementation of the ERP. The two phases of the study are designated as the pre-protocol and post-protocol phases. Effectiveness of the ERP was evaluated by the number of replacement doses indicated but not given as well as the number of doses and total dose required to normalise the low electrolyte level. As per our hospital laboratory, normal ranges for the given electrolytes were as follows: potassium 3.5—5.0 mmol/L, magnesium 0.7—1.10 mmol/L, and phosphorus 0.8—1.45 mmol/L. Timeliness of electrolyte replacement was evaluated by the time between the laboratory reporting the low electrolyte level and administration of the replacement dose.

We empirically aimed to obtain 50 patients in each phase of the study. Since approximately 30 patients are admitted to our ICU each month, we estimated the need to collect data for a two-month period in each phase to achieve the desired number of patients. The ERP was developed in June 2007, and implemented in September 2007 after being revised based on physician and nursing feedback and receiving approval for use. Since prescribing practices of the physicians began to change as draft protocols were circulated, the projected data collection period for the pre-protocol phase was from April 2007 to May 2007. In order to account for the training and adjustment period after implementation of the protocol, the projected data collection period for the post-protocol phase was from November 2007 to December 2007.

Upon completion of data collection from the projected periods in each phase, we only obtained 33 patients in