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ORIGINAL ARTICLE

Comparative dose response using the intravenous versus enteral route of administration for potassium replenishment

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Summary
Objective: To compare the change in potassium concentration (dose—response) using the intravenous versus enteral route for potassium replenishment.
Research Methodology/Design: Cross-sectional analysis of individual potassium chloride doses with resulting changes in plasma potassium concentrations in intensive care patients. Potassium chloride was administered according to potassium replenishment protocols. For inclusion, doses were required to have pre- and post-dose plasma potassium concentrations obtained within 8 hours of administration.
Setting: Medical and surgical intensive care units of a United States Veterans Affairs Medical Center.
Main Outcome Measures: The primary outcome was the dose—response slope for intravenous versus enteral potassium administration as estimated by linear regression analysis. Multivariable linear regression was employed to adjust for potential confounders.
Results: The sample had 278 potassium chloride doses administered to 142 patients. The potassium concentration change per 20 mmol of potassium chloride was similar for intravenous and enteral routes, 0.25 mmol/L (95% confidence interval 0.16—0.33) versus 0.27 mmol/L (0.15—0.39) respectively ($p = 0.73$). Multivariable linear regression did not alter results. The success of achieving a minimum potassium concentration defined by the specific protocol was similar for intravenous (61%) and enteral (59%) administration. Overall, 77% of potassium chloride doses were administered at a time when patients were eligible to receive an enteral dosage form.

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Conclusion: The enteral route was as effective as the intravenous route in increasing the plasma potassium concentration. The enteral route was widely available for potassium replenishment. Despite enteral route availability and the well-known reliability of potassium chloride absorption, the majority of doses were administered intravenously.
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Implications for Clinical Practice

- The enteral route was available for potassium chloride administration in 77% of intensive care patients.
- The mean dose—response per 20 mmol of potassium chloride was 0.25 mmol/L (95%CI 0.16—0.33) versus 0.27 mmol/L (0.15—0.39) when administered intravenously and enterally, respectively ($p = 0.73$).
- The dose—response remained comparable after adjustment for patient weight, time elapsed between plasma potassium measurements, medical vs. surgical care, receipt of drugs that may affect potassium concentration, and the amount of potassium delivered via intravenous fluids or nutrition.
- The overall success of each dose achieving the minimum potassium concentration as defined by the specific protocol used was similar whether doses were administered intravenously (61%) or enterally (59%).
- Since the use of the intravenous formulation of potassium chloride has been associated with numerous reports of medical mistakes leading to disabling injuries and fatalities, using the enteral route may substantially reduce patient risk, when that route is available.

Introduction

Potassium replenishment is often performed via automated protocols to prevent or treat hypokalaemia in acute care hospitals, particularly in intensive care units. This practice began more than 30 years ago when evidence appeared to associate hypokalaemia with the occurrence of ventricular arrhythmias, principally in the setting of myocardial ischaemia (Friedensohn et al., 1991; Hulting,1981; Nordrehaug et al., 1985; Nordrehaug et al., 1983; Solomon and Cole, 1981). Protocol-driven potassium replenishment has also been adopted after cardiovascular surgery based on evidence indicating association of potassium concentrations less than 3.5 mmol/L with the occurrence of peri-operative arrhythmias (Wahr et al., 1999). Many potassium replacement protocols used in intensive care rely predominately on the intravenous administration of potassium chloride (Chalwin et al., 2012; Couture et al., 2013; Hijazi and Al-Ansari, 2005; Kanji and Jung K, 2009). Although intravenous potassium replacement in the intensive care area has become routine, its use has been implicated in numerous reports of medical and nursing errors resulting in disabling injuries and fatalities (Ceuppens et al., 1982; Cohen, 1990; Cox and Starbuck, 1986; ISMP Canada Safety Bulletin, 2002; Lakhani, 1987; Lawson, 1974; Liu and Chia, 1995; Reeve et al., 2005; Romagnoni et al., 1998; Shanker et al., 1985; Tessler et al., 1988; Wetherton et al., 2003). Accordingly, recommendations for appropriate replenishment of potassium call for the preferential use of the enteral route when it is available (Alfonzo et al., 2006; Asmar et al., 2012; Gennari, 1998; Kim and Han, 2002; Mount, 2014). Potassium chloride is extensively absorbed from the gastrointestinal tract and typically well tolerated. Potential adverse effects with enteral administration include unpalatable taste, nausea, and abdominal discomfort. Adverse effects with intravenous administration include venous sclerosis, infusion-related pain, and phlebitis when delivered via peripheral vein and the risk of cardiac arrest due to excessive infusion rates when administered via a central intravenous catheter.

A preference for the intravenous delivery of potassium in the intensive care unit may exist due to the lack of a viable enteral route in critically ill patients as a result of mechanical ventilation and/or immediate post-operative conditions. Another reason may be a perception of greater efficacy and quicker potassium replenishment compared to relying on enteral absorption in a critically ill patient. A review of current and past literature did not reveal any investigation or evidence of intravenous route superiority nor data quantifying the availability of the enteral route for administration in the intensive care patient.

To evaluate these issues we performed a cross-sectional analysis of potassium chloride replenishment via automated protocol in the intensive care units of our medical centre. The primary objective was to compare the dose response, or change in plasma potassium concentration from before to after administration, of potassium chloride delivered intravenously versus enterally. Secondary objectives examined the success of protocol doses and the frequency at which the enteral route was available for potassium chloride administration.

Methods

All patients in medical intensive care and surgical intensive care units receiving potassium chloride via a replenishment protocol in December 2007 and April 2008 were identified. Patient demographics, body weight, concentrations of plasma potassium, serum magnesium, and serum creatinine were extracted from the electronic medical record. Bar coded-medication administration records were searched to obtain the date, time, dose and route of administration for