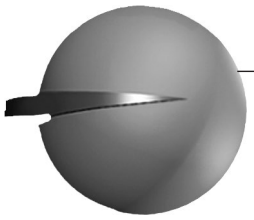

Special Issue

Administration of 3% Sodium Chloride Through Peripheral Intravenous Access: Development and Implementation of a Protocol for Clinical Practice

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ABSTRACT

Background: Patients with traumatic brain injury, cerebral edema, and severe hyponatremia require rapid augmentation of serum sodium levels. Three percent sodium chloride is commonly used to normalize or augment serum sodium level, yet there are limited data available concerning the most appropriate route of administration. Traditionally, 3% sodium chloride is administered through a central venous catheter (CVC) due to the attributed theoretical risk of phlebitis and extravasation injuries when hyperosmolar solution is administered peripherally. CVCs are associated with numerous complications, including arterial puncture, pneumothorax, infection, thrombosis, and air embolus. Peripherally infused 3% sodium chloride may bypass these concerns.

Aims: To explore the evidence for peripherally infused 3% sodium chloride and to implement the findings.

Methods: The Iowa Model of Evidence-Based Practice (EBP) was used to guide the project. A multidisciplinary team was established, and they developed an evidence-based protocol for the administration of 3% sodium chloride using peripheral intravenous catheters (PIVs), identified potential barriers to implementation, and developed targeted education to implement this practice change in a large academic medical center.

Results: Of the 103 patients in this project, only three (2.9%) identified adverse events. Two were associated with continuous infusions, and one was associated with a bolus infusion.

Linking Action to Evidence: This is the first study to describe a multidisciplinary protocol development and implementation process for the administration of 3% sodium chloride peripherally. Utilizing a multidisciplinary team is critical to the success of an EBP project. Implementing an evidence-based PIV protocol with stringent monitoring criteria for the administration of 3% sodium chloride has the potential to reduce adverse events related to CVC injury.

INTRODUCTION

Evidence-based practice (EBP) refers to the conscientious, explicit, and judicious use of current best evidence in making sound clinical decisions (Sackett, 2000). Hence, EBP must incorporate the best systematic and empirical evidence with expert clinical opinion while considering the values and preferences of patients (Kang, 2016). EBP is dynamic, and clinicians are expected to reexamine the evidence-based literature at regular intervals to make informed decisions, which may result in sustained improvement in patient-centered outcomes.

The acute management of traumatic brain injury (TBI), cerebral edema, and severe hyponatremia related to catastrophic neurologic injury and illness can be challenging in neurocritical care. There are limited data available to guide the most appropriate route of administration of 3% sodium chloride (Jones, Bode, Riha, & Erdman, 2017). Commonly 3% sodium chloride, with an osmolality of 1,026 mOsm/L, is used to normalize or augment serum sodium level. Historically, the general practice has been the administration of 3% sodium chloride through a central venous catheter (CVC) due to the attributed theoretical risk of phlebitis or extravasation injuries when hyperosmolar solution is administered peripherally. This theoretical risk is extrapolated from total parenteral nutrition literature that suggests the maximum

osmolarity of peripherally infused solutions be restricted to 900 mOsm/L (Timmer & Schipper, 1991). Although CVCs are valuable tools for patient care, they are associated with numerous complications, including arterial puncture, pneumothorax, infection, thrombosis, and air embolus. They can potentially delay medication therapy in time-sensitive circumstances (Parienti et al., 2015). More recent research suggests that hypertonic solutions with osmolality higher than 900 mOsm/L could be administered peripherally (Dillon, Merchan, Altshuler, & Papadopoulos, 2018; Jones et al., 2017; Luu et al., 2011; Meng, Nguyen, Patel, Mlynash, & Caulfield, 2018; Perez & Figueroa, 2017).

Using the Iowa Model of Evidence-Based Practice (IM-EBP; Titler et al., 2001), the authors explored the evidence for peripherally infused 3% sodium chloride, organized a multidisciplinary team to develop a protocol for the administration of 3% sodium chloride using peripheral intravenous catheters (PIVs), identified potential barriers to implementation, and developed targeted education to implement this practice change in a large academic medical center.

METHODS

The initiative was operationalized based on a methodology outlined by the IM-EBP (Titler et al., 2001).

Problem Identification and Prioritization

It was an institutional standard to administer 3% saline via CVC only. During a routine monthly meeting of the Neurocritical Care Service Quality Improvement Council, an adverse event (AE) was identified. A CVC was placed emergently for the sole purpose of administering 3% sodium chloride and was associated with a pneumothorax. Given the known risks associated with central line insertion and the necessity for rapid augmentation of serum sodium levels in patients with TBI, cerebral edema, and severe hyponatremia, consideration of an alternative route of administration was prioritized.

Create a Multidisciplinary Team

A collaborative group of healthcare professionals who provide routine clinical care to patients with neurological injuries was identified: nurses (a neurocritical care nurse manager, a neurocritical care nurse educator, and a clinical nurse specialist); neurocritical care advance practice providers (advanced registered nurse practitioners and physician assistants); neurocritical care and critical care pharmacists; and physicians (neurocritical care service director and the director of neurocritical care quality improvement). Once interest in participation was evaluated and confirmed, the collaborative group met to set goals for the project. A task list with expectations and deadlines for each team member was developed in the initial meeting.

Potential barriers to implementation were identified, and strategies to overcome these barriers were discussed. The first barrier identified was safety concerns from the pharmacists. A representative from each discipline was involved with completing a review of the literature to assess a minimum level of safety associated with 3% sodium chloride peripheral administration. Other barriers identified included acceptance of nurses' practice change and compliance with ordering the medication using distinct safety parameters. The clinical nurse specialist and clinical nurse educator wrote a nursing policy and procedure to support the new practice. A protocol was developed to set distinct safety parameters for the administration of 3% sodium chloride peripherally. The pharmacists and advanced practice providers worked with the electronic medical record technicians to develop an order set that included the safety parameters identified in the protocol. Hypertonic saline education sheets and nurse information cards were also updated to reflect the new protocol.

Literature Review and Analysis

Prior to the development of an administration protocol, a review of the literature was performed. The review focused on the available literature related to the administration of 3% saline via peripheral intravenous access, as well as any national or international guidelines related to intravenous drug administration. The databases utilized to collect systematic evidence include PubMed, EMBASE, Web of Science, and Google Scholar. The keywords searched included any combination of "hypertonic saline," "sodium chloride," "3% saline," "brain injury," "hyponatremia," "cerebral edema," "central venous catheter," and "peripheral IV" from 1990 through 2018.

Inclusion criteria included studies performed in adults. Children and animal studies were excluded, and articles were limited to the English language. Besides, specific search strategies were utilized to identify the best classification of an infiltration scale to fit this project's purpose. Each specialty focused on literature from their respective areas, and a matrix of articles was then created to synthesize the data. It was essential to develop a protocol that was simple to follow but comprehensive in its inclusion of practice parameters identified in the data as potential triggers for AE such as infiltration, phlebitis, and extravasation.

Protocol Development

After a review of the empirical evidence, the following practice parameters of the protocol were identified. The principal practice parameters identified included setting specific requirements for insertion site, PIV catheter gauge, existing PIV specifications, monitoring the site, duration of the treatment, maintenance of the site, and infusion specifications. The PIV insertion site must be in an upper extremity from the antecubital fossa to the wrist. Catheter gauge

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should range between 18 and 22. For existing PIV sites, they must be less than 24 hr old, flush easily, have blood return, and not be a field start. The PIV site was monitored every 2 hr. The nurses assessed the defined criteria based on the validated Infusion Nurses Society (INS) Infiltration and Phlebitis Scale (INS, 2016). This was used to grade AEs: Grades ranged from 0 to 4, and higher numbers indicated higher grades of AEs (Groll, Davies, Mac Donald, Nelson, & Virani, 2010; INS, 2016).

Nursing documentation of the PIV site included skin blanching, cold temperature, pain, gross edema, numbness, translucence of skin, tight or leaking skin, discoloration and bruising of the skin, pitting edema, and circulatory impairment (Reynolds, MacLaren, Mueller, Fish, & Kiser, 2014). Nurses were required to notify providers of any suspected infiltration or phlebitis to assess whether the infusion could be transitioned to another existing PIV site or whether new peripheral access would be required. Finally, infusion specifications were identified, including a maximum rate of infusion (100 mL/hr), a maximum bolus of medication based on indication (100 mL for hyponatremia or 250 mL for acute intracranial hypertension), and the total duration of the infusion, which was not to exceed 48 hr even if multiple PIV sites were used.

In addition to creating a protocol, the team identified any potential barriers to implementing the protocol, which guided the next steps in the pre-implementation phase of this project. First, a nursing policy and procedure was written to include 3% sodium chloride as a medication that can be administered peripherally for up to 48 hr (INS, 2016; Jones et al., 2017; Meng et al., 2018; Nagler et al., 2014; Reynolds et al., 2014). This encouraged broad acceptance for the practice change, as there was a tangible policy to support nursing practice. Then, the clinical nurse specialists and the clinical nurse educator developed a targeted strategy for pre-implementation education to the nursing staff with a focus on specific data elements in the protocol, as well as empowering the nurses to advocate for using less-invasive techniques to improve patient care (INS, 2016; Nagler et al., 2014; Perez & Figueroa, 2017; Reynolds et al., 2014). Next, the team worked with our electronic medical record (EMR) technologist to create a standardized order set to administer 3% sodium chloride peripherally. To guide clinician best practice, this order set included maximum rate and options for bolus dosing, highlighted a maximum duration of infusion, and had pre-selected laboratory monitoring and frequency incorporated. Each component of the protocol was reviewed numerous times individually and as a group; the consensus was reached by discussion among the group and an iterative process of an additional literature review. The protocol was presented to the hospital's Medication Administration Committee, the Critical Care Advisory Board, and the Chief Nursing Officer. Once approval was obtained, a date for integration was determined.

Table 1. Nurse Pocket Card

SODIUM CHLORIDE + SODIUM ACETATE 2%, 3%
USE: Increased ICP, hyponatremia
CLASS: Hypertonic saline solutions
CONCENTRATION: 2%, 3%
BOLUS: Per provider
USUAL STARTING DOSE: 30–50 mL/hr
USUAL DOSING RANGE: 2% 50–125 mL/hr 3% peripheral 30–100 mL/hr 3% central 30–150 mL/hr
TITRATE: Per provider to ICP < 20–25 mm Hg, or per ordered sodium level
WEAN: Prescriber to adjust specific rates with an order. Risk of rebound edema and seizures if wean is too abrupt
ACTIONS: Plasma volume expander for hemodynamic support; creates osmotic gradient between intravascular space and cerebral tissue causing passive water diffusion, water follows sodium
MONITOR: Sodium and osmolarity every 4–6 hr per order
NOTE: 2% peripheral line OK, ICU, and 3W only
3% central line preferred; peripheral line for short term (<48 hrs) use only; ICU only

Note: Courtesy of Harborview Medical Center Professional Development and Nursing Excellence Department, Seattle, WA. (2020).

Integration into Practice

Based on the institutional policy, this new procedure was conceptualized and implemented as a quality improvement project, and hence, full review by the Institutional Review Board was not required. This project was approved by the following entities: Neurocritical Care Quality Improvement, Harborview Critical Care Council, clinical nursing, intravenous therapy nursing, and the pharmacy and therapeutics committee. A pilot implementation into critical care units, operating rooms (OR), and the emergency department (ED) was the first step for integration into practice. Pre-implementation education by the clinical nurse specialist and clinical nurse educator utilized electronic mail communication so that all nurses could review the protocol and policy and procedure change, and this was followed by face-to-face education and review of the protocol on multiple days and times to assure that both day and night clinicians received adequate education. As a reinforcement method by email and face-to-face teaching, a pocket-sized, laminated RN reference card with the protocol elements was developed and distributed (Table 1) by the clinical nurse specialist and clinical nurse educator and reviewed by a larger team. Although infiltration monitoring already existed in the EMR, nurse education also included specific details for

documenting events related to 3% sodium chloride administration. Further, a designated infusion services RN followed quarterly patient safety net data and provided it to the designated data manager. Pre-implementation training was provided to clinicians, similarly, utilizing email to introduce the practice change, followed by face-to-face education to reinforce the new policy and procedure. Finally, the protocol was integrated into monthly onboarding materials for rotating resident physicians with a one-page "practice pearls" reference sheet (Table 2). A weekly pharmacy report was generated to track any 3% sodium chloride administration, and this was used to populate the data collection.

Evaluation

The six-month pilot phase consisted of data collection regarding adherence to the protocol and evaluated any AEs. The multidisciplinary team met to review the 40 cases of 3% sodium chloride administered peripherally. Although there were no identified AEs reported, the data collection manager identified some challenges in adherence. There were inconsistent practice patterns in documenting several data elements, most notably the PIV catheter site and gauge. Once this barrier was identified, further targeted education and reminders were given to the nursing staff to improve charting compliance. As there were no reported AEs, the policy was adopted and has become the standard of practice in our institution. One of the pharmacists reported a confidential list of patients on a weekly basis regarding the utilization of 3% saline via peripheral intravenous access to the study team. Authors AVL and BGB entered data into a secure REDCap database specifically created for this project. The data collected included patient age, sex, admitting diagnosis, the specifications related to intravenous access (gauge, location of the intravenous catheter, clinical care area where intravenous access was placed), and the duration of use of the 3% saline infusion. Data collection and AE monitoring continued for a total of 19 months after implementation. Providers noted that pharmacists and nursing colleagues were vocal in advocating for the use of the policy. Nursing also reported feeling empowered to suggest utilizing 3% sodium chloride peripherally when treatment decisions were made.

PATIENT RESULTS

Sample Characteristics

A total of 103 individual patients received 3% sodium chloride through PIV. The patient population was comprised of males (64.4%) and females (35.6%) between 18 and 88 years of age. Patients' admitting diagnoses included TBI (36.5%), ischemic stroke (16.3%), hyponatremia (9.6%), brain tumor (4.8%), subarachnoid hemorrhage (7.7%), intraparenchymal hemorrhage (23.1%), and seizure (1.9%; Table 3).

Peripheral Intravenous Access

Administration of 3% sodium chloride was initiated in the ED, OR, and ICU via dedicated PIVs and did not exceed 48 hr of infusion time. The majority of the catheters were placed in the antecubital (55.6%) and forearm (32.1%) regions. The PIVs gauge ranged from 14 gauge to 22 gauge, with the majority being 18–20 gauge (85%). One-time bolus administration of 3% sodium chloride comprised 56.3% of the reported cases, and 43.7% was infused continuously.

Adverse Events

Of the 103 patients observed, there were three (2.9%) identified AEs. Two were associated with continuous infusions,

Table 2. Clinician Practice Pearls Reference Sheet

Site selection	Upper extremities only (antecubital fossa to wrist)
Catheter type/size	• 18–22 gauge • Must flush smoothly with positive blood return
Existing PIV specifications	• No field start PIVs are to be used • Must be < 24 hours old
Monitoring	Q 2-hr site assessment by ICU RN
Maintenance	RN to notify ordering provider and pharmacy of suspected infiltration with or without thrombophlebitis immediately • Please also send email to one of clinical contacts listed below • Plan to transition to alternate PIV versus facilitate central access • Alternate option: temporarily run 2% at higher rate pending restoration of suitable access for 3%
Infusion specifications	• Rate max: 100 mL/hr • Bolus max: 100 mL (hyponatremia) or 250 mL (acute intracranial hypertension) • Total duration of infusion is 48 hr total, even if multiple PIVs are used • Goal correction is no more than 8–10 mEq/L in 24 hr (or per attending MD discretion)

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and one was associated with a bolus infusion (Table 4). The AEs were graded using the INS Infiltration and Phlebitis Scale. Two cases were grade 1 infiltrations that correlated with skin blanching, cold skin, and edema (1 to 6 inches in all directions). One case was identified as a grade 2 infiltration, that is, cold skin, blanching skin, edema 1 to 6 inches in all directions accompanied by grade 1 phlebitis (i.e., erythema with pain around the IV site). In each of these cases, 3% sodium chloride administration was transitioned to a newly inserted PIV and did not require further intervention.

DISCUSSION

An evidence-based quality improvement project was undertaken to develop a multidisciplinary protocol to implement a practice change to administer 3% sodium chloride through PIV. To our knowledge, this is the first study to describe a multidisciplinary protocol development and implementation process for the administration of 3% sodium chloride peripherally. In the context of predetermined guidelines for specific patient populations and with specific monitoring criteria, our results show a low rate of AEs. Our AE rate is lower than other published data (Dillon et al., 2018; Jones et al., 2017; Luu et al., 2011; Meng et al., 2018; Perez & Figueroa, 2017), and this may be related to the patient population studied or sequelae from implementing the protocol with stringent monitoring criteria.

Reluctance to accept published data to change hospital policies and protocols can be a significant hurdle in the fast-paced environments of the ICU, ED, and OR and has specific clinical implications. The administration of 3% sodium chloride may be restricted due to hospital policies and procedures related to the requirement of infusion via CVCs. Such a policy was prevalent at our institution and maybe elsewhere. Our study supports the short-term administration of 3% sodium chloride to manage neurocritical care emergencies and provide adequate time for clinicians to establish central access if prolonged use of 3% sodium chloride is warranted (Jones et al., 2017; Perez & Figueroa, 2017).

There are known complications associated with CVC insertion. Allowing 3% sodium chloride to be administered peripherally for a limited time frame permits the patient to receive time-sensitive treatment while reducing the need for the emergent placement of a CVC. Duration of infusion was a particularly difficult parameter to define. Given the association with increased risk of AE for more prolonged duration infusions of hyperosmolar drugs (Meng et al., 2018), the multidisciplinary team agreed upon 48 hr as a reasonable time frame to allow for treatment effects and for the clinician to safely obtain central access if further hyperosmolar therapies were indicated.

Garnering multidisciplinary stakeholders is an effective strategy for organizing and implementing successful practice changes. The practice of peripheral administration of 3% sodium chloride, though limited to certain acute cases, preceded institutional guidelines. As such, safely expanding this practice was brought through a pharmacy-led medication administration committee for input and final updates to medication-related supporting documents. Ultimately, the group could use a thorough review of the literature to provide evidence for this effective practice change. Nurses played a crucial role in implementing this protocol and were empowered to advocate for less-invasive techniques to achieve optimal care for their patients. Adequate notification and targeted education to all members of the healthcare team were required for successful implementation.

Table 3. Sample Characteristics

Age range (years)	19–88
Gender (%)	
Male	64.4
Female	35.6
Admitting diagnosis (%)	
Traumatic brain injury	36.5
Hyponatremia	9.6
Brain tumor	4.8
Non-traumatic subarachnoid haemorrhage	7.7
Intraparenchymal haemorrhage	23.1
Ischemic stroke	16.3
Seizure	1.9

Table 4. Summary Characteristics of Adverse Events

Gender	Age (years)	IV site	IV gauge	Total volume of infusion (mL)	Maximum rate of infusion (mL/hr)
Male	77	Right antecubital	18	250	250
Male	51	Right forearm	20	860	30
Male	37	Left forearm	18	500	100

Strengths and Limitations

Our project has certain strengths and limitations. Multidisciplinary stakeholder buy-in was crucial in the successful development and implementation of this protocol, and this may not be reproducible in all institutions. In addition, our protocol required fresh start PIVs, and a certain gauge of PIV was preferred. These are two important practical considerations that require nursing staff to insert new PIVs with specific parameters in critically ill patients. We did not collect data for cases where a PIV could not be established within our protocol guidelines. This could have potentially identified limitations in these aspects of our protocol. Although measures were taken to ensure all phlebitis and infiltration cases were identified, it is possible that the system may not have captured all events.

LINKING EVIDENCE TO ACTION

- This is the first study to describe a multidisciplinary protocol development and implementation process for the administration of 3% sodium chloride peripherally.
- Utilizing a multidisciplinary team is critical to the success of an EBP project.
- Implementing an evidence-based PIV protocol with stringent monitoring criteria for the administration of 3% sodium chloride has the potential to reduce AE related to CVC injury.

CONCLUSION

EBP provides clinicians with opportunities to implement practice changes with the goal of improving patient health (Kang, 2016). The IM-EBP provided a comprehensive foundation upon which to systematically create the structure and process for successfully developing and implementing this project. Developing a multidisciplinary team of clinician–researchers was paramount in our success. Each team member could critically evaluate existing research and clinical practice from their respective specialties and advocate for comprehensive implementation strategies in their respective departments. We suggest clinicians involved in the acute management of patients who require 3% sodium chloride administration to consider implementing a similar protocol.

Future studies should include tracking CVC placement in cases where the protocol parameters cannot be followed, extending the duration of administration time beyond 48 hr, broadening criteria to use PIVs in other locations, including all age groups, and increasing sample size.

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