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Administration of 3% Sodium Chloride Via a Peripheral Vein

A Literature Review

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ABSTRACT

Three percent sodium chloride (3% NaCl) is a hyperosmolar agent that can be lifesaving for patients with severe hyponatremic encephalopathy, traumatic brain injury, and cerebral edema. Until recently, many institutions restricted the infusion of 3% NaCl to a central venous site to avoid infusion related adverse events (IRAEs) in peripheral veins. A growing number of studies have reported relatively safe administration of 3% NaCl through a peripheral vein. The incidences of IRAEs were evaluated in 9 studies that included 837 patients who received 3% NaCl through a peripheral vein. Infusion reactions were either uncommon or no more frequent than with routine solutions. The authors provide guidelines for the administration of and monitoring for complications associated with 3% NaCl through a peripheral vein, discuss the management of symptomatic hyponatremia, and provide illustrative cases.

Key words: 3% NaCl, adverse event, catheterization, cerebral edema, encephalopathy, fluid therapy, hypertonic, hyponatremia, infusions, intravenous, peripheral, phlebitis, saline solutions, sodium chloride, vascular access devices

Until recently, many institutions restricted the infusion of 3% NaCl to a central vascular access device (CVAD) to avoid risk for phlebitis and tissue ischemia at a peripheral site.[1] However, in urgent situations, a growing number of studies have reported the administration of 3% NaCl with relative safety through a peripheral intravenous catheter (PIVC) when a CVAD is not already in place.[2-4] Because of this change in practice, nurses need to be familiar with guidelines for the safe administration of 3% NaCl in a peripheral site.

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PURPOSE

The purpose of this article is to describe situations in which it may be appropriate to administer 3% NaCl via a peripheral vein and review current recommendations for reducing risk for adverse events at a 3% NaCl peripheral infusion site while adhering to principles for safe management of symptomatic hyponatremia. We provide guidelines for the administration of and monitoring for complications associated with 3% NaCl through a peripheral vein, discuss the management of symptomatic hyponatremia, and provide illustrative cases.

METHOD

A systematic literature search was conducted in the PubMed, CINAHL Plus with Full Text, and Scopus databases in October 2020 to identify studies in which the incidence of infusion-related adverse events (IRAEs) were assessed during the peripheral administration of 3% NaCl.

A combination of key words and database-specific subject headings were used; search terms included: *hypertonic saline*, *3% NaCl*, *peripheral catheterization*, *peripheral vein*, *peripheral venous*, *peripheral intravenous*, *extravasation*, *phlebitis*, *infiltration*, *thrombosis*, and *adverse effects*. The searches were limited to English language. Reference lists of relevant articles were carefully reviewed for additional sources. Two reviewers independently examined the titles and abstracts of retrieved citations for inclusion, and discrepancies were resolved by

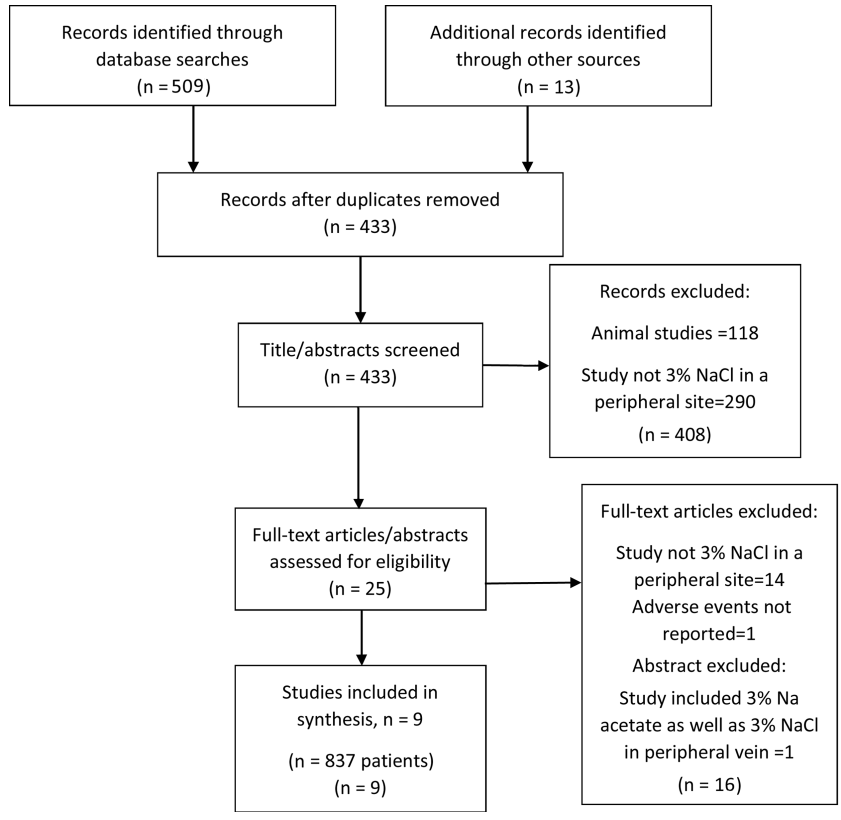

Figure 1 Flow diagram of search process.

consensus (Figure 1). Inclusion criteria were administration of 3% NaCl in a peripheral vein, reported incidence of IRAEs at infusion site, any age, and any setting. Animal studies were excluded.

RESULTS

Nine studies involving 837 patients who received 3% NaCl through a peripheral vein met the inclusion criteria and are summarized in Table 1.[2-10] Variables listed in the table include: type of study, number of patients, number of PIVCs, age, data collection site, catheter size, infusion sites, flow rates, duration of infusion, and scoring and incidence of IRAEs. Settings in which the studies took place included emergency departments (EDs), intensive care units, step-down units, general wards, and critical care transport.

Evidence Supporting Use of 3% NaCl in a Peripheral Vein

Of the 9 studies identified in the review, all included findings that support relative safety in infusing 3% NaCl via a peripheral vein.

Adults in Acute Care Facilities

Six of the 9 studies evaluated the relationship between IRAEs and the peripheral administration of 3% NaCl in adult patients cared for in acute care facilities.[2-6,10] One of the 6 studies was conducted prospectively in a single site and found no local infusion reactions in 64 cases in which 3% NaCl solution was administered via large-bore catheters in peripheral veins of severely hyponatremic patients.[5] Missing from the report was information about specific peripheral sites and criteria for detecting local infusion reactions. A second study was a multisite randomized controlled trial (RCT) conducted to compare the efficacy of rapid intermittent boluses versus slow continuous infusions of 3% NaCl in treating symptomatic hyponatremia.[10] Phlebitis was found in 2.2% of the 91 patients who received slow continuous infusions; none were found in the 87 who received rapid intermittent boluses. Three other studies reported similar incidences of IRAEs (6.1%, 7.0%, and 10.7%) and provide additional support for the safe administration of 3% NaCl in peripheral veins.[2-4] Dillon et al[2] reported a single-site, retrospective study in intensive care and step-down units; chart review of 66 patients revealed a 6.1% incidence of IRAEs. A retrospective, 2-site study reported by Jones et al[3] had a much larger sample size (213 patients) and found a 7% incidence of IRAEs (9 cases of phlebitis and 6 cases of extravasation). Perez and Figueroa[4] reported a quality improvement project that was conducted in a surgical intensive care unit (ICU) with a sample size of 28 patients; the purpose of the project was to assess the safety of administering 3% NaCl in a peripheral site at rates not exceeding 50 mL/h. Two patients experienced infiltration, and 1 developed thrombophlebitis; the investigators concluded that these were minor complications, and more serious complications could possibly occur with use of a CVAD. A prospective, observational study reported by Meng et al[6] evaluated the frequencies of phlebitis in 60 adult patients who received

TABLE 1

Incidence of Infusion-Related Adverse Events Associated With the Peripheral Infusion of 3% NaCl

Source	Type of study	No. of patients No. of PIVCs Age	Location	Catheter size	Infusion sites	Flow rate	Duration of infusion	Scoring of IRAE	IRAEs
Ayus et al, 2015[5]	Single-site prospective study	64 patients 71 PIVCs Mean age 68 y	Emergency department of a university hospital	Large-bore cannula (gauge not defined)	Peripheral vein	83 mL/h (500 mL 3% NaCl over 6 h)	6 h	"No local infusion reaction" Definitions and scoring of infusion reaction not provided	**0%** (0/64)
Baek et al, 2020[10]	Multicenter randomized controlled trial to compare efficacy of rapid intermittent bolus vs slow continuous infusions of 3% NaCl in treatment of hyponatremia	178 patients (175 received peripheral infusions only) (2 received mixed peripheral/central infusions) Age >18 y (mean ~73 y)	Emergency department, general ward	Not described	Not described	Based on severity of hyponatremia symptoms and treatment guidelines	Based on severity of hyponatremia symptoms and treatment guidelines	Not described	Phlebitis: **0%** (0/87) Rapid intermittent infusion group Phlebitis: **2.2%** (2/91) Slow continuous infusion group
Dillon et al, 2018[2]	Single-site retrospective chart review	66 patients 168 PIVCs Median age, 68 y	Neurosurgical ICU, 50% Medical step-down unit, 27% Medical ICU, 23%	≤20-gauge, 60% ≥22-gauge, 40% (most were 20 or 22 gauge)	Antecubital, 37% Forearm, 36% Hand, 25% Upper arm, 2% Foot, 0.6%	Median flow rate: 34 mL/h Range, 30-50 mL/h	Median 14 h	Infusion Nurses Society Infiltration Scale (range, 0-4) Phlebitis defined as redness, tenderness, swelling, or bruising requiring removal of PIVC.	**6.1%** (4/66) (Phlebitis and infiltration, n=2; Erythema, n=1; Edema, n=1)
Jones et al, 2016[3]	Retrospective chart review study at 2 academic medical centers to identify infusion-related reactions requiring intervention	213 total patients 157 (peripheral site only) 56 (switched from peripheral to central site) Median age, 59 y	Neurocritical care	16-gauge, 3.8% 18-gauge, 47.4% 20-gauge, 46.5% 22-gauge, 2.3%	Antecubital, 64.3% Forearm, 16.9% Hand, 10.3% Wrist 8.5%	Median 30 mL/h (maximum flow allowed at 1 hospital was 30 mL/h maximum was 75 mL/h at the second hospital)	Median 44 h for peripheral site only	Primary observation was for any infusion-related reaction requiring intervention One hospital used a visual phlebitis scale (not identified), a score >1 required removal of catheter - method used in second hospital not described	**7% (15/213)** Phlebitis (9/ 213) Extravasation (6/213).. Administration changed to a central catheter for 5 patients due to an infusion-related reaction
Perez and Figueroa, 2017[4]	Single-site quality improvement, prospective study	28 patients 34 PIVCs Mean age 39 y	Surgical ICU	16-20 gauge	Arm, 68% Hand, 18% Foot, 12% Ankle, 3%	30-50 mL/h	Median 36 h Range 1-124 h	Routine assessments for phlebitis, infiltration and thrombosis made by nurses and doctors during infusions. Scoring for assessments not described.	**10.7% (3/28)** Infiltration, n=2 Thrombophlebitis, n=1

(*continues*)

TABLE 1

Incidence of Infusion-Related Adverse Events Associated With the Peripheral Infusion of 3% NaCl (*Continued*)

Source	Type of study	No. of patients No. of PIVCs Age	Location	Catheter size	Infusion sites	Flow rate	Duration of infusion	Scoring of IRAE	IRAEs
Meng et al, 2018[6]	Single-site observational project to compare phlebitis among patients who received both 3% NaCl infusions and routine infusions through separate sites	60 patients 291 PIVCs Mean age, 61 y	Academic medical center 47% in ICU	16-24 gauge	Flexion site: 97 catheters Non-flexion site: 193 catheters	Mean flow rate 3% NaCl: 42 mL (range, 15-100 mL/h)	Rate of 3% NaCl infusions: Categorized as Low rate (≤30 mL/h or High rate (>30 mL/h)	Primary outcome was development of phlebitis (INS scale grade 1 or higher) Pharmacist assigned phlebitis severity scores, using Infusion Nurses Society definition and assessment descriptions made by nurses	In same 60 patients: 3% NaCl: **47% (28/60)** Routine care solutions: **43% (26/60)** % Catheters associated with phlebitis with infusion of 3% NaCl: 16-18 gauge, 35% 20-24 gauge, 29% % Catheters associated with phlebitis with infusion of routine fluids: 16-18 gauge, 30% 20-24 gauge, 19%
Brenkert et al, 2013[7]	Retrospective study	56 patients Infusion sites available for 53 children; of these, 87% of doses given by PIVC (n=46) Age range: 0-18 y Median age: 11.3 y	Pediatric emergency department	Described for one child: 2-month old infant received 3% NaCl via a 24-gauge catheter in the left hand	Described for one child: 2-month old infant received 3% NaCl via a 24-gauge catheter in the left hand	Median dose 4.1 mL/kg	Median time for administration 17 min About ¼ received dose in 10 min or less	Not described	**0% (0/46)** No evidence of adverse events in medical records
Luu et al, 2011[8]	Retrospective study	101 patients (97 received peripheral infusions) Age range: 2 months to 17 y Mean age: 5.9 y Mean weight: 27.6 kg	Critical care transport	Not described	Peripheral sites not described	Bolus ranged from 1.2 to 24 mL/kg (mean 5.3 mL/kg)	Duration of initial infusion ranged from 9 to 180 min (mean 47 min)	Not described	**0% (0/97)** No infusion related reactions were recorded
Mesghali et al, 2019[9]	Retrospective cohort study to compare the incidence of extravasation related to 3% NaCl and mannitol infusions	192 adult and pediatric patients 85 patients received 3% NaCl 107 patients received mannitol	Emergency department	Not described	Not described	Not described	Not described	Extravasation defined as administration of solution into surrounding tissues (no scoring provided) Secondary outcomes included severity of infusion-related injury per Infusion Nurses Society definitions Data obtained from progress notes	**0% (0/85) extravasation in 3% NaCl Group** **0% (0/107) extravasation in Mannitol Group** Because health care professional notes were used, investigators were unable to determine whether extravasation or other IRAEs occurred but was not documented

Abbreviations: ICU, intensive care unit; IRAE, infusion related adverse event; NaCl, sodium chloride; PIVC, peripheral intravenous catheter.

infusions of 3% NaCl through a PIVC, as well as infusions of routine care solutions through separate PIVCs. No significant difference was found in the incidence of phlebitis associated with 3% NaCl (47%) and routine care fluids (43%; $P = .19$). In the same study, phlebitis occurred more often when the infusion rate of 3% NaCl exceeded 30 mL/h. It is difficult to compare findings from the studies due to occasional missing data, as well as variability in device sizes, peripheral infusion sites, and flow rates. For example, device sizes ranged from 16- to 24-gauge, and infusion sites varied from the arm to the ankle or foot. In the Dillon et al[2] study, in which the incidence of IRAEs was 6.1%, the locations of PIVCs were predominantly in large veins. Large-diameter veins allow for greater blood flow, which facilitates rapid distribution of the hypertonic solution, subsequently minimizing the duration of contact with the vascular epithelium, minimizing rapid osmotic shifts or tissue damage.

Children in Pediatric ED or During Critical Care Transport

Two of the 9 studies identified in the review included only children. As shown in Table 1, a retrospective study reported by Brenkert et al[7] included 56 children (ranging in age from 0 to 18 years) who received 3% NaCl in an ED in the setting of traumatic brain injury, diabetic ketoacidosis, and hyponatremia with and without seizures. Infusion sites were determined for 53 of the 56 children; of these, 87% ($n = 46$) were in a peripheral site. None of the patients exhibited signs of phlebitis or local tissue injury. Missing from the report was criteria for detecting local infusion reactions. Size of the PIVC was not available in the majority of the children. A 2-month-old infant received an infusion of 3% NaCl via a 24-gauge catheter in the left hand reportedly without complication. The second pediatric study included in Table 1 was a retrospective report of 101 children (mean age of 5.9 years and mean weight of 27.6 kg), who received 3% NaCl during critical care transport as treatment for suspected cerebral edema, intracranial bleed with edema, or symptomatic hyponatremia.[8] A peripheral site was used for 97 of the 101 children; no infusion-related reactions were reported locally or systemically. However, criteria for detecting local infusion reactions were not described. The duration of the initial infusion ranged from 9 to 180 minutes (mean = 47 minutes). The bolus amount ranged from 14 to 600 mL of 3% NaCl (mean = 5.3 mL/kg). The investigators commented that the obvious significance of this finding is that use of a peripheral site during transport allowed for quick implementation of a potentially beneficial treatment.

Adults and Children in ED

As shown in Table 1, a retrospective, single-center cohort study of 192 adult and pediatric patients was undertaken to compare the incidence of extravasation in patients who received 3% NaCl versus mannitol in a peripheral vein to manage elevated intracranial pressure.[9] Of the 192 patients, 85 received 3% NaCl and 107 received mannitol. Unfortunately, no information was provided about specific peripheral infusion sites or device sizes. *Extravasation*, the primary outcome, was defined as administration of solution into the surrounding tissue instead of the intended peripheral vascular pathway. A secondary outcome was severity of infusion-related injury per the definitions found in the 2016 edition of the Infusion Nurses Society's (INS') *Infusion Therapy Standards of Practice* (the *Standards*).[11] The results were gathered from progress notes in the electronic health record. No reports of extravasation were found in either group; however, the investigators stated that extravasation or other IRAEs may have occurred but were not documented. Authors of the study stated that clinicians should reconsider recommendations to restrict 3% NaCl or mannitol to a central line.

A study of adults treated for hyponatremia at a high-endurance exercise event was excluded from Table 1 due to lack of information about the incidence of IRAEs. These events can lead to serious and even fatal hyponatremia (referred to as exercise-associated hyponatremia [EAH]). Because of this, it is important to have emergency treatment on hand at these events when possible. A study was conducted at the Western States Endurance Run in California to determine whether asymptomatic EAH in ultramarathon runners could be corrected with either orally or intravenously administered 3% NaCl.[12] While 14 runners were found to have EAH, only 8 agreed to participate in the study; 5 were randomly assigned to receive 100 mL of 3% NaCl in a peripheral vein, and 3 were randomly assigned to drink the same volume of 3% NaCl. Sixty minutes after the administration of the solution, only those who received 3% NaCl intravenously had a significant elevation in their serum sodium concentrations (mean elevation from 130.8 to 134.6 mmol/L). Because EAH is an acute condition, athletes presenting with this condition can be treated with hypertonic saline without risk of osmotic demyelination.

Evidence That Does Not Support Use of 3% NaCl in a Peripheral Vein

No studies were identified that reported unacceptable incidences of IRAEs associated with the peripheral infusion of 3% NaCl. According to the nutrition literature, parenteral nutrition with an osmolarity >900 mOsm/L is associated with increased risk for phlebitis when delivered peripherally.[13] Because the osmolarity of 3% NaCl (1026 mOsm/L) exceeds this level, it is also thought to present an increased risk for phlebitis in a peripheral vein.

Technical Aspects of Administering 3% Sodium Chloride Peripherally

Infusion Site

A 3% NaCl solution should be delivered through a CVAD if one is already in place. However, in the absence of a CVAD, several small studies suggest that 3% NaCl can be administered safely via a peripheral vein when urgent treatment is necessary.[2-4] Use of the largest accessible vein with good

blood flow (preferably in an upper extremity) may reduce the risk for phlebitis by allowing dilution of the infused hypertonic solution. During the infusion, frequent assessments for phlebitis and infiltration should be performed. In situations where repeated infusions of 3% NaCl over days is anticipated, placement of a CVAD should be considered. While the possibility of phlebitis is a concern, it is far less significant than is the potential for neurologic complication due to delayed treatment for hyponatremic encephalopathy. Regardless of whether 3% NaCl is administered via a central or a peripheral vein, patients with severely symptomatic hyponatremia should be cared for in an environment where close clinical monitoring can be provided during the infusion.[14]

Peripheral Device Size

As noted in Table 1, 16- and 18-gauge devices were often used to administer 3% NaCl in a peripheral vein.[2-4,6] However, the rationale for this practice was not provided and is contrary to the practice criteria in the *Standards*.[11] Large-bore devices (eg, ≥18-gauge diameter) are typically recommended for the administration of viscous substances or for rapid infusion of fluids to treat hypovolemia. Hypertonic saline is not a viscous fluid, and the volumes used to treat hyponatremia do not require rapid administration.

While physicians prescribe intravenous fluids to be administered via a peripheral site, it is typically a nursing responsibility to select the device size to deliver the prescribed therapy. INS[11] and the Royal College of Nurses[15] recommend selecting the smallest-gauge catheter to accommodate the prescribed therapy and patient need. A small-gauge catheter results in less trauma to the vessel, promotes proper hemodilution of the infusate, and allows adequate blood flow around the catheter wall.[16] Using a large-bore device (eg, ≥18-gauge) without a clear rationale is questionable since it may increase the risk for phlebitis due to mechanical irritation of the vein. It is helpful to consider the following information provided in the *Standards*.[11]

- "Consider a 20 to 24-gauge catheter for most infusion therapy. Peripheral catheters larger than 20-gauge are more likely to cause phlebitis."[11(pS51)]
- "Consider a 22- to 24-gauge catheter for neonates, pediatric patients, and older adults to minimize insertion related trauma."[11(pS51)]
- "Consider a larger-gauge catheter (16- to 20-gauge) when rapid fluid replacement is required, such as with trauma patients."[11(pS51)]

A 2011 guideline for the prevention of intravascular catheter-related infections recommends "selecting catheters on the basis of the intended purpose and duration of use, known infectious and non-infectious complications (such as phlebitis and infiltration) and experience of the individual catheter operator."[17(p1088)] This recommendation is significant since there is probable increased risk for phlebitis when a large-bore device is used. For example, a multivariate analysis of data from an RCT that included over 3000 adult medical–surgical patients with over 5000 PIVCs showed that phlebitis risk increased with having an 18-gauge or larger diameter catheter.[18] Other investigators have reported that the incidence of phlebitis is higher in patients with 18-gauge or larger diameter devices.[19,20] In contrast, there are studies where investigators found no significant relationship between catheter size and phlebitis.[21,22]

A summary of technical considerations for peripheral infusion of 3% sodium chloride is presented in Table 2.

Monitoring for Neurologic Changes

Regardless of the infusion site (central or peripheral), the most important assessments during the administration of 3% NaCl are neurologic signs, serum sodium concentrations, and fluid status. A summary of factors to consider when monitoring for responses to the infusion of 3% sodium chloride is presented in Table 3.

Treatment Considerations Related to Administering 3% NaCl

Administration of 3% NaCl is primarily indicated to treat symptomatic hyponatremia. The severity of neurologic symptoms is the primary determinant of rapidity and magnitude of correction of hyponatremia, more so than the degree or duration of hyponatremia.[14] While hyponatremic encephalopathy primarily

TABLE 2

Technical Considerations for Peripheral Infusion of 3% NaCl

Site of administration	• 3% NaCl should be administered through a CVAD if one is already in place. • In the absence of a CVAD, multiple studies suggest it is safe to administer 3% NaCl in a peripheral vein to treat severe hyponatremia in situations in which a delay in therapy could result in neurologic complications.[2-10]
Peripheral venous site	• Select the largest accessible vein (preferably in an upper extremity) to reduce risk for phlebitis. • Avoid placing the device in a flexion site if possible.
Size of device	• The *Infusion Therapy Standards of Practice* recommends selecting the smallest-gauge catheter that will accommodate the prescribed therapy.[11]
Monitoring infusion site	• Monitor IV site for redness, swelling or tenderness, and ask the patient to report any pain.[11]
Infusion pump	• Administer the fluid with infusion pump to assure the correct flow rate.

Abbreviation: CVAD, central vascular access device; NaCl, sodium chloride.

TABLE 3

Monitoring Patient Responses to Infusion of 3% NaCl

Setting	• Patients treated with 3% NaCl for severe symptomatic hyponatremia should be cared for in an environment where close clinical monitoring can be provided during the infusion.[14]
Serum sodium levels	• Serum sodium levels should be measured at designated intervals during the infusion of 3% NaCl. ◦ Ensure that laboratory personnel draw blood specimens on time. ◦ Ensure that the treating physician is made aware of laboratory results in a timely fashion.
Neurological status	• Neurologic status should be monitored at regular intervals during infusion of 3% NaCl ◦ Compare neurologic findings at baseline with serial observations of neurological function. ◦ If neurologic function worsens during treatment, the possibility of overcorrection of serum sodium levels should be considered. ◦ Report changes promptly to the treating physician.
Pulmonary edema	• Monitor for pulmonary edema, especially in patients with a history of cardiac or renal disease ◦ Auscultate lungs for crackles. ◦ Observe for decreases in pulse oximetry. ◦ Perform chest radiographs to assist in the detection of pulmonary edema during long-term infusions of 3% NaCl.
Fluid balance	• Monitor hourly fluid intake and output.

occurs in severe (Na <125 mmol/L) and acute hyponatremia (<48 hours), there are numerous risk factors for developing hyponatremic encephalopathy, including females of reproductive age, children <16 years of age, hypoxemia, and underlying central nervous system disease, where hyponatremic encephalopathy can develop at milder levels or with chronic hyponatremia.[23] These risk factors either impair brain cell volume regulation or decrease intracranial capacity for brain expansion. Presenting symptoms of hyponatremic encephalopathy include headache, nausea and vomiting, lethargy, and confusion with more advanced symptoms being seizures, coma, and respiratory distress from apnea or pulmonary edema. The goal of therapy is to increase the serum sodium by approximately 5 mmol/L to acutely decrease brain swelling and reverse neurologic symptoms. This can be accomplished by either repeated intermittent boluses or continuous infusions. Bolus therapy has the advantage of a more rapid controlled increase in serum sodium with less risk of overcorrection[24] and is currently the recommended therapy by consensus panels.[14] A potential complication from administering 3% NaCl is cerebral demyelination resulting from the overcorrection of hyponatremia. This is a rare complication that is primarily seen in individuals with severe (≤115 mmol/L) and chronic (≥48 hours) hyponatremia who have additional risk factors for developing demyelination, such as alcoholism, severe liver disease, malnutrition, and hypokalemia.[25,26] Consensus guidelines recommend a safe limit of correction of serum sodium of 10 mmol/L within the first 24 hours and 18 mmol/L within the first 48 hours, acknowledging that high-risk patients can develop demyelination even with careful correction.[14]

Dosage Variations/Expected Increase in Serum Sodium Level According to Treatment

Administration of 1 mL/kg of 3% NaCl will generally increase the serum sodium by 1 mmol/L. Guidelines for the treatment of symptomatic hyponatremia recommend a 2-mL/kg bolus of 3% NaCl given over 10 minutes with 1 to 2 repeated doses to achieve an increase in serum sodium of 4–6 mmol/L acutely to reverse brain swelling.[14,24] Alternatively, hypertonic saline can be administered as a slow continuous infusion with a goal of increasing the serum sodium by 0.5 and 1.0 mEq/h.[5,27] Studies have demonstrated that approximately 500 mL of 3% NaCl is required to treat hyponatremic encephalopathy in adults.[5,27] The increase in serum sodium levels that results from 3% NaCl administration is largely related to the renal response to therapy, with larger corrections due to a free water diuresis and lesser corrections due to a natriuresis. For this reason, formulas calculating the correction of hyponatremia are only helpful as an initial guide to therapy and cannot be relied on to predict the magnitude of correction. The amount of hypertonic saline administered will need to be titrated and individualized for each patient. For this reason, periodic checks of serum sodium concentrations are required. An important nursing responsibility is to assure that laboratory results are promptly reported to the treating physician.

ILLUSTRATIVE CASE STUDIES

Below are 4 illustrative cases where the administration of 3% NaCl through a PIVC to treat hyponatremia would be the appropriate therapy and where controversy could occur among nursing, physicians, or pharmacy, relating to the route of administration. The first 2 cases are examples of hyponatremic encephalopathy where bolus therapy with 3% NaCl is indicated, and the second 2 cases are examples where a continuous infusion of 3% NaCl is indicated to correct hyponatremia more gradually.

Case No. 1: Bolus 3% NaCl for Acute-Hospital Acquired Hyponatremic Encephalopathy

A 16-year-old female with von Willebrand disease had undergone surgery for a cleft lip and palate repair. She had

received desmopressin and 5% dextrose in 0.45% NaCl. Following surgery, she developed postoperative nausea and vomiting, followed by headache, confusion, combativeness, and lethargy. The serum sodium was 120 mmol/L. An order of 500 mL of 3% NaCl was delivered to the bedside with 100 mL to be administered urgently, as the patient was at risk for impending herniation with respiratory arrest and seizures. The nursing staff would not administer the 3% NaCl through a PIVC on the unit as they believed it was unsafe. The physician administered 3 consecutive 100-mL boluses of 3% NaCl manually. During the bolus administration, the patient progressively became more lucid and alert. A follow-up sodium was 126 mmol/L, and within a few hours she was completely awake and alert.

Case Study No. 2: Bolus 3% NaCl for Marathon-Associated Hyponatremic Encephalopathy

A 23-year-old obtunded and intubated female presented to the ED by emergency medical services. She had completed the local marathon earlier in the day and was found by her roommate unconscious and unresponsive 4 hours after completing the marathon. On arrival to the ED she was hypoxemic, with an oxygen saturation of 90%, had pulmonary edema on chest x-ray, and a serum sodium level of 124 mmol/L. The ED physician recognized that she had noncardiogenic pulmonary edema as a complication of marathon-associated hyponatremia and wanted to administer a bolus of 3% NaCl. The physician was told that 3% NaCl could not be administered through a peripheral site in the ED. A 1000-mL bolus of 0.9% NaCl was administered, and the patient subsequently developed a generalized tonic-clonic seizure followed by cardiac arrest. A repeat serum sodium was 119 mmol/L and the patient expired. Administration of 0.9% NaCl can aggravate hyponatremia in the presence of elevated antidiuretic hormone and is contraindicated for the treatment of hyponatremic encephalopathy.[28] In this case, failure to treat hyponatremic encephalopathy with 3% NaCl through a PIVC resulted in a poor outcome.

Case Study No. 3: Continuous Infusion of 3% NaCl for Brain Edema

A 78-year-old male with prostate cancer that was complicated by disseminated intravascular coagulation developed an intracranial hemorrhage. Emergency surgery was unsuccessful, and the patient was expected to expire within a matter of days. The neurosurgeon approached the family to obtain consent for a CVAD to administer a slow continuous infusion of 3% NaCl to control brain edema, as the serum sodium was 131 mmol/L. The family requested that it be administered through a peripheral site. The neurosurgeon thought that it was against hospital policy, though, at the family's request, the pharmacy was contacted and the pharmacy policy did allow 3% NaCl as a continuous infusion through a peripheral IV site at a rate of up to 30 mL/h. A slow continuous infusion of 3% NaCl was administered to keep the serum sodium above 140 mmol/L, and there were no complications associated with the infusion.

Case Study No. 4: A Short-Term Continuous Infusion of 3% NaCl to Correct Chronic Hyponatremia

A 3-year-old child with severe neurologic impairment from holoprosencephaly and a seizure disorder managed with oxcarbazepine was admitted with pneumonia and serum sodium 128 mmol/L. Over the course of the admission, the serum sodium decreased to 123 mmol/L. The child was neurologically stable on the acute care unit and was not in need of a transfer to the ICU. The child was unable to take oral therapy for the correction of hyponatremia, such as sodium chloride, urea, or a V2 receptor antagonist, and the child did not have a gastrostomy tube or feeding tube. The consulting nephrologist recommended a 1 mL/kg/h infusion of 3% NaCl over 5 hours to correct the serum sodium to 128 mmol/L. Nursing and pharmacy did not believe that the peripheral administration of 3% NaCl was allowed in an acute care unit. The pharmacy director did allow it, and the serum sodium corrected uneventfully to 128 mmol/L following the 5-hour infusion.

LIMITATIONS

Only 9 studies were identified in the literature search, sample sizes varied, and data were not consistently available for important variables as shown in Table 1. Most of the studies relied on retrospective reviews of medical/nursing records to identify IRAEs; therefore, it is possible that other adverse events occurred that were not documented. Definitions of phlebitis and infiltration, as well as scoring of their severity, were often missing. Despite promising results in the reviewed studies, larger controlled prospective studies with consistent definitions and scoring of IRAEs are recommended to better assess the risk of administering 3% NaCl through a peripheral vein.

CONCLUSIONS

When a CVAD is already in place, 3% NaCl should be administered centrally. In the absence of a CVAD, multiple small studies provide support for using the peripheral route to infuse 3% NaCl when urgent treatment is needed to prevent neurologic complications. Settings in which peripheral infusions of 3% NaCl have been used include: EDs, ICUs, step-down units, general wards, critical care transport, and community sports events. If prolonged or repeated infusion of 3% NaCl is anticipated over days, placement of a CVAD should be considered. While the possibility of an IRAE is concerning, it is far less significant than the potential for neurologic complication due to delayed urgent therapy for severe hyponatremia. Frequent assessments for phlebitis

and infiltration should be performed during the infusion, as well as frequent monitoring of the patient's neurologic status, serum sodium concentrations, and fluid status. Significant changes should be promptly reported to the treating physician.

Basing practice on the most currently available evidence is critical to improving patient outcomes. Typically, hospital policies are formulated by an interdisciplinary committee based on literature reviews, as well as current guidelines from practice organizations. Since hospital policies may differ, nurses should review institutional policies before participating in the administration of 3% NaCl. Finally, additional well-designed studies with adequate sample sizes and consistent definitions of IRAEs are needed to better assess the risk of administering 3% NaCl through a peripheral vein.

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