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Safety of Administration of Hypertonic Sodium Chloride Solution Through Peripheral IV in Neuroscience Intensive Care Unit, KAMC, Makkah

Shafi M. Akbar[1] & Muath M. Ali[1]

[1] Nursing Administration, King Abdullah Medical City, Makkah, Saudi Arabia

Correspondence: Shafi M. Akbar, Nursing Administration, King Abdullah Medical City, Makkah, Saudi Arabia.

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Abstract

Background: Infusions of 3% sodium chloride are routinely recommended to be given through central venous catheters, not peripheral IV lines. In addition, no data are available on the proper site for administration of a continuous intravenous infusion of 3% sodium chloride solution in adults. Some recent studies have illustrated that this theory may not be relevant, and that 3% sodium chloride may be safe for administration in peripheral IV lines**.** ***Aims and Objectives:*** To evaluate the incidence of infusion-related reactions in neuro intensive care patients treated with continuous intravenous infusion of hypertonic sodium chloride up to 3% solution via peripheral IV catheter. ***Methods:*** Data on patients treated with continuous intravenous infusion of hypertonic sodium chloride up to 3% solution through peripheral IV cannula for at least 24 hours at neuroscience intensive care unit were evaluated by using prospective observational design to determine the complications in administration site such as phlebitis, infiltration, extravasation, thrombosis and line infection. ***Results:*** Out of 43 patients with peripheral hypertonic saline infusion (up to 3%), no incidence of complications were reported after 24 hours of continuous infusion. Out of 34 patients who continued their infusion to second day, one incidence of phlebitis and 2 incidences of extravasation were reported. 20 patients were on continuous infusion towards day 3, where also one incidence of phlebitis and 2incidencese of extravasation were reported. Overall complications reported in all 97 peripheral hypertonic saline infusion days were 2 incidence of phlebitis and 4incidences of extravasation. ***Conclusion:*** Current recommendations that a central catheter is required for continuous intravenous infusion of hypertonic sodium chloride up to 3% should be reconsidered. Only a few patients who had peripheral infusions had infusion-related complications. Peripheral intravenous administration of hypertonic saline can be used safely and effectively in patients without a central line.

Keywords: sodium chloride 3%, peripheral administration, safety, hypertonic saline

1. Introduction

It is typically advised to administer hypertonic saline infusions like 3 % or 2% sodium chloride solutions using central venous catheter rather than peripheral IV lines. This recommendation is based on the idea that infusions such as 3 % sodium chloride has an osmolality that is more than 900 mOsm/L, it puts the patient at risk for thrombophlebitis, tissue necrosis, and extravasation reactions. (https://www.rxlist.com/hypertonic-saline-drug.htm)

Furthermore, there is not much evidence on where in an adult to administer a continuous intravenous infusion of hypertonic sodium chloride solution. Recent research has shown that 3 % sodium chloride may be safe for administration in peripheral IV lines. Extravasation, phlebitis, tissue ischemia, and venous thrombosis could be

potential safety issues with the peripheral delivery of a continuous intravenous infusion of a 3% sodium chloride solution. (https://www.rxlist.com/hypertonic-saline drug.htm)

Numerous neurological injuries are associated with cerebral edema and increased intracranial pressure that can be effectively treated with various concentrations of hypertonic saline. (G. F. Strandvik, 2009) In the emergency room (ER), mannitol and hypertonic saline are routinely used to treat increased intracranial pressure (ICP). (Mesghali, E., & Moussavi, K., 2019). In order to properly treat hyponatremia and neurocritical damage, it is important to take into account the safety issues surrounding peripheral intravenous delivery of hypertonic solutions. (A. O. Alenazi, 2021).

A hospital policy modification that permitted the delivery of 3% sodium chloride via 16- to 20-gauge peripheral IVs to a maximum infusion rate of 50 mL/hr in patients lacking central venous access was evaluated for safety in a single-center prospective research involving 28 patients. Infiltration, erythema, edema, phlebitis, thrombosis, and line infection were all evaluated in patients. Overall, patients received infusions of 3 percent sodium chloride at rates of 30 to 50 mL/hr for periods ranging from 1 to 124 hours. Complication rates were 10.7% with Infiltration (2 patients) which occurred in 6% of cases, and thrombophlebitis (1 patient), which occurred in 3% of cases. (Perez, C., & Figueroa, S., 2017)

15 (7%) of 213 patients who received peripheral continuous intravenous infusions of 3% sodium chloride solution in a retrospective two-center study experienced infusion-related complications. Only 5 of the 56 patients (26.3%) who had their administration switched to a central catheter because of an infusion-related reaction. The majority of patients (73.7 %; 157 patients) underwent peripheral therapy for a median of 44 hours, 3 minutes. Hyperchloremia (49.3% of patients) and hypokalemia (46.9%) were the most typical electrolyte abnormalities. The maximal peripheral infusion rate at one institution was 30 mL/hr, while it was 75 mL/hr at the other (Jones, G. M., et, al., 2017).

Together, these results suggest that patients without existing central venous access benefit from receiving hypertonic saline up to 3% through peripheral IV line. On demand of timely administration, sodium chloride 3% is frequently administered using peripheral IV catheters in clinical practice. It is time to reassess the current guidelines that state a central venous catheter is necessary for a continuous intravenous infusion of hypertonic saline such as 2% or 3% sodium chloride solutions. The study's intention was to influence hospital policy such that patients without central venous access could receive hypertonic sodium chloride solutions up to 3 % using 16- to 20-gauge peripheral IV cannula. This study's objective was to test the safety of administering hypertonic sodium chloride up to 3 % via peripheral venous route.

2. Aim of the Study

The Aim of this study was to evaluate the safety of administration of hypertonic sodium chloride solution up to 3% through peripheral IV in Neuroscience ICU in KAMC. This aim can be achieved through following objectives:

1) To assess the incidence of infusion related complications;
2) To reduce the complication related to continuous administration of hypertonic sodium chloride up to 3%.

3. Subjects and Methods

3.1 Research Design, Setting, and Participants

This study used a prospective observational design. All patients receiving an infusion of hypertonic sodium chloride up to 3% at the KAMC Neuroscience Intensive Care Unit were included in the study's population.

3.2 Sample Size

The sample was chosen using a simple random sampling method. Patients admitted to the Neuroscience ICU who were receiving an infusion of hypertonic sodium chloride up to 3% through a peripheral line for at least 24 hours or longer met the inclusion criteria. The exclusion criteria included patients who were with existing peripheral IV related complications, patients who were with existing risk for peripheral IV related complications other than IV infusions and patients who were with infusion of hypertonic sodium chloride through central line. The sample size included 43 patients with infusion of 2 % or 3 % hypertonic sodium chloride through peripheral IV line.

3.3 Tool of Data Collection

Three parts of data were gathered utilizing data collection tools: Patient demographic information, including age, gender, height, weight, Glasgow coma scale (GCS), neurological injury, length of stay, and medical history, is presented in Part 1 of the data. Part 2: Contain Information related to infusion of hypertonic sodium chloride such as concentration, infusion rate (ml/hr.), peripheral administration site, peripheral IV needle gauge, and duration of infusions. Part 3: Contain patient observation checklist for peripheral IV related complications such

as Phlebitis, Infiltration, Extravasation, Thrombosis and Line infections.

4. Ethical Considerations

IRB approval was obtained from the KAMC research center, letter 21-774, dated 08/04/2021. Study activities started after obtaining approval from IRB. Research objective and information component detailing research data were included in the study to ascertain their collaboration under ethical consideration. In the study, participants were not identified. The participant's anonymity and confidentiality were preserved in this way by the researcher.

5. Data Collection

After getting official permission from the IRB, the investigator selected the sample as per inclusion criteria. The investigator checked up on the patient who was receiving hypertonic sodium chloride solution up to 3% via peripheral IV. Age, sex, height, weight, GCS, neurological injury, length of stay, and medical history were among the data collected. Data on concentration of sodium chloride in hypertonic saline solution, infusion rate (ml/hr.), peripheral administration site, peripheral IV needle gauge, and infusion duration were also collected. The following complications associated with infusions were observed: Phlebitis, Infiltration, Extravasation, Thrombosis and Line infections.

6. Statistical Analysis

The collected data was quantitatively examined. Multiple data sets were analyzed using the SPSS 25 model to draw out important trends and statistics. Demographic information about the participants was examined using descriptive statistics. Discrete variables were reported using counts and percentages, while continuous variables using the mean, median, range and standard deviation.

7. Results

7.1 Demographic Data

Table 1 reveals that 20 (46.5%) patients were male and 23 (53.5%) patients were female across the 43 samples. Majority of all sample patients were diagnosed as having Subarachnoid Hemorrhage which was 22 in number (51.2%) and the remaining neurological conditions consist of diagnosis including Intracerebral hemorrhage 9 (20.9 %) Brain neoplasm 5 (11.6 %), Intraventricular hemorrhage 4 (9.3 %), Ischemic stroke 3 (7 %), Brain stem stroke 2 (4.7 %), Brain abscess 1 (2.3 %), Epilepsy 1 (2.3 %) and Hyponatremia 1 (2.3 %). Around half out of 43 patients, more accurately 22 patients (51.2 %) were not having any kind of underlying illness. Whereas 16 (37.2 %) patients were hypertensive, 14(32.6 %) were diabetic. Two patients (4.7%) had known ischemic heart disease, two (4.7%) had chronic kidney disease, two (4.7%) had an old stroke, one patient (2.3%) had renal impairment and one (2.3%) was suffering from Systemic lupus erythematosus.

Table 1. Sociodemographic and general characteristics of the study population (n=43)

Variables	Categories	Frequency	Percentage
Gender	Female	23	53.5
	Male	20	46.5
Neurological Injury	Subarachnoid Hemorrhage	22	51.2
	Intracerebral Hemorrhage	9	20.9
	Brain neoplasm	5	11.6
	Intraventricular Hemorrhage	4	9.3
	Ischemic Stroke	3	7
	Brain stem stroke	2	4.7
	Brain abscess	1	2.3
	Epilepsy	1	2.3
	Hyponatremia	1	2.3
Medical History	Nil	22	51.2
	Hypertension	16	37.2
	Diabetes Mellitus	14	32.6
	Ischemic Heart Disease	2	4.7

	Chronic Kidney Disease	2	4.7
	Old Stroke	2	4.7
	Renal impairment	1	2.3
	Systemic Lupus Erythematosus	1	2.3

Table 2 illustrates that the mean age, height, weight, Glasgow Coma Scale and length of stay in the Neuroscience Intensive Care Unit. The Mean age for the patients were 53.77 and mean height was 163.95-cm. Mean weight was around 75 kg (75.47) with mean GCS of 11 on 15. Mean of length of stay in Neuroscience Intensive Care Unit was 14.65 days.

Table 2. Mean, Standard deviation, Median and Range of general characteristics of the study population (n=43)

Variables	**Mean**	**SD**	**Median**	**Range**
Age (Years)	53.77	18.67	55	81
Height (cm)	163.95	8.72	165	30
Weight (kg)	75.47	13.52	80	57
Glasgow Coma Scale	11.09	4.41	12	12
Length of stay (day)	14.65	5.24	15	22

7.2 Hypertonic Saline Infusion Related Data

Figure 1: The number of peripheral lines receiving continuous infusions of hypertonic saline is shown in Figure 1 for each day. Through a newly inserted peripheral line, 43 patients were receiving hypertonic saline (2% or 3% sodium chloride). On the second day of treatment, the infusion was halted for nine of those patients. 34 patients so continued receiving infusions on day 2. Only 20 patients kept receiving their infusion on day 3; all other patients' treatments were stopped due to clinical reason of improvement.

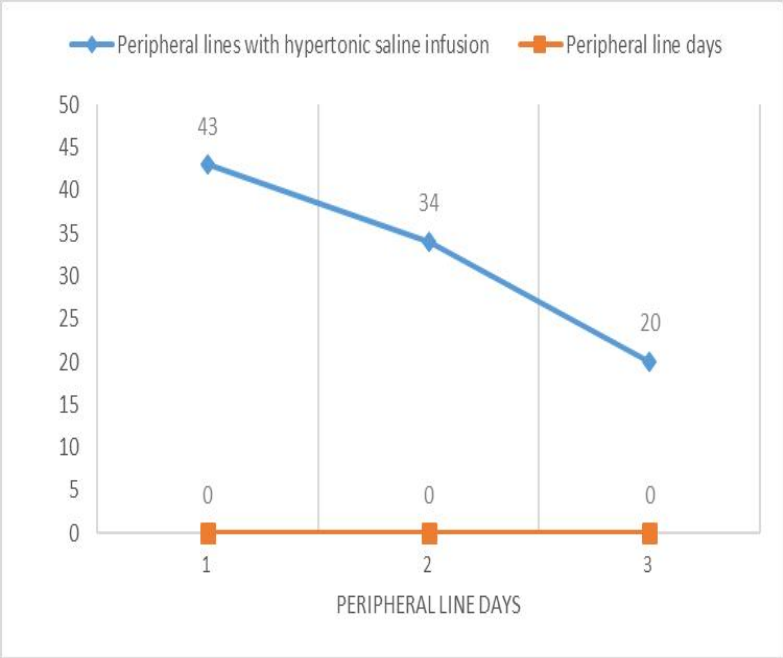

Figure 1. Hypertonic saline infusion through peripheral lines in each day

Figure 2 shows that 22 patients out of 43 were treated with 2 % Sodium chloride that is 51% of all cases and 21 (49%) patients were on 3% Sodium chloride infusion.

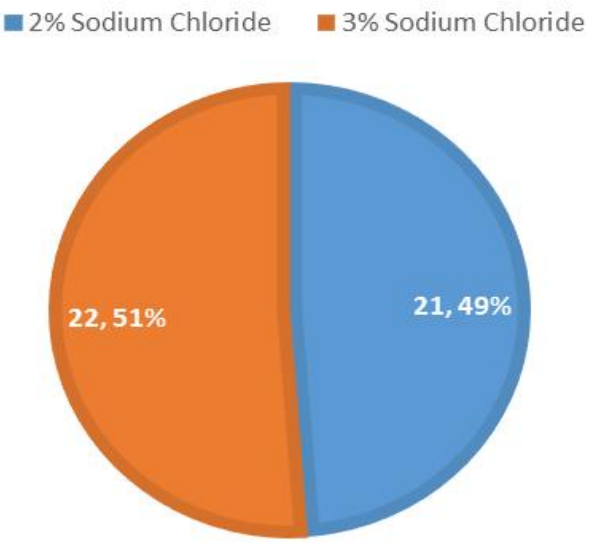

Figure 2. Sodium Chloride Concentration

Figure 3: The peripheral veins where the IV cannulas were inserted are shown in Figure 3 as well. Peripheral lines were accessed to every patient in the forearm veins. Access was through the cephalic vein in 15 patients, that is 34.9% of total. 14 (32.6%) patients to get their hypertonic saline infusion used the basilic venous route. Seven patients each received access through the median cubital vein and the palmar venous arch (16.3 %). None of the patients received infusions through brachial or antecubital access.

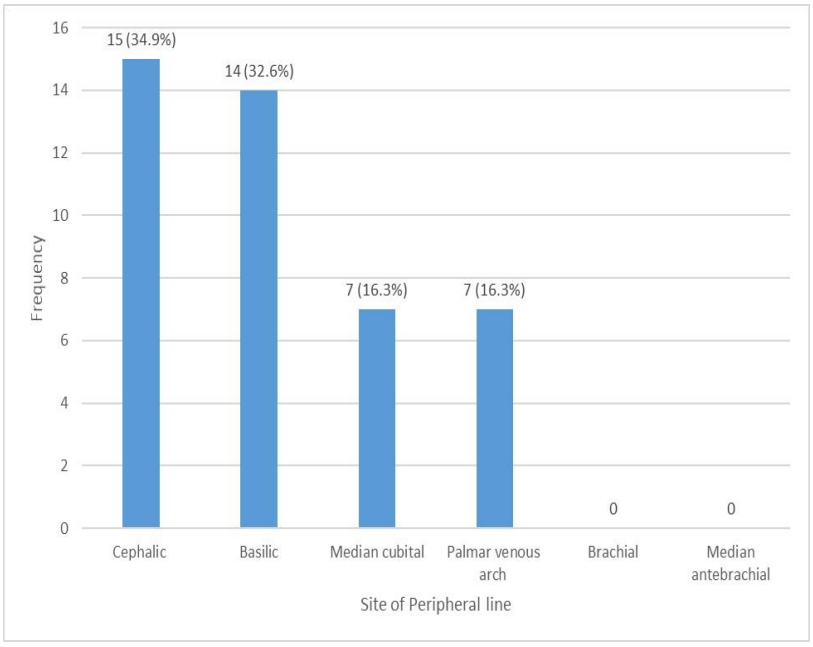

Figure 3. Site of Peripheral line

Figure 4: The size of the IV cannula used for peripheral infusion of hypertonic saline is depicted in Figure 4. Only 18 and 20 Gauge IV cannulas were used in this investigation to provide peripheral IV access. A total of 24 patients, or around 55.8%, received their hypertonic saline infusion with an 18-Gauge IV cannula. 20- Gauge IV cannulas were used to treat 19 (44.2%) patients.

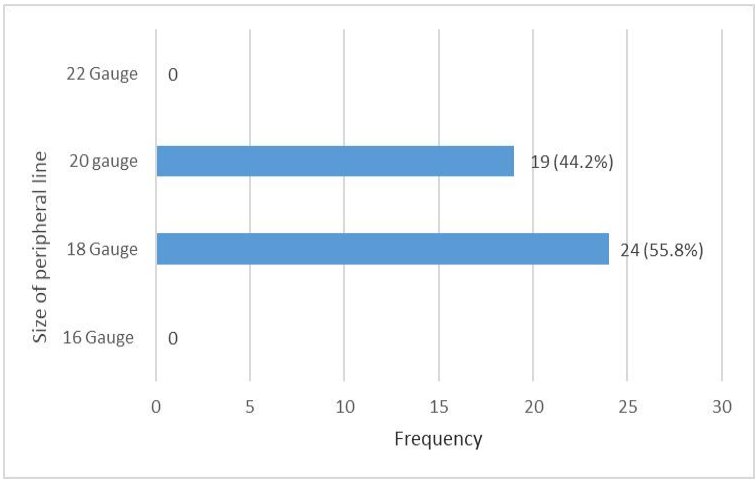

Figure 4. Size of Peripheral line

Table 3 of section 2 represents the rate and duration of hypertonic saline infusion. Mean rate was 52.56 ml/ hour and the mean duration was 52.42 Hours.

Table 3. Rate and duration of hypertonic saline infusion

Variables	Mean	SD	Median	Range
Rate (ml/hour)	52.56	16.16	50	70
Duration of infusion (Hours)	52.42	22.13	48	68

7.3 Peripheral Infusion Related Complications

Table 4: The complications associated with administering hypertonic saline through peripheral lines are listed in Table 4. During the administration of hypertonic saline, all patients were assessed for five major peripheral infusion-related complications. Phlebitis, infiltration, extravasation, thrombosis, and line infection were all complications that were being observed. Every single day of the hypertonic saline infusion, each patient was evaluated. 43 patients were receiving hypertonic saline infusions through peripheral lines on day 1; none of them experienced any complications linked to the infusions. On day 2, 34 patients continued their treatment while 9 of the 43 patients finished their hypertonic saline therapy.

One patient developed symptoms of inflammation at the site of the IV cannula on day 2, which was classified as phlebitis (2.3 %), and there were two cases of extravasation (4.7 %). All patients were managed clinically, and treatment terminated through that particular peripheral lines. 20 patients continued their treatment until day 3, where the remaining patients finished their treatment at the end of day 2 of their hypertonic saline infusion. Additionally, on day 3, two cases of extravasation (4.7 %) were observed, and one patient displayed symptoms of phlebitis (2.3 %) at the site of the IV cannula.

Table 4. Hypertonic saline peripheral infusion related complications

Day 1					
Peripheral lines with hypertonic saline infusion	**Variable**	**Yes**		**No**	
		Frequency	**%**	**Frequency**	**%**
43	Phlebitis	0	0	43	100
	Infiltration	0	0	43	100
	Extravasation	0	0	43	100
	Thrombosis	0	0	43	100
	Line Infection	0	0	43	100
Day 2					

Peripheral lines with hypertonic saline infusion	Variable	Yes		No	
		Frequency	%	Frequency	%
34	Phlebitis	1	2.3	33	76.7
	Infiltration	0	0	34	79.1
	Extravasation	2	4.7	32	74.4
	Thrombosis	0	0	34	79.1
	Line Infection	0	0	34	79.1
Day 3					
Peripheral lines with hypertonic saline infusion	**Variable**	**Yes**		**No**	
		Frequency	**%**	**Frequency**	**%**
20	Phlebitis	1	2.3	19	44.2
	Infiltration	0	0	20	46.5
	Extravasation	2	4.7	18	41.9
	Thrombosis	0	0	20	46.5
	Line Infection	0	0	20	46.5

8. Discussion

It is typically advised to administer IV infusions of hypertonic saline such as 3% or 2% sodium chloride using central venous catheter rather than peripheral IV lines. Theoretically, administering a continuous 3% sodium chloride solution to adults via peripheral intravenous catheters poses a risk of infiltration, thrombophlebitis, tissue ischemia, and venous thrombosis (Perez & Figueroa, 2017). Therefore, it is crucial to assess the safety of peripheral IV administration of hypertonic sodium chloride solution. Therefore, this study aims to assess the incidence of infusion related complications and to reduce the complication related to continuous administration of hypertonic sodium chloride solution up to 3% through peripheral IV in Neuroscience Intensive Care Unit, King Abdullah Medical City, Makkah. The findings are divided into key parts for discussion to achieve the study's goal.

The complications caused by administering hypertonic saline up to 3% through peripheral lines were identified in the current investigation. During the delivery of hypertonic saline, all patients were assessed for five major peripheral infusion-related complications. Phlebitis, infiltration, extravasation, thrombosis, and line infection were all complications that were being monitored. Each patient had a daily evaluation during the hypertonic saline infusion.

No hypertonic saline infusion related complications were observed in day 1. One patient developed symptoms of inflammation at the location of the IV cannula on day 2, which was identified as phlebitis, and there were two cases of extravasation. All patients were managed clinically, and treatment terminated through that particular peripheral IV lines. On day 3, two cases of extravasation were observed, and one patient had symptoms of phlebitis at the site of the IV cannula. Previous studies reported the findings that the documented complications included infiltration and thrombophlebitis and rate of complications observed among some subjects. (Ca & Sa, 2017). Another finding reported in an observational study that phlebitis occurred during infusions of 3 % sodium chloride through peripheral line (Meng et al., 2018; Dillon et al., 2018)

The complications associated with administering hypertonic saline solutions such as 2% or 3% sodium chloride via peripheral IV were found to be minimal in this study's findings. It has also been found in earlier studies that the adverse events associated with infusion and the electrolyte abnormalities brought on by administering 3 percent hypertonic saline through a peripheral intravenous catheter were insignificant. (Meng et al., 2018; Alenazi et al., 2021). According to one of the study's findings, only a small number of patients who had peripheral infusions of 3% sodium chloride solution experienced complications. (Perez & Figueroa, 2017; Jones et al., 2016)

Current study recommend that peripheral lines can be used for continuous intravenous infusion of hypertonic sodium chloride solution up to 3%. Only a few patients who had peripheral infusions experienced complications due to the infusion. The need for a central catheter for a continuous intravenous infusion of a 3 % sodium chloride solution should be reevaluated, according to earlier investigations (Lv & Zhang, 2020). (Mesghali et al., 2019). A rising number of studies have noted that administering 3 % NaCl through a peripheral vein is generally

safe (Metany & Moritz, 2021)

9. Conclusion

Hyponatremia-causing complications are highly frequent in critical care, particularly in neuro critical care. Hypertonic sodium chloride solutions, such as 2% and 3% sodium chloride, are used to treat many of these patients. Generally, those patients are hemodynamically stable and current guideline to insert central venous catheter exclusively for hypertonic saline administration produces greater unfavorable impact in terms of central line associated complications such as injuries, pneumothorax, barotrauma and blood stream or other infections. Health care professionals have long debated whether to place a central venous catheter just for the administration of hypertonic saline.

The complications associated with peripheral administration of hypertonic saline were only reported in a small number of patients in this study, specifically 2 incidences of phlebitis and 4 incidences of extravasation. This study evaluated 43 patients receiving sodium chloride infusions of 2% or 3% for longer than 24 hours. The majority of hypertonic saline treatments last 24 to 48 hours and the complication rate for first two days were much lesser.

The study shown that hypertonic saline up to 3% can be administered through peripheral IV line safely and successfully, hence the current recommendation of administering hypertonic saline up to 3% through central line should be reevaluated.

10. Implications and Recommendations

The findings of this study offer a persuasive argument for changing the current recommendation that hypertonic saline only be administered through a central venous catheter. Current institutional policy also supports the insertion of central venous catheters for hemodynamically stable patients only to administer 2% or 3% sodium chloride. According to the study's findings, it is safe and efficient to administer hypertonic saline up to 3 % through a peripheral IV line.

According to the study, institutional policies should be amended to accommodate for the effective administration of hypertonic saline up to 3 % through peripheral IV lines. This will also aid in preventing complications for patients related to central venous catheters caused by unnecessary placement of central venous catheters and, ultimately, facilitate patients' quick recovery.

This study's contribution will aid in the implementation of modifications to protocols and policies and can provide guidelines for the administration of hypertonic saline up to 3 % through peripheral line in patients without any other indications of insertion of a central venous catheter. Central venous catheters that are placed unnecessarily carry a higher risk of complications than advantages.

11. Limitations of the Study

This research had some restrictions. It was done in a single unit. As a result, there is a chance to carry out a significant study to emphasize the outcome. Second, notwithstanding the low research participation rate, careful consideration should be given to the interpretation. Finally, yet importantly, this study suffered from a scarcity of samples that met the inclusion criteria. Obtaining enough samples to finish the data collection took a year.

References

Alenazi, A. O., Alhalimi, Z. M., Almatar, M. H., & Alhajji, T. A. (2021). Safety of Peripheral Administration of 3% Hypertonic Saline in Critically Ill Patients: A Literature Review. *Critical Care Nurse, 41*(1), 25–30. https://doi.org/10.4037/ccn2021400.

Bodoky, A., Zbinden, A., Müller, J., & Leutenegger, A. (1980). [Peripheral venous tolerance of hyperosmolar infusion solutions]. *Helvetica Chirurgica Acta, 47*(1–2), 151–156.

Brenkert, T. E., Estrada, C. M., McMorrow, S. P., & Abramo, T. J. (2013). Intravenous hypertonic saline use in the pediatric emergency department. *Pediatric Emergency Care, 29*(1), 71–73. https://doi.org/10.1097/PEC.0b013e31827b54c3.

Ca, P., & Sa, F. (2017). Complication Rates of 3% Hypertonic Saline Infusion Through Peripheral Intravenous Access. *The Journal of Neuroscience Nursing: Journal of the American Association of Neuroscience Nurses, 49*(3).

Dillon, R. C., Merchan, C., Altshuler, D., & Papadopoulos, J. (2018). Incidence of Adverse Events During Peripheral Administration of Sodium Chloride 3. *Journal of Intensive Care Medicine, 33*(1), 48–53. https://doi.org/10.1177/0885066617702590

Pharmacy Joe, (2019, January 28). Episode 368: Can 3% (hypertonic) sodium chloride be given through a peripheral IV?

https://www.pharmacyjoe.com/can-3-hypertonic-sodium-chloride-be-given-through-a-peripheral-iv/.

Hauer, E.-M., Stark, D., Staykov, D., Steigleder, T., Schwab, S., & Bardutzky, J. (2011). Early continuous hypertonic saline infusion in patients with severe cerebrovascular disease. *Critical Care Medicine, 39*(7), 1766–1772. https://doi.org/10.1097/CCM.0b013e318218a390.

RxList, (n.d.). Hypertonic Saline (3% and 5% Sodium Chloride Injection): Uses, Dosage, Side Effects, Interactions, Warning. Retrieved March 1, 2021, from https://www.rxlist.com/hypertonic-saline-drug.htm.

Jannotta, G. E., Gulek, B. G., Dempsey, J. S., Blissitt, P. A., Sullivan, H. C., Tran, K., Joffe, A., & Lele, A. V. (2021). Administration of 3% Sodium Chloride Through Peripheral Intravenous Access: Development and Implementation of a Protocol for Clinical Practice. *Worldviews on Evidence-Based Nursing, 18*(2), 147–153. https://doi.org/10.1111/wvn.12501.

Jones, G. M., Bode, L., Riha, H., & Erdman, M. J. (2016). Safety of Continuous Peripheral Infusion of 3% Sodium Chloride Solution in Neurocritical Care Patients. *American Journal of Critical Care: An Official Publication, American Association of Critical-Care Nurses, 26*(1), 37–42. https://doi.org/10.4037/ajcc2017439.

Jones, G. M., Bode, L., Riha, H., & Erdman, M. J. (2017). Safety of Continuous Peripheral Infusion of 3% Sodium Chloride Solution in Neurocritical Care Patients. *American Journal of Critical Care, 26*(1), 37–42. https://doi.org/10.4037/ajcc2017439.

Luu, J. L., Wendtland, C. L., Gross, M. F., Mirza, F., Zouros, A., Zimmerman, G. J., Barcega, B., & Abd-Allah, S. A. (2011). Three-percent saline administration during pediatric critical care transport. *Pediatric Emergency Care, 27*(12), 1113–1117. https://doi.org/10.1097/PEC.0b013e31823aff59.

Lv, L., & Zhang, J. (2020). The incidence and risk of infusion phlebitis with peripheral intravenous catheters: A meta-analysis. *The Journal of Vascular Access, 21*(3), 342–349. https://doi.org/10.1177/1129729819877323.

Meng, L., Nguyen, C. M., Patel, S., Mlynash, M., & Caulfield, A. F. (2018). Association between continuous peripheral i.v. Infusion of 3% sodium chloride injection and phlebitis in adults. *American Journal of Health-System Pharmacy: AJHP: Official Journal of the American Society of Health-System Pharmacists, 75*(5), 284–291. https://doi.org/10.2146/ajhp161028.

Mesghali, E., Fitter, S., Bahjri, K., & Moussavi, K. (2019). Safety of Peripheral Line Administration of 3% Hypertonic Saline and Mannitol in the Emergency Department. *The Journal of Emergency Medicine, 56*(4), 431–436. https://doi.org/10.1016/j.jemermed.2018.12.046.

Metheny, N. A., & Moritz, M. L. (2021). Administration of 3% Sodium Chloride Via a Peripheral Vein: A Literature Review. *Journal of Infusion Nursing, 44*(2), 94–102. https://doi.org/10.1097/NAN.0000000000000420.

Moussavi, K., & Mesghali, E. (2019). 767: safety of peripheral line administration of 3% hypertonic saline and mannitol in the ed. *Critical Care Medicine, 47*(1), 362. https://doi.org/10.1097/01.ccm.0000551516.45863.c7.

Perez, C. A., & Figueroa, S. A. (2017). Complication Rates of 3% Hypertonic Saline Infusion Through Peripheral Intravenous Access. *The Journal of Neuroscience Nursing: Journal of the American Association of Neuroscience Nurses, 49*(3), 191–195. https://doi.org/10.1097/JNN.0000000000000286.

Perez, C., & Figueroa, S. (2017). Complication Rates of 3% Hypertonic Saline Infusion through Peripheral Intravenous Access. *Journal of Neuroscience Nursing, 49*(3), 191–195. https://doi.org/10.1097/JNN.0000000000000286.

Strandvik, G. F. (2009). Hypertonic saline in critical care: A review of the literature and guidelines for use in hypotensive states and raised intracranial pressure. *Anaesthesia, 64*(9), 990–1003. https://doi.org/10.1111/j.1365-2044.2009.05986.x.

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