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Prospective study of post-operative hyponatremia in patients undergoing lower-limb orthopedic surgery

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ABSTRACT

Background: Hyponatremia is a common electrolyte imbalance in hospitalized patients, including those undergoing orthopedic surgery. It is associated with increased mortality and morbidity. Early symptoms of hyponatremia are often vague and can be mistaken for normal post-operative sequelae. Therefore, it is important to be aware of hyponatremia's risk factors and symptoms in post-operative orthopedic patients, especially in older patients. **Aims and Objectives:** The aims and objectives are to study the incidence of post-operative hyponatremia in patients undergoing lower-limb orthopedic surgery. **Materials and Methods**: This prospective observational study was done on 140 elective and emergency lower-limb surgery patients. The patients were divided into two groups based on their age. Group A comprised 70 patients under 65, and Group B comprised 70 patients over 65. The patients underwent pre-operative assessments, including complete physical and systemic examinations and routine pre-operative workups, including checking serum sodium and potassium levels. **Results**: In a study of 140 post-operative orthopedic patients, 55 (39%) had low serum sodium levels on post-operative day 1. Of these, 46 had mild hyponatremia, 7 had moderate hyponatremia, and 2 had severe hyponatremia. Elderly patients were more likely to develop hyponatremia than younger patients (27% vs. 12%, P=0.003). The most common symptoms of hyponatremia were headache (8.6%), nausea (3.6%), lethargy (7.1%), confusion (6.4%), and disorientation (1.4%). Hyponatremic patients had longer hospital stays than normal patients (13 days vs. 5–11 days). **Conclusion**: The elderly population had a higher incidence of post-operative hyponatremia and was more vulnerable to developing symptoms. Although hyponatremia following surgery is common after orthopedic surgeries, it is primary, temporary, and easily treatable.

Key words: Fluid balance; Orthopedic surgery; Post-operative complication; Sodium; Hyponatremia

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INTRODUCTION

Electrolytes play a major role in maintaining homeostasis in our body. Hyponatremia is the most typical electrolyte imbalance seen in hospitalized patients. The main cation in the extracellular fluid is sodium, and complex homeostatic systems regulate sodium levels. Patients undergoing orthopedic surgery are susceptible to hyponatremia, a frequent electrolyte imbalance that occurs post-operatively in roughly 30% of orthopedic procedures.[1]

Patients with cardiovascular disease, cancer patients with metastatic disease, and people undergoing orthopedic surgery are most likely to have a link between hyponatremia and mortality.[2] A higher risk of 30-day death is linked to both hyponatremia and hypernatremia.[3]

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Compared to normonatremic patients, this could lead to a longer hospital stay, raising the patient's financial burden.[3,4] Hyponatremia is frequently mistaken for post-operative sequelae in post-operative orthopedic patients because it presents vague symptoms.[5,6] Hyponatremia so frequently goes undiagnosed and untreated. Early symptoms are frequently ignored or considered typical post-operative side effects, increasing morbidity and death. Hyponatremia is easily treated. Thus, early diagnosis and treatment of hyponatremia prevent terrible side effects.

After any surgical operation, post-operative hyponatremia and related consequences are frequent in older patients. One-third of all hospitalized patients are older people. Patients aged 65 and older tend to stay in hospitals longer and have surgery rates 2–3 times greater than younger adults. Orthopedic wards contain the highest proportion of elderly patients among surgical units. Following orthopedic surgeries, hyponatremia and accompanying morbidity are strongly correlated. It is so because hyponatremia's initial symptoms are ambiguous and moderate, but if not treated, they can escalate to serious neurological disorders and even result in patient death.[3-6]

Although hyponatremia is frequently reported after orthopedic procedures, most of these investigations were retrospective. To our knowledge, no prospective studies have been conducted to determine the incidence of post-operative orthopedic injuries in the Indian context. Regionalized studies are required to evaluate the disease burden and to perform the proper preventive and therapeutic actions for post-operative hyponatremia due to the variations in surgical and anesthetic procedures between nations. The current study assessed the post-operative serum sodium level change, estimated the incidence of post-operative hyponatremia (POH) in patients undergoing major orthopedic procedures, and assessed risk factors.

Aims and objectives

The aims and objectives are to study POH incidence and outcome in patients undergoing lower-limb orthopedic surgery.

Primary objective

The primary objective is to determine the incidence of POH within 24 and 48 h after lower-limb orthopedic surgery.

Secondary objective

The secondary objective is to assess the association between POH and two key clinical outcomes: duration of hospital stay and complications.

MATERIALS AND METHODS

This prospective observational study was conducted at Government Vellore Medical College and Hospital, Vellore, from May 2018 to July 2019 on 140 patients undergoing elective and emergency lower-limb surgeries.

Inclusion criteria

ASA physical status I and II, patients aged between 21 and 80, and patients with diabetes mellitus and hypertension were included in the study.

Exclusion criteria

ASA III and IV, age <20 and >80 years, pregnant and lactating women, patients with low sodium values per-operatively, patients with head trauma, and patients on medications such as thiazides, selective serotonin reuptake inhibitors, angiotensin-converting enzyme inhibitors, and angiotensin receptor blockers were excluded from the study.

The patients were randomly selected and divided into two groups based on their age. Group A comprised patients under 65, and Group B comprised patients over 65.

The patients underwent pre-operative assessments, including complete physical and systemic examinations and routine pre-operative workups, including checking serum sodium and potassium levels. Upon arrival in the operation theatre, baseline pulse rate, blood pressure, and oxygen saturation measurements were documented. Standard monitoring equipment was applied, including continuous pulse oximetry, ECG, and non-invasive blood pressure (NIBP) monitoring. The surgery was conducted under regional anesthesia, and oxygen was administered at 4–6 L/min through a face mask.

Heart rate, NIBP, and oxygen saturation were systematically recorded at 5-min intervals throughout the intraoperative procedure. Additionally, patients received an intravenous infusion of isotonic Ringer lactate solution at a rate of 100 mL/h. A standard intravenous fluid regimen was followed for post-operative care after the surgery.

The following observations were made post-operatively: The GCS score was regularly assessed to monitor the patient's level of consciousness. The patient was closely monitored for any symptoms of hyponatremia, such as nausea, headaches, confusion, or seizures. Serum sodium and potassium levels were checked 24 and 48 h after the surgery to assess the patient's electrolyte balance.

Statistical analysis

The data were analyzed using the Statistical Package for the Social Sciences (SPSS) version 20.0. Data were presented as frequency and percentage for categorical variables and mean and standard deviation (SD) for continuous variables. Chi-square analysis was used to examine categorical variables. An independent sample t-test was used to compare continuous variables. A 95% confidence level and a P=0.05 were used to determine statistical significance.

RESULTS

Among the 140 patients, 80 were male and 60 were female. They were not equally distributed according to sex. Among the age groups, an equal population distribution was taken, and 70 patients were in each group. The total number of patients who underwent below-hip surgery was 66, below-knee 65, and below-ankle 9 (Table 1).

Of the 140 patients, 12 (8.6%) presented with headache symptoms, five (3.6%) presented with nausea, nine patients (6.4%) presented with symptoms of confusion, two patients (1.4%) were disoriented during the post-operative period, and ten (7%) had lethargy (Table 1).

Pre-operative normonatremia patients alone were taken. During post-operative day 1, among 140 patients, 55 had low serum sodium levels of varying severity. Forty-six patients presented with mild hyponatremia, 7 with moderate hyponatremia, and 2 with severe hyponatremia.

Following the correction of hyponatremia on post-operative day 1, the number of patients presented with mild hyponatremia was 17 and moderate hyponatremia was 3. The study population with normal serum sodium levels was 120 (86%) (Table 2).

Pre-operative sodium was normal, and the mean value was 139.58 mEq/L. On post-operative day 1, the mean sodium level was 134.9 mEq/L. On post-operative day 2, the mean sodium concentration was 137 mEq/L, which shows significance with a P<0.001 (Table 3).

On post-operative day 1, among 70 patients in the age group <65 years, 53 had normal sodium levels, 15 had mild hyponatremia, and 2 had moderate hyponatremia. In the age group >65, 32 patients were normonatremic, 31 had mild hyponatremia, 5 had moderate hyponatremia, and 2 had severe hyponatremia. Elderly patients had a higher incidence of hyponatremia than young adult patients, which shows a significant statistically with a P=0.003.

On post-operative day 2, among 70 patients in the young adult group, three patients had mild hyponatremia, and in the elderly group, 14 patients had mild and three patients had moderate hyponatremia. The senior population was more prone to hyponatremia. Three patients had moderate hyponatremia, with 100% in the elderly age group, which is statistically significant at P<0.005.

Both sexes had equal numbers of patients with mild and moderate hyponatremia except severe hyponatremia, and this is statistically insignificant among the sexes, as the P=0.199.

On post-operative day 2, all moderate hyponatremia patients were males, which shows no statistical significance (P=0.140). The type and level of surgery are statistically insignificant on post-operative days 1 and 2 (Table 4).

Comparing symptoms between post-operative day 1 in 46 mild hyponatremic patients, most are asymptomatic, but 7 had symptoms of lethargy, 6 had headaches, 3 presented with nausea, and 2 had confusion. In 7

Table 1: Demographic data of the study

Variables	Frequency	Percentage
Sex		
Male	80	57.1
Female	60	42.9
Age group		
<65 years	70	50
>65 years	70	50
Type of surgery		
Below hip	66	47.1
Below knee	65	46.4
Below ankle	9	6.4
Symptoms		
Headache		
No	128	91.4
Yes	12	8.6
Nausea		
No	135	96.4
Yes	5	3.6
Confusion		
No	131	93.6
Yes	9	6.4
Disoriented		
No	138	98.6
Yes	2	1.4
Lethargy		
No	130	92.9
Yes	10	7.1

Table 2: Pre- and post-operative sodium level

Variables	Frequency	Percentage
Pre-operative sodium level		
Normal	140	100
Post-operative day 1 sodium level		
Normal	85	60.7
Mild	46	32.9
Moderate	7	5
Severe	2	1.4
Post-operative day 2 sodium level		
Normal	120	85.7
Mild	17	12.1
Moderate	3	2.1

moderate hyponatremic patients, 3 had lethargy, 5 had headaches and confusion, and 2 had nausea as their symptoms. Severe hyponatremia patients had symptoms such as headaches, confusion, and disorientation. The majority of symptomatic patients belonged to the elderly age group.

Patients with lethargy, headache, nausea, confusion, and disorientation significantly differ in sodium levels. None of the patients had developed seizures or dreadful complications like coma (Table 5).

Comparing symptoms between post-operative day 2, out of 17 patients with mild hyponatremia, 5 had lethargic symptoms, 7 had headache, 6 had confusion, and 3 had nausea. Of the three moderate hyponatremia patients, one had lethargy, one a had headache, and 3 presented with confusion. Two patients with moderate hyponatremia experienced disorientation.

Patients with lethargy, headache, nausea, confusion, and disorientation significantly differ in sodium levels. None of the patients had developed seizures or dreadful complications like coma (Table 6).

Normal patients had hospital stays of at least 5 days to a maximum of 11 days. Hyponatremic patients had a maximum stay of 13 days. A minimum number of hospital stays depends on the severity of hyponatremia, with mild, moderate, and severe having 5, 8, and 9 days, respectively. This is significant statistically, as hyponatremic patients had prolonged hospital stays (P<0.001) (Table 7).

DISCUSSION

The most common electrolyte disorder is hyponatremia, and its frequency rises with age. When the serum sodium level is <135 mEq/L, hyponatremia is diagnosed. Clinically, hyponatremia may be hypovolemic, euvolemic, or hypervolemic. The main causes of hyponatremia in post-operative orthopedic patients are blood loss and surgical stress. Hypovolemia and blood loss cause the release of AVP, which boosts renal water reabsorption. AVP is stimulated by trauma, surgical stress, pain, fever, and painkillers. This non-osmotic, non-hypovolemic stimulus is termed SIADH. As a result of perioperative fluid treatment, fluid excess can also result in hyponatremia.[6-8]

Due to decreasing body water, hyponatremia is more prevalent in elderly individuals. Even little alterations in the body's fluid balance can significantly impact salt and osmolality homeostasis. Sodium levels of 130 mEq/L typically result in the majority of patients being asymptomatic or exhibiting mild, ambiguous symptoms. The severity and rate of hyponatremia development affect the symptoms.[6,7,9] In <48 h, acute symptoms of hyponatremia begin to appear. The brain is the organ that is most vulnerable to hyponatremia. The brain cell typically needs a few days to adjust to the hypotonic state. Most patients with chronic hyponatremia do not exhibit any symptoms. Patients with acute severe hyponatremia exhibit various symptoms of the central nervous system, including fatigue, headaches, nausea, vomiting, confusion, seizures, obtundation or coma, cerebral herniation, and respiratory problems.[1,2,9]

Table 3: Mean pre- and post-operative sodium level

Sodium	Mean	Std. Deviation	95% Confidence interval		P-value
			Lower bound	Upper bound	
Pre-operative	139.579	2.189	139.213	139.944	<0.001
Post-operative day 1	134.979	4.123	134.29	135.668	
Post- operative day 2	137.243	2.866	136.764	137.722	

Table 4: Comparison of demographic data between post-operative sodium level

Variables	Post-operative day 1 sodium level					Post-operative day 2 sodium level			
	Normal (%)	Mild (%)	Moderate (%)	Severe (%)	P-value	Normal (%)	Mild (%)	Moderate (%)	P-value
Age group									
<65 years	53 (62.4)	15 (32.6)	2 (28.6)	0	0.003	67 (55.8)	3 (17.6)	0	<0.005
>65 years	32 (37.6)	31 (67.4)	5 (71.4)	2 (100)		53 (44.2)	14 (82.4)	3 (100)	
Sex									
Male	53 (62.4)	22 (47.8)	3 (42.9)	2 (100)	0.199	65 (54.2)	12 (70.6)	3 (100)	0.140
Female	32 (37.6)	24 (52.2)	4 (57.1)	0		55 (45.8)	5 (29.4)	0	
Type of surgery									
Below hip	36 (42.4)	24 (52.2)	6 (85.7)	0	0.226	53 (44.2)	12 (70.6)	1 (33.3)	0.263
Below knee	42 (49.4)	20 (43.5)	1 (14.3)	2 (100)		58 (48.3)	5 (29.4)	2 (66.7)	
Below ankle	7 (8.2)	2 (4.3)	0	0		9 (7.5)	0	0	

Table 5: Symptoms between post-operative day 1 sodium level

Variables	Post-operative day 1 sodium level				
	Normal (%)	Mild (%)	Moderate (%)	Severe (%)	P-value
Lethargy					
No	85 (100)	39 (84.8)	4 (57.1)	2 (100)	<0.001
Yes	0	7 (15.2)	3 (42.9)	0	
Headache					
No	85 (100)	40 (87)	2 (28.6)	1 (50)	<0.001
Yes	0	6 (13)	5 (71.4)	1 (50)	
Nausea					
No	85 (100)	43 (93.5)	5 (71.4)	2 (100)	<0.001
Yes	0	3 (6.5)	2 (28.6)	0	
Confusion					
No	85 (100)	44 (95.7)	2 (28.6)	0	<0.001
Yes	0	2 (4.3)	5 (71.4)	2 (100)	
Disoriented					
No	85 (100)	46 (100)	7 (100)	0	<0.001
Yes	0	0	0	2 (100)	
Seizures					
No	85 (100)	46 (100)	7 (100)	2 (100)	-
Yes	0	0	0	0	
Coma					
No	85 (100)	46 (100)	7 (100)	2 (100)	-
Yes	0	0	0	0	

Table 6: Symptoms between post-operative day 2 sodium level

Variables	Post-operative day 2 sodium level			
	Normal (%)	Mild (%)	Severe (%)	P-value
Lethargy				
No	116 (96.7)	12 (70.6)	2 (66.7)	<0.001
Yes	4 (3.3)	5 (29.4)	1 (33.3)	
Headache				
No	116 (96.7)	10 (58.8)	2 (66.7)	<0.001
Yes	4 (3.3)	7 (41.2)	1 (33.3)	
Nausea				
No	118 (98.3)	14 (82.4)	3 (100)	<0.001
Yes	2 (1.7)	3 (17.6)	0	
Confusion				
No	120 (100)	11 (64.7)	0	<0.001
Yes	0	6 (35.3)	3 (100)	
Disoriented				
No	120 (100)	17 (100)	1 (33.3)	<0.001
Yes	0	0	2 (66.7)	
Seizures				
No	120 (100)	17 (100)	3 (100)	-
Yes	0	0	0	
Coma				
No	120 (100)	17 (100)	3 (100)	-
Yes	0	0	0	

Hyponatremia is frequently present in orthopedic surgical patients. Treatment of hyponatremia is simple. Understanding the mechanism and early recognition of symptoms is paramount to avoiding dreadful complications.[2,9,10] In the study by Sah, out of 392 hip and knee arthroplasties, 155 (40%) presented with hyponatremia. Among them, 127 were mild cases, 22 were moderate, and six were severe cases of hyponatremia. Hyponatremia occurred mostly in POD-1. Hyponatremia was more common in women (P<0.048) and the elderly (P<0.0001). Knee arthroplasty patients were more prone than hip arthroplasty patients P<0.04. Post-operative nausea was significant number P<0.01. The length of hospital stay is prolonged in hyponatremic patients with knee arthroplasty P<0.02.[11]

In the study by Mujtaba et al., the mean age group for the development of post-operative hyponatremia was 58.179±16.95 years, and the mean age group for normal sodium level was 37.54±19.21 years, which was statistically significant at P<0.05. Of 60 patients, 18 had complications, 15 were hyponatremic, and three (30%) patients had normal sodium levels. 92.9% of patients with normal sodium have no symptoms.[12]

In our study, on post-operative day 2, there was a significant difference in the persistence of hyponatremia among the geriatric age group (P<0.05). POH has been linked to intraoperative variables, including intraoperative fluid, particularly Ringers Lactate and fluids containing dextrose, kind of operation, and length of surgery. Hyponatremia can also be brought on by administering hypotonic fluids.[1,4] Hennrikus et al., found that hypovolemia and inappropriate antidiuretic hormone secretion syndrome were the two main causes of post-operative hyponatremia in orthopedic patients.[1] In both situations, hypotonic fluids will decrease plasma Na and should be avoided. Children who consume hypotonic fluids as opposed to isotonic fluids have a higher chance of developing hospital-acquired hyponatremia, according to Carandang et al.[13] In post-operative children, Neville et al., found that isotonic

Table 7: Comparison of hospital stay for normal and hyponatremic patients

Hospital stay	n	Mean	Standard Deviation	95% Confidence interval for mean		P-value
				Lower bound	Upper bound	
Normal	85	5.4235	1.23805	5.1565	5.6906	<0.001
Mild	46	7.413	2.11425	6.7852	8.0409	
Moderate	7	10.4286	2.22539	8.3704	12.4867	
Severe	2	11	2.70711	3.1469	15.8531	
Total	140	6.3857	2.11397	6.0325	6.739	

saline solution, not fluid restriction, reduced the likelihood of hyponatremia.[14]

In our study, the type of surgery also does not influence hyponatremia, which is statistically insignificant (P=0.226). Sex does not influence the development of hyponatremia. Approximately both sexes had an equal number of patients with mild and moderate hyponatremia, which is statistically insignificant among the sexes (P=0.199). Symptoms in the post-operative period were significant. Nausea in 5 patients out of 55 hyponatremia patients, lethargy in 10 patients, headache in 12 patients, confusion in 9 patients, and disorientation in 2 hyponatremic patients show a significant (P<0.001).

There are several risk factors for reducing salt levels after surgery, but the exact explanation is unknown. POH has been linked to several risk variables, including age, gender, current medications, pre-operative serum sodium and glucose levels, kind of surgery, length of operation, and perioperative fluid management. Age, female sex, low body weight, and diabetes mellitus have been identified as the main risk factors among the patient characters.[2-6] Increased idiopathic SIADH and "frailty" incidence have been linked to a probable risk of hyponatremia with age.[15,16]

The mean length of hospital stay of patients with normal sodium levels was 5.42±1.24 days. Patients with mild hyponatremia had 7.41±2.1 days. The mean hospital stay of patients with moderate and severe hyponatremia was 10.4±2.2 days and 11±2.7 days, respectively. Significantly, hyponatremia patients had prolonged hospital stays (P<0.001).

Typically, mild hyponatremia manifests as vague symptoms, including nausea, vomiting, and weakness. These symptoms frequently go undiagnosed and untreated because they may occasionally be mistaken for signs of the patient's post-operative condition. When bone trauma is being mobilized in an elderly patient, hyponatremia might cause confusion, weakness, etc., increasing the danger of falls or slowing down the process.[6] Consequently, during the post-operative phase, keeping a close eye on and regularly testing serum electrolytes is essential.

Limitations of the study

The study did not attempt to categorize hyponatremia as euvolemic, hyper, or hypovolemic hyponatremia. Thus, we cannot determine the etiology of hyponatremia. The study did not measure the number of analgesics administered and intra-operative blood loss, which could impact the post-operative sodium level. Institutional differences in patient characteristics, surgical approaches, and anesthesia regimens could prevent the study's findings from being applied universally.

CONCLUSION

The senior population has a higher incidence of post-operative hyponatremia and is more susceptible to the development of symptoms related to hyponatremia. The length of hospital stay is prolonged in the elderly group compared to young adults. Even though post-operative hyponatremia is typical following orthopedic procedures, it is early, temporary, and easily treatable. The primary risk factors for POH are the pre-operative sodium level and the length of the procedure. Since salt level changes are predictable, preventing POH may be achieved by maintaining normal sodium levels before surgery, creating protocols for geriatric patient care, and cutting operating time.

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