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Electrolyte imbalance after total joint arthroplasty: risk factors and impact on length of hospital stay

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Abstract

Background Clinical as well as subclinical hyponatremia is frequently seen after orthopedic surgery. The study was aimed to determine the frequency and severity of hyponatremia in a cohort of total joint arthroplasty cases and identify the risk factors and their impact.

Methods This is a retrospective observational study of 546 consecutive cases of total joint arthroplasty patients from a single institution. Only primary hip and knee replacements were included. The study was approved by the institutional review board. Preoperative and postoperative serum electrolytes were recorded till 45-day review. This was correlated with the age, gender, BMI, drug intake, and comorbidities.

Results We identified 84.9% postsurgical hyponatremia in our cohort. Of these 80% were mild, 16% moderate and 4% severe. Preoperative hyponatremia was a consistent finding in most severe cases. Thaizides, ACE inhibitors, and longer surgeries like bilateral TKRs had more hyponatremia. Hospital stay was not impacted in this study for reasons discussed. There were no deaths in this series during the follow-up period, but two patients were rehospitalized.

Conclusion Postsurgical hyponatremia occurs in up to 85% of primary hip and knee arthroplasty patients. The most consistent predictor of severe electrolyte disturbance postsurgery is preoperative hyponatremia. Older age, female gender, longer surgery, and drugs like thiazides and ACE inhibitors seemed contributory.

Keywords Hyponatremia · Postoperative hyponatremia · Postsurgical electrolyte imbalance · SIADH

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Introduction

Serum electrolyte disturbances after surgery are one of the more commonly encountered problems in surgical practice, and the current literature ranks it among the top 10 reasons for 30-day readmission after total knee replacement [1]. Considering that most surgeons encounter postoperative electrolyte imbalance at fairly frequent intervals in their clinical practice, the paucity of literature on this subject is rather surprising. The precise incidence of this complication is said to vary from 2.8 to 83% [2–5] in orthopedic surgery, evidently depending on the age of population, the intervention undertaken, and other comorbidities. It has also been demonstrated to directly cause significant mortality and morbidity in about 20% of the patients [3, 5, 6]. While the etiology of these disturbances has several contributing factors, the precise mechanism of the development of hyponatremia postsurgery is largely conjectural [4].

This report is a retrospective observational study. The aim of the present review was to identify the prevalence of electrolyte disturbance following total joint arthroplasty surgery in an Indian population sample. Additionally, we aimed at identifying the risk factors for developing this complication and also analyze whether these disturbances have a significant impact on the surgical outcomes for patient.

Materials and methods

This study was approved by the institutional review board and the ethics committee. From January 2014 to June 2015, 481 consecutive patients who underwent total joint arthroplasty procedures in our hospital were retrieved from the electronic database. Eighteen patients who had undergone revision surgery, one patient with total shoulder replacement, and six patients with chronic kidney disease were excluded from the study. Thus, 456 patients who underwent primary hip and knee arthroplasty procedures were included in this retrospective analysis. Case sheets and laboratory records were scrutinized to collect the data. The documents were evaluated by two independent surgeons and spread sheets were prepared. All the authors studied the tabulated results. There were 311 females and 145 males in this cohort. The mean age of the patients was 62.9 years with average height of 155.8 cm and average weight of 72.8 kg. The mean BMI was 29.5 (The details of patient demographic data are appended in Table 1.) The 63 hip replacements, 316 unilateral knee replacements, and 77 bilateral knee replacements were evaluated together because the patient demographics, anesthetic strategies, surgical duration (except the bilateral TKRs), blood loss, and fluid resuscitation were similar.

For the purpose of this study, hyponatremia was defined as serum Na less than 135 mmol/L. It was further graded as mild (≥ 130 mmol/L), moderate (≥ 125–129 mmol/L) and severe (< 125 mmol/L). The discrete parameters studied included preoperative medications, intraoperative and postoperative intravenous fluid intake, oral intake of fluids, urine output, and serum electrolytes preoperatively, postoperatively, and after hospital discharge. Additionally, the duration of hospital stay and ICU stay were documented, and any additional symptoms were closely monitored and documented. The data collection was completed at 45 days from the time of discharge after surgery. No long-term follow-up was mandated for the research question.

Statistical analysis

Linear and logistic regression analysis was used to find the significance of postoperative hyponatremia in relation to the preoperative variables.

Results

Hyponatremia occurred in 387 of 456 (84.9%) hip and knee procedures, while hypokalemia occurred in 19 (4.6%). Hyponatremic episodes included 311 (80%) mild, 60 (16%) moderate, and 16 (4%) severe cases (Table 2). When corrected for elevated glucose levels, no episode of hyponatremia was corrected to normal ranges.

Preoperative hyponatremia appeared to be a significant factor leading to postoperative hyponatremia (Table 3). Of the 16 severe postoperative hyponatremic patients, all had a prior electrolyte abnormality identified. Of the 60 moderate hyponatremic patients, 38 had a preoperative electrolyte anomaly. Thus it appears that the more severe pre-operative electrolyte imbalance leads to more frequent and more severe post-operative electrolyte disturbances. Preoperative mild and moderate hyponatremic patients were taken up for

Table 1 Demographic details of the patients in the study cohort

	N
Gender	
Male	145 (31.8%)
Female	311 (68.2%)
Mean age at surgery (years)	62.9 ± 11.9
Mean body mass index (kg/m^2)	29.5
Anesthetic	
General	5.92%
Spinal	3.07%
Spinal + Epidural	91.0%
Bilateral TKR	77 (16.88)
Unilateral TKR	316 (69.29)
THR	63 (13.81)

Table 2 Incidence of hyponatremia pre- and postsurgery in terms of severity

	Frequency	%
Preoperative sodium		
< 125 (severe)	9	2.0
125–129.9 (moderate)	18	3.9
130–134.9 (mild)	143	31.4
> 135 (normal)	286	62.7
Total	456	100.0
Postoperative sodium		
< 125 (severe)	16	3.5
125–129.9 (moderate)	60	13.2
130–134.9 (mild)	311	68.2
> 135 (normal)	69	15.1
Total	456	100.0

Table 3 Correlation of preoperative sodium concentration with postoperative sodium concentration

Preoperative sodium concentrate	Postoperative sodium concentrate				Total
	< 125 (severe)	125–129.9 (moderate)	130–134.9 (mild)	> 135 (normal)	
< 125 (severe)	5	3	1	0	9
125–129.9 (moderate)	6	5	7	0	18
130–134.9 (mild)	4	30	99	10	143
> 135 (normal)	1	22	204	59	286
Total	16	60	311	69	456
Pearson χ^2: 165.363[a]			*p* value: 0.000		

[a]Six cells (37.5%) have expected count less than 5. The minimum expected count is 0.32. So use this table only as descriptive table without the *p* value

surgery as scheduled but after oral correction of sodium levels; the severe hyponatremic patients were treated with hypertonic saline infusions, and the surgery was deferred till serum levels normalized. This often delayed the surgery by 1–3 days.

In our study, patients undergoing knee replacement appeared more prone to experiencing hyponatremia than hip surgery patients. Another interesting observation was that knee replacement patients had greater total fluid intake (both intra- and postoperatively) compared with the hip patients. The etiological significance of this is finding is not known at present. Simultaneous bilateral knee replacement patients also were more susceptible to develop hyponatremia; clearly the surgery duration was longer, and they received more intravenous fluids during and immediately after their surgery, than the unilateral knees. The documentation regarding the precise nature and volume of the fluid replacement therapy provided was incomplete and hence not analyzed. Nevertheless, the hospital policy is not to give any dextrose or dextrose saline to patients intraoperatively, and all patients received isotonic saline and Ringer lactate infusions during and after surgery. Our anesthesia department's internal audit report for the period shows that a unilateral knee replacement patient is typically given 1–1.5 L of IV fluids and a bilateral TKR typically gets 1.5–2 L of fluid (personal communication), while the hip replacement patient gets 1 L.

Thiazide diuretics were associated with hyponatremia in 42 of 83 patients who were on this drug ($p < 0.05$). Patients on ACE inhibitors experienced hyponatremia in 38 of 76 cases ($p < 0.05$). Furosemide, selective serotonin reuptake inhibitors (SSRIs), oral hypoglycemics, and carbazepine were not associated with hyponatremia in this series.

All patients who had mild and moderate hyponatremia were treated with total fluid restriction, sodium chloride supplementation in their drinks (lime juice and other aerated beverages), and tablet Soda Mint once or twice a day. Of the 16 patients with severe hyponatremia, seven were symptomatic with episodes of delirious behavior. All such patients were further evaluated with urine osmolality, serum osmolality, urinary sodium, serum calcium, and TSH. All severely hyponatremic patients were treated with 3% hypertonic saline infusions in the intensive care unit under the supervision of the intensivist and endocrinologist till their symptoms abated and their blood levels returned to near normal values.

Of the severely hyponatremic patients, 12 were discharged prior to complete normalization of the hyponatremia but on resolution of clinical features. Ten of these 12 cases maintained normal serum electrolyte values at 45 days of review and were asymptomatic. Two cases of severe hyponatremia had to be rehospitalized for persisting low sodium values (sodium of 117 mmol/L and 121 mmol/L) with clinical features consisting of nausea and confusion. They were successfully treated by medical means. The details of ICU stay of the patients are depicted in Table 4. The total length of hospital stay was not significantly affected in patients with electrolyte disturbance in our study because we tend to keep the patients admitted till suture removal that is 12–14 days from surgery. (This policy of hospitalization was evolved for two reasons—Firstly, most patients travel from remote regions of the state for surgery at our center, and frequent follow-up is impractical; secondly, community nursing services are nonexistent in this part of the country, and adequate supervision of postoperative care is therefore difficult.)

Discussion

The impact of postoperative electrolyte disturbance in orthopedic practice has been adequately addressed in the medical literature of the last two decades. Paradoxically, there is scant mention of this important condition in the recent literature. Andrew Severn and coworkers have published a remarkable review of the subject [7], and they highlight the arguments why orthopedic surgeons are most impacted by this knowledge: Orthopedic patients represent the largest group of elderly patients undergoing elective and emergency surgeries. They have multiple comorbidities and are

Table 4 Correlation of postoperative sodium concentration with length of ICU stay

Length of ICU stay	Postoperative sodium concentrate				Total
	< 125 (severe)	125–129.9 (moderate)	130–134.9 (mild)	> 135 (normal)	
1 day	12	50	256	47	365
2 days	3	8	49	19	79
3 days	0	2	3	2	7
4 days	1	0	3	1	5
Total	16	60	311	69	456
Pearson χ^2: 14.390[a]			*p* value: 0.109 (not significant)		

[a]Nine cells (56.2%) have expected count less than 5. The minimum expected count is 0.18. So use this table only as descriptive table without the *p* value

on medications including NSAIDs; most of the lower limb procedures are performed under spinal or epidural anesthesia which tends to cause an adreno/sympathetic block. To quote these authors—"Orthopedic practice in general and joint replacements more specifically involves 'an old patient who is taking non steroidal anti-inflammatory drugs and receives too much free water while the adrenal axis is affected by a spinal block.'" They have already pointed out the dangers of fluid overload in patients under spinal anesthesia and called for a critical review of guidelines on fluid management of surgical patients. Moreover, factors like the higher prevalence of hypertension, cardiac ailments, and diabetes in these patients who are often on diuretics and ACE inhibitors appear to aggravate the problem. Other authors have also highlighted the same issue [3] and suggested streamlining postsurgical fluid management regimes.

Another important consideration in postoperative electrolyte disturbance is the syndrome of inappropriate antidiuretic hormone (SIADH) [8, 9], which is thought to be precipitated by postoperative pain and agents acting on the pituitary–thalamic axis. The present authors feel that it might be too simplistic to attribute all postoperative electrolyte changes to SIADH. Cummings et al. [10] reported 27% of their cases of electrolyte disturbances as due to SIADH, but they do mention in their study that this is not the most frequent cause of electrolyte disturbances in hospitalized patients. In our case series, the urinary tests for osmolality and sodium concentration were done only for the severe postoperative hyponatremic cases, and they did not support the diagnosis of SIADH. Nevertheless, the treatment for both conditions remains more or less the same—restriction of free water intake and supplementation of hypertonic sodium chloride solutions.

This study had close to 85% prevalence of postoperative hyponatremia (80% mild and 4% severe). Mannesse [11] reports mild electrolyte changes in 22.2% cases and severe aberrations in 4.5% cases in hospitalized patients (not necessarily surgical cases). Corona et al. [12] have performed a systematic review of the condition and also studied the economic impact that it has on healthcare delivery system. Both Rittenhouse [13] and Tolouian [14] have established that preexisting electrolyte disturbances can be a significant factor in causing falls and hip fractures in the elderly. The present authors feel that paucity of the literature might be due to the failure to recognize milder variants of the condition in the routine postsurgical setting. Moreover, early symptoms of hyponatraemia such as nausea, vomiting, weakness, and headache, drowsiness, confusion, and delirious behavior, which occur in majority of the cases, are often confused with normal recovery from anesthesia. It is only the high index of suspicion and the routine testing of blood for electrolytes that enable one to diagnose these cases early and intervene adequately.

Postoperative electrolyte imbalance is a marker of "very frail medical status" and a risk factor for death among elderly orthopedic patients [15]. The incidence of postoperative electrolyte imbalance and fatality was 15% and 8.8%, respectively, in Antonelli's study which is considered the classic for this disorder [16]. The authors of that study also demonstrate that electrolyte imbalance was independently predicted by spinal anesthesia. The current study failed to confirm that spinal anesthesia is associated with more electrolyte disturbance compared with general or epidural anesthesia. It also did not reveal any correlation with the preoperative ASA grade. Several authors have reported that women are more affected than men, as a result of their smaller fluid volume and other sex-related hormonal factors [17–19]. Our results also suggest that female gender and older age patients are more prone to electrolyte disturbances. Lower BMI has been reported to be a major association with postsurgical electrolyte disturbance but our study does not find any significant association with BMI.

The impact of hyponatremia in hospitalized patients has been published before [20]. Even serum sodium levels reported as low normal (133–137 mmol/L) have been shown to be associated with prolonged hospital stays, discharge to facilities, and increased mortality as much as 7–60-fold [5, 21]. Cumming et al. [22] have reported the prevalence as

26% in patients over 65 years and that it can independently cause increased hospital stay. Severe hyponatremia reported in 3–7% of all hospitalized patients have a mortality of near 45% [6]. Specific to the orthopedic patient, mortality is 2.1-fold higher in the less severe cases and 4.6-fold higher in the more severe cases [3, 6]. Interestingly, our study did not show any mortality in the short term (45 days postsurgery); though the ICU stay was prolonged, it was not statistically significant (Table 4). The length of hospital stay was not impacted in our study perhaps because our standard protocol of discharging patients on the 12th postoperative day. It may be significant if patients were planned for shorter hospital stay as in many Western countries. Improved analgesia, reduction in surgical stress responses, early mobilization, etc., have all contributed to the reduction in hospital stay in patients undergoing TKR/THR. In recent years, the procedure has been put under "fast track" and with good results [23–26]. Despite the strict optimization protocols in these studies, the authors reported that the most common reasons for patients overstaying was nausea, vomiting, and feeling of weakness. Although the reasons for these symptoms are varied, one of the more easily recognizable and avoidable causes is electrolyte disturbance [27]. While the effective implementation of these protocols in India is still in its infancy, preventing, identifying, and managing electrolyte disturbances would be an important part of the management strategy. It would also help us identify the "at-risk" patients for such complications and thus help us individualize the fast track protocol post-TKR or THR.

Thiazides and ACE inhibitors are well established as medications associated with postsurgical hyponatremia [28, 29]. Diuretics especially thiazide or thiazide-like agents make up one of the most common causes of hyponatremia, with an estimated incidence of 11% in one series of 114 geriatric patients. In our study, most patients receiving thiazides and ACE inhibitors were associated with preoperative hyponatremia and consequently had postoperative hyponatremia. Hyponatremia has reportedly been associated with carbamazepine therapy [30–32]. Carbamazepine can induce hyponatremia by increasing ADH release from the neurohypophysis. The incidence of carbamazepine-induced hyponatremia ranged widely from 4.8 to 41.5%, depending on the patient population studied [30]. Specifically, this electrolyte disturbance is frequently encountered in the elderly or subjects who simultaneously use other medications known to cause hyponatremia (mainly diuretics) [30]. Our study had two patients on carbamazepine but were not significantly associated with postoperative hyponatremia. Though there is some evidence in the literature that fluid retention is a common adverse effect of thiazolidinediones (pioglitazone and rosiglitazone), hyponatremia related to these drugs have not been reported. There is only one case report with Metformin-related hyponatremia [33] to the best of our knowledge. Our study shows oral hypoglycemics are not frequently associated with postoperative hyponatremia. Rudge et al. [34] did demonstrate a higher prevalence of hyponatremia in patients on proton-pump inhibitors and SSRI. Cummings' study [22] also suggested that PPIs might be implicated besides thiazides, but these observations were not reproduced in our study.

Our study has several limitations. It is a retrospective, single-center experience. The very nature of data extraction might have eliminated minor complications from the picture. Additionally, since our present hospital protocol allows a 12-day stay (till suture removal), the impact of duration of stay could not be adequately evaluated. This regime appears unavoidable in our practice setting since many of the patients travel from far for the surgery and are not available for frequent outpatient reviews. Moreover, community nursing services are not available in this part of our country. No long-term follow-up was performed since the objective was to look at a short-term complication of electrolyte imbalance alone. Perhaps, the total fluid intake and output of each patient in the surgical suite and early postoperative period would give us more insight into the volume dilution and electrolyte shifts that we induced in these patients. It might also have been worth studying whether the early postoperative hyponatremia had any impact on the long-term outcome of the surgery as measured by the Knee Society Score. Other outcomes such as patient satisfaction and economic impact of this complication were beyond the scope of this study. Nonetheless, given that this is the first study of its kind from the Indian subcontinent, the authors believe that it is hugely valuable in understanding the causes and impact of electrolyte disturbances in the population studied.

The observations of the authors can impact clinical practice significantly. Two studies are under way at our center—one is to retrospectively stratify the risk factors for the development of postoperative hyponatremia and create a scoring system and also to prospectively validate the schema. Secondly, given that 85% of our patients have varying grades of hyponatremia postsurgery, a prospective study looking at prophylactically correcting their electrolyte status against such deficiency is under way.

Conclusion

Hyponatremia of some grade appears to occur in 85% of the patient undergoing total joint replacement. The most common precipitating factors appear to be preoperative hyponatremia, female gender, older age, and patients on preoperative treatment with thiazides/ACE inhibitors. Our study did not reveal any correlation with BMI and some of the other drugs like oral hypoglycemics and carbemazepine.

In our cohort of patients, the ICU stay and total hospital stay were not impacted for reasons explained though published literature does show such a correlation. Evidently, identifying the "at-risk" patients would help us monitor them closely and detect the condition early thus help institute aggressive treatment protocols. Based on this study, the authors would suggest preoperative hyponatremia be treated as a major risk factor for developing postoperative hyponatremia after lower limb joint replacement surgery. This may have to be considered seriously in centers where early aggressive discharge policies are practiced to shorten hospital stay.

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Compliance with ethical standards

Conflict of interest The authors declare that they have no conflict of interests.

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