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Clinicoepidemiological profile of acute postoperative hyponatraemia in patients undergoing joint replacement surgery: A prospective observational study

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Abstract

Background: Postoperative hyponatraemia is frequently misunderstood or undiagnosed after orthopaedic surgery, such as total knee and hip replacements, which is associated with increased morbidity. Limited and primarily retrospective literature exists on postoperative hyponatraemia in hip and knee arthroplasties. Key risk factors include preoperative hyponatraemia, older age, female sex, lower body weight, fluid imbalance, and surgical stress.
Methods: This prospective observational study aimed to investigate the incidence of postoperative hyponatraemia and associated factors in 225 orthopaedic surgical patients. Pre-existing hypornatremia cases were excluded. The patients' serum sodium, potassium, blood urea nitrogen, creatinine, glucose, and haemoglobin levels were measured before the surgery and on the first postoperative day.
Results: Postoperative hyponatraemia was detected in 30.6% ($n=69$) of the 225 participating patients; among them, 91.6% had mild, 7.2% had moderate, and 1.4% had severe hyponatraemia. People with diabetes (odds ratio = 3.4; 95% confidence interval 1.36–13.4) and patients with blood loss > 300 mL (odds ratio = 10.3; 95% confidence interval 2.98–16) were more susceptible. Patients with hyponatraemia experienced an extended hospital stay.
Conclusion: One-third of the normonatraemic orthopaedic surgical patients developed postoperative hyponatraemia. Significant risk factors identified include diabetes and intraoperative blood loss exceeding 300 mL. This study allows for a focused evaluation of how surgical procedures influence sodium levels by excluding patients with preoperative hyponatraemia, unlike previous research studies.

Keywords

Hyponatraemia / Hip arthroplasty / Knee arthroplasty

Provenance and Peer review: Unsolicited contribution; Peer reviewed; Accepted for publication 23 February 2025.

Introduction

Postoperative dyselectrolytaemia, particularly hyponatraemia, is one of the most frequently encountered challenges following surgical interventions and is often attributed to the 30-day readmission (Vorhies et al 2012). Hyponatraemia usually occurs when the total body water content exceeds the total body sodium content. Its incidence can vary depending on patient characteristics and surgical factors (Rondon & Badireddy 2021).

Mild hyponatraemia often remains undiagnosed due to lack of symptoms. However, moderate-to-severe cases can present with nausea, headache, agitation, disorientation, lethargy, confusion, ataxia, falls, tremors, seizures, delirium, focal neurological deficits, coma, pseudobulbar palsy, Cheyne–Stokes breath, and even death (Sinno et al 2020). In surgical patients, these symptoms are often overlooked as usual postoperative effects following anaesthesia exposure. POH is associated with a greater risk of wound infections and significant complications, such as

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pneumonia and coronary disease (Leung et al 2012). These conditions are associated with prolonged hospitalisation.

Previous research on acute postoperative hyponatraemia (POH) has generally included a mix of surgical groups, combining elective and emergency cases (Cecconi et al 2016, Harris et al 2015, Hennrikus et al 2015, McCausland et al 2014), particularly in transsphenoidal surgery (TSS) for pituitary adenomas with incidence ranging from 1.8% to 35% (Hong et al 2021), with a limited focus on elective arthroplasty populations.

Orthopaedic patients, particularly those undergoing joint replacement, are prone to develop POH due to frailty, associated comorbidities, multiple medications, and inadvertent perioperative fluid management (Channareddy & Sharma 2018, Lane & Allen 1999). POH following orthopaedic surgery carries a 2.1- to 4.6-fold increased risk of perioperative morbidities and mortality (Channareddy & Sharma 2018). Other studies indicated that the incidence of POH can go up to 83% (depending on the patient's age, type of intervention, and comorbidities) and was associated with significant mortality and morbidity in approximately 20% of patients (Waikar et al 2009, Wald et al 2010).

An audit of 1000 patients who underwent elective primary hip and knee arthroplasty reported the incidence of POH was 21.7% (Cunningham et al 2021). It was associated with age, pre-existing hyponatraemia, and higher fasting glucose (Cunningham et al 2021). Another study found that 84.9% of patients following total joint arthroplasty developed hyponatraemia (Mukartihal et al 2019). The current literature regarding POH is primarily retrospective and is prone to bias and confounding factors (Gankam Kengne et al 2008, Soiza & Talbot 2010, Tambe et al 2003).

However, the exact mechanism of hyponatraemia development remains largely unclear.

The pathophysiology is multifactorial. Dilutional hyponatraemia is common due to excessive administration of hypotonic fluids during surgery or postoperative care. Alternatively, a syndrome of inappropriate antidiuretic hormone secretion (SIADH) triggered by surgical stress and medications, such as opioids or anaesthetic agents, can exacerbate sodium imbalances (Li et al 2022). Arthroplasty patients are susceptible due to predisposing factors, such as advanced age frailty and comorbidities (e.g. heart failure or chronic kidney disease).

In addition, surgical stress and pain may lead to increased secretion of antidiuretic hormone (ADH), compounding the risk of hyponatraemia through inappropriate water retention. The clinical manifestations may vary widely, so clinicians must maintain a high suspicion index. Routine monitoring of serum electrolytes before and after surgery is essential, particularly in high-risk patients (Teo et al 2023).

Lack of careful perioperative fluid management and monitoring of serum electrolytes can result in severe neurological complications. Prompt identification of the aetiology and severity allows tailored interventions to address the underlying cause while minimising the risk of adverse outcomes. While the mild cases may be managed by fluid restriction or adjustment of intravenous fluid composition, moderate-to-severe hyponatraemia may necessitate more aggressive interventions, such as hypertonic saline administration, under close monitoring to prevent osmotic demyelination syndrome. Multidisciplinary care involving anaesthetists, surgeons, and endocrinologists is often necessary to optimise outcomes and reduce the risk of recurrence. Preventive strategies (e.g. preoperative risk stratification, judicious fluid management, patient education about medication) are equally essential to improve patient safety and recovery outcomes and reduce the burden on health care systems.

The increase in older and comorbid patients opting for elective orthopaedic surgery and a shift towards shorter inpatient stays and day-case arthroplasty necessitates early identification of vulnerable patients at risk, and implementing appropriate monitoring and management protocols is essential to mitigate the impact of this complication on patient outcomes. Thus, this prospective study aims to determine the incidence of new-onset hyponatraemia postoperatively in patients undergoing joint replacement surgeries. The secondary outcome was an assessment of different etiological factors.

Materials and methods

This prospective, single-blinded observational study was conducted in a tertiary care centre in North India after obtaining institutional ethics committee approval (IEC-887/03.01.2020, RP06/2020, dated 14 February 2020) and written informed consent from 225 patients who underwent total joint arthroplasty between 2019 and 2021 under the same group of surgeons. Patients with conditions known for hyponatraemia (e.g. cirrhosis, chronic renal failure, congestive cardiac failure, or AIDS) and SIADH secretion (head trauma, meningitis, stroke, subarachnoid or subdural haemorrhage, Guillain–Barre syndrome, aspergillosis, lung abscess, pneumonia, tuberculosis, intermittent porphyria, and acute psychosis) were excluded.

Anaesthesia management

A lumbar epidural catheter was placed in every patient before induction. All the patients received standardised techniques of regional or general anaesthesia. They

Table 1 Demographics variables of patients with and without POH

	Postoperative hyponatraemia ($n = 69$)	No postoperative hyponatraemia ($n = 156$)	p
Age (years)	60 (55–67)	56 (43–64)	0.16[a]
Sex (M/F)	33/36	72/84	0.81[b]
Weight (kg)	65 (60–77)	65 (60–71)	0.91[a]
Height (cm)	165 (158–170)	162.5 (155–16)	0.11[a]
ASA (grade)	2 (1–3)	1 (1–2)	0.001[a]
MFI	1 (0–1)	0 (0–1)	0.14[a]
Anaesthesia (GA/regional)	5/64	3/153	0.05[b]
Blood loss (mL)	500 (375–600)	200 (200–300)	<0.001[a]
ICU admission (instances)	3	5	0.65[b]
Period of stay (days)	5 (4–6)	5 (5–7)	0.01[a]
Diabetes (instances)	20	22	0.008[b]

MFI: Modified Frailty Index; GA: General Anaesthesia; ICU: Intensive care unit; ASA: American Society of Anaesthesiologists Physical Status.
Data expressed as number or median (interquartile range).
[a]Two-sample Wilcoxon rank-sum (Mann–Whitney U) test. [b]Fisher's exact test.

received either Ringer's lactate, Plasmalyte-A, or Sterofundin, according to the Holliday-Segar formula, for maintenance as per the discretion of the treating anaesthetist. The postoperative analgesia was achieved with epidural morphine 50 mcg/kg /12 hourly. The rescue analgesia consisted of intravenous fentanyl boluses (0.5 mcg/kg) if the visual analogue scale (VAS) for pain was > 4.

Measurement

The patient's age, gender, regular medication, comorbidities, modified frailty index, type of surgery, and surgical duration were noted. Serum sodium (Na), potassium, blood urea nitrogen (BUN), creatinine (Cr), glucose, and haemoglobin (Hb) preoperatively and postoperative day one from a single laboratory were recorded.

Statistical analysis

Windows programme SPSS 15.0 was used for the statistical analysis. Kolmogorov–Smirnov and Shapiro–Wilk tests were used to assess the normality, and internal consistency was evaluated by estimating Cronbach's alpha (0.74). Descriptive statistics were expressed in terms of numbers and percentages for categorical variables and in terms of the median and interquartile range for the continuous variables. A comparison of two independent groups of variables was carried out using the *t*-test and Wilcoxon rank-sum tests accordingly, and binary variables were compared with Fisher's exact test. Spearman's rho estimation was done to identify the correlation between variables and postoperative serum sodium concentration. The multivariable logistic regression analysis was conducted to detect the potential variables' impact on developing POH. The statistical significance level was accepted with the *p*-value of less than 0.05.

Sample size calculation

The sample size was derived based on the findings of a previous study by Hennrikus et al (2015) in which the prevalence rate was 30%. For estimating similar findings with a confidence level α of 95% and a 6% margin of error, a sample size of 225 was calculated.

Results

Of the 225 patients, 111 (49.3%) underwent hip arthroplasty (23 underwent hemi replacement arthroplasty, 68 a total hip arthroplasty, and 20 a revision hip arthroplasty), while 103 (46%) underwent total knee arthroplasty (86 for primary and 17 for revisions) and 11 (4.7%) received partial knee arthroplasty. The incidence of POH, that is, Na < 135 mmol/L, was 30.6% ($n = 69$), out of which 63 (91.6%) had mild (Na 130–134 mmol/L), 8 (7.2%) had moderate (Na 125–129 mmol/L), and 1 (1.4%) had severe (Na < 125 mmol/L) hyponatraemia. Patients with hyponatraemia had a longer duration of hospital stay. However, the requirement for ICU admission did not increase. The baseline characteristics and perioperative variables for all 225 patients are shown in Table 1, which compares those with and without POH.

A negative correlation of age ($\rho = -0.08$, $p = 0.04$), amount of blood loss ($\rho = -0.23$, $p = 0.05$), and diabetes ($\rho = -0.385$, $p = 0.001$) with serum sodium concentration was found (Table 2).

In multivariable logistic regression analysis, diabetes (OR = 3.4; 95% CI 1.36–13.4), intraoperative blood loss > 300 mL blood loss (OR = 10.3; 95% CI 2.98–16), age (OR = 1.09; 95% CI 1.02–1.15) were significantly associated with hyponatraemia. (Table 3).

Discussion

This study evaluated the postoperative sodium imbalance in joint replacement surgery, probable precipitating causes, and its clinical impact on the participating Indian population.

Around 2.8%–29.5% of patients with fractured hips had developed POH (Aicale et al 2017, McPherson & Dunsmuir 2002, Tinning et al 2015). Similarly, another study indicated that one-third of the patients who underwent orthopaedic surgery developed POH (Hennrikus et al 2015). However,7% of the incorporated patients had preoperative hyponatraemia (Hennrikus et al 2015).

Another study found the overall prevalence around 39.5% (32.4% had mild, 5.6% had moderate, and 1.5% had severe hyponatraemia) among the patients following total knee replacement (TKR) and total hip replacement (THR), and more prevalent following knee surgery, resulting in an increased period of hospital stay. Preoperative hyponatraemia, older age, female sex, lower body weight, and bilateral knee arthroplasty have been attributed as risk factors (Sah 2014). However, that study incorporated a slightly older population than the present study (mean 70.4 vs 60.5 years), patients with preoperative hyponatraemia (8.4%), and the distribution of type of procedure was also different (HIP: 35.5% vs 49.7%; KNEE: 64.5% vs 50.7%). The possibility of existing preoperative dyselectrolytaemia masking the role of the nature of surgery cannot be ruled out.

Table 2 Correlation of different factors and postoperative serum sodium concentration

	Spearman's rho	*p*
Age	−0.08	0.04
Blood loss	−0.232	0.05
Diabetes	−0.385	0.001
ASA	−0.24	0.3
MFI	−0.07	0.56

MFI: Modified Frailty Index; ASA: American Society of Anaesthesiologists Physical Status.

Thus, unlike earlier studies, the current study excluded patients with preoperative hyponatraemia from the analysis. This critical decision was paramount in assessing the impact of joint replacement surgery on the development of POH.

There was no relevant difference in operating time between patients with and without POH. The balanced use of Ringer's lactate and normal saline solution during the perioperative period may be a probable explanation for the lack of association with operating time. However, some studies have implied the duration of surgery, blood loss, and surgical stress as the main attributing factors for POH (Channareddy & Sharma 2018, Hennrikus et al 2015, 2016).

Hyperglycaemia in arthroplasty has been studied mostly because of its role in joint infection (Hillier et al 1999). However, in hyperglycaemia, the Serum Sodium (Na) level is often lowered (Katz 1973, Liamis et al 2013). Diabetics had an increased incidence of hyponatraemia and elevated ADH levels (Hwang et al 2015, Mohan et al 2013).

This study also found diabetic patients undergoing joint replacement surgery are prone to develop POH. The conventional formulae for adjusting Na in hyperglycaemia also indicate other possible contributory mechanisms.

While few studies indicated an increased period of hospital stay with POH (Hennrikus et al 2015, Hillier et al 1999), this study found no such difference. Thus, patients with normal electrolytes who underwent total joint arthroplasty after receiving a cautious perioperative IV fluid management often develop a transient mild-to-moderate laboratory condition without relevant clinical impact. However, preprocedural hyponatraemia should be corrected before intervention as it may turn mild hyponatraemia into a severe POH, resulting in multiple complications described in earlier studies (Hillier et al 1999, Sah 2014) which may have contributed to prolonged hospitalisation. The period of hospital stay was not impacted in this study, perhaps due to protocolised analgesia, which reduced the surgical stress responses and facilitated early mobilisation.

Table 3 Multivariable logistic regression analysis for hyponatraemia

Variables	Odds ratio	95% CI	*p*
ASA	1.12	0.29–4.2	0.86
MFI	1.62	0.19–2	0.42
DM	3.4	1.36–13.4	0.01
Age	1.09	1.02–1.15	0.002
Blood loss > 300 mL	10.3	2.98–16	0.0002

MFI: modified Frailty Index; ASA: American Society of Anaesthesiologists Physical Status.

Strengths and limitations

This prospective study from South Asia is valuable in understanding the causes and impact of electrolyte disturbances in the population studied. However, serum and urinary osmolarities, daily fluid balance, and whether cardiac drugs were held over the perioperative period were not described. The generalisability is also limited for being a single-centre study.

Conclusion

One in every three normonatriemic patients undergoing joint placement is prone to develop POH, especially those with diabetes or significant blood loss, and this suggests the need for careful perioperative fluid management to prevent this condition.

Author contributions

R.K.A., R.M., and P.K. contributed to conceptualisation. D.G., R.K.A., D.G., S.B., R.M., P.K., and D.K.B. were involved in data collection. R.K.A. and P.K. participated in writing. S.S. performed data extraction, data analysis, and drafted the article.

Data availability statement

The data that support the findings of this study are available from the corresponding author on reasonable request.

Declaration of conflicting interests

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Ethical clearance

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Prior presentations

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