Integration of an Artificial Intelligence-Based Alert System into Clinical Workflow Resulted in a Reduction in the Incidence of Hyponatremia after Total Joint Arthroplasty

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INTRODUCTION: Hyponatremia after total joint arthroplasty (TJA) is common, with certain reports estimating the incidence to approach 85% in high-risk populations. Even with sodium levels in the low-normal range (mild hyponatremia), clinically significant complications have been observed. Hyponatremia may lead to several adverse events, including nausea, confusion, wound healing complications, seizures, and mortality. In cases where additional treatment or observation is necessary, this may also result in increased hospital-related costs associated with prolonged length of stay, conversion of ambulatory cases to inpatient admission, and required interventions. This study group previously developed a machine learning (ML)-derived risk calculator from a study cohort of over 30,000 total joint arthroplasty (TJA) patients that demonstrated excellent performance. This risk calculator included several factors associated with the development of hyponatremia (Na<135mEq/L), including preoperative serum sodium concentration ≤138 mEq/L, age >73 years, ASA score >2, intraoperative blood loss >407-mL, BMI ≤26 kg/m^2, and procedure time >111 minutes. The purpose of the current study was to implement this risk calculator tool to 1) prospectively identify patients undergoing TJA who were at-risk for developing hyponatremia and 2) utilize plasma-lyte intravenous fluid instead of lactated ringers (standard of care) as an intervention for at-risk patients to determine whether this could decrease the incidence of hyponatremia.

METHODS: In this prospective non-randomized study, a total of 22,271 consecutive patients that underwent TJA between March 2022 and March 2023 were included. A best practice alert (BPA) system derived from an artificial intelligence (AI) based clinical prediction model was integrated into the electronic medical record system and available for all patients. The BPA alert was triggered when patients were identified as being at-risk of developing hyponatremia based on four preoperative risk factors, since two of the original risk factors (blood loss and procedure time) from the previously validated machine learning model were intraoperative variables (**Table 1**). For patients with 3/4 preoperative risk factors, the BPA was triggered to the anesthesiologist advising them to use plasma-lyte intravenous fluid instead of lactated ringers (standard of care). Trends in the incidence of hyponatremia before and after this institutional practice change were quantitively evaluated using descriptive statistics.

RESULTS: The BPA was triggered 16,357 times for 1,078 patients determined to be at-risk for hyponatremia over a one-year time period based on the alert criteria. Of patients whose risk factors triggered an alert, 31% (n=334) developed mild hyponatremia (Na = 130-135) and 10% (n=108) developed moderate hyponatremia (Na = 125-129), while none of these patients developed severe hyponatremia. When considering all patients, statistically significant reductions in the incidence of mild, moderate, and severe hyponatremia were observed after integration of this BPA (**Table 2**). Specifically, the overall rate of hyponatremia at the study institution decreased from 29% to 14% by March 2023 ($p<0.05$). The rate of mild hyponatremia decreased from 25.9% to 12.6%, while the rate of moderate hyponatremia decreased from 3.4% to 1.3% in March 2023, and the rate of severe hyponatremia decreased from 0.57% to 0.22% in March 2023 ($p<0.01$ all; **Figure 1**).

DISCUSSION AND CONCLUSION: Integrating a ML-based BPA led to a statistically significant reduction in the incidence of mild, moderate, and severe hyponatremia after TJA. Patients identified as at-risk for hyponatremia based on these criteria may benefit from administration of intravenous plasma-lyte instead of a lactated ringers intravenous solution.

Figure 1. Hyponatremia Trends Over the Study Period

Table 1. Best Practice Alert (BPA) example. The BPA is triggered when 3 of 4 criteria are met.

This patient is at high risk for hyponatremia. • Consider Plasma-lyte as IV fluid solution. • Hold Hydrochlorothiazide • Consider holding Duloxetine and/or NSAIDs
Risk Factors: • Preoperative sodium ≤ 138 • Age > 73 • BMI ≤ 26 • ASA score > 2

Table 2. Hyponatremia Incidence Prior to Implementation of Tool (March 2022) and After One-Year in Clinical Practice (March 2023).

	March 2022	March 2023	p-value
Hyponatremia Rate (Overall)	29.0%	14.0%	<0.001
Mild Hyponatremia Rate (Sodium = 130 – 135)	25.9%	12.6%	<0.001
Moderate Hyponatremia Rate (Sodium = 125 – 129)	3.4%	1.3%	<0.05
Severe Hyponatremia Rate (Sodium < 125)	0.57%	0.22%	<0.05