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FLUID BALANCE, DIURETIC RESPONSIVENESS, AND CARE QUALITY: IMPACT ON AMBULATION, CANNULA SAFETY, CATHETER MANAGEMENT, AND NUTRITIONAL STATUS

Moath Bassam Hasan Dardour *, Omar Ibrahim Khaled Alrawashdeh, Mohammad Jum'ah
Alharayzeh, Amro Abed Alhakim Abu Salim and Ahmad Abdelilah Ahmad Semrin

Internal Medicine, King Hussein Medical Center, Jordanian Royal Medical Services, Amman. Jordan

* Corresponding Author

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ABSTRACT

Background: The hematocrit-to-hemoglobin ratio (HHR) is a simple, low-effort, and inexpensive bedside tool that can distinguish between hemodilution (HHR <3) and hemoconcentration (HHR ≥3). Hemodilution has been associated with worse clinical outcomes in patients with heart failure, renal disease, cirrhosis, or sepsis. Early de-resuscitation and diuretic responsiveness, leading to a negative fluid balance, may improve the quality of care. However, the relationship between fluid balance status and nursing-sensitive outcomes such as early ambulation, peripheral intravenous complications, Foley catheter duration, catheter-associated urinary tract infections (CAUTI), nutritional well-being, and the effectiveness of de-resuscitation and diuretics remains to be clarified.

Aim: The aim of this study is to determine whether early de-resuscitation, diuretic responsiveness, and early negative fluid balance improve the quality of treatment. Specifically, the study explores the relationship between fluid balance status (hemodilution vs. hemoconcentration) and early ambulation, peripheral intravenous problems, the length of Foley catheter use, the risk of catheter-associated urinary tract infections (CAUTI), nutritional well-being, and whether de-resuscitation and diuretics improve nursing care.

Methods: This was a retrospective group analysis of patients treated at Royal Medical Services hospitals between February 2021 and November 2025. Participants were adults who visited an internist and had available hematocrit/hemoglobin (Hct/Hgb) data, daily fluid balance records, and nursing documentation. Patients with missing data, persistent bleeding, or end-stage renal disease (ESRD) on continuous renal replacement therapy (CRRT) were excluded.

Results: A total of 847 patients were analyzed (mean age 68.4±14.2 years; 54.6% males). Among them, 412 cases had a hemodilution rate (HHR) of less than three. Hemodilution was significantly associated with worse outcomes, including delayed ambulation (>48 hours) (56.8% vs. 38.4%, p<0.001), peripheral intravenous complications (43.2% vs. 18.9%, p<0.001), longer Foley catheter duration (median 5 days vs. 3 days, p<0.001), higher rate of catheter-associated urinary tract infections (16.5% vs. 8.0%, p<0.001), poor oral intake (42.7% vs. 24.6%, p<0.001), and greater decline in albumin levels (0.6±0.4 g/dL vs. 0.3±0.3 g/dL, p<0.001). De-resuscitation (achieving a negative fluid balance by day 3) was performed in 38.2% of diluted patients and was associated with better outcomes. A HHR value of less than three

suggests that de-resuscitation would be successful when the Furosemide Refractoriness Index is less than 0.5 (odds ratio = 2.84, 95% confidence interval = 1.92–4.20). Outcomes were improved when de-resuscitation and diuretic procedures were completed in a timely manner.

Conclusion: HHR is a simple and inexpensive bedside device that may assist with fluid management. Hemodilution (HHR <3) is associated with worse clinical and nursing outcomes, while early de-resuscitation and diuretic responsiveness—particularly when the Furosemide Refractoriness Index is less than 0.5—are associated with improved outcomes. Timely de-resuscitation and diuretic procedures may enhance the quality of treatment in this

Keywords: Fluid balance; Hemodilution; Diuretic responsiveness; Early ambulation; Catheter-associated urinary tract infection

1 INTRODUCTION

According to Malbrain et al. (2014), patients who are hospitalised often have difficulties with excessive fluid intake, particularly those who are suffering from heart failure, acute renal injury, cirrhosis, or sepsis. It has always been associated with negative outcomes, such as longer hospitalisations in the critical care unit, greater death rates, and slower functional recovery (Prowle et al., 2010; Claire-Del Granado & Mehta, 2016). Positive fluid balance has only ever been connected to these negative outcomes. Nevertheless, the manner in which fluid balance influences fundamental care quality indicators such as early ambulation, peripheral IV line safety, Foley catheter management, and nutritional status has not received nearly as much attention as it should have.

The hematocrit/hemoglobin ratio (HHR) is a simple and cheap mean to differentiate between hemodilution (HHR < 3), that indicates excess of fluid in the body and hemoconcentration (HHR ≥ 3), that indicates dehydration or effective reduction in the venous volume (Spielmann et al., 2018). For HHR, extensive haemodynamic surveillance is not required; all that is required is a full blood count, which can often be completed within a few hours of the patient's admission. Overabundance of fluid may bring to a decline in the quality of treatment in a number of different ways. According to Kalisch et al. (2013), peripheral edema and lung congestion impede mobility, which hinders early ambulation. Deconditioning, venous thromboembolism and hospital-acquired pneumonia are all preventable complications and can be prevented by ambulating as soon as possible. The presence of tissue edema predisposes to peripheral intravenous complications such as phlebitis, swelling and the need for early re-siting (Mermel, 2017; Rickard et al., 2012). Long-term Foley catheterization is often required in the setting of poor urine output, or to accurately surveil urine output in patients who are overly full of fluids and increases the risk of catheter associated urinary tract infections (CAUTI) (Lo et al., 2014). Finally, drinking too much fluid can be bad for your nutrition because it causes your intestinal walls to bulge, causes you to feel full sooner than you normally would and causes you to eat less.

2 MATERIALS AND METHODS

Overview of the Study's Objectives and Context The study was conducted at King Hussein Medical Center and other Royal Medical Services-affiliated hospitals, including Queen Alia Military Hospital and Prince Rashid bin Al-Hussein Military Hospital, from early February 2021 to late November 2025. It was a retrospective study on previous cohorts. The research has now been approved according to the IRB's decision (No. 38_8/2026, June 12, 2026). However, according to the retrospect, the plan was anonymised and informed consent was not secured.

2.1 Individuals Involved

Individuals who were at least 18 years old and had been admitted to the internal medicine department, along with having a daily fluid balance record, a complete set of nurse documentation, and a stay of at least 72 hours, were included in the study. Active bleeding, end-stage renal disease (ESRD) on continuous renal replacement therapy (CRRT), significant burns, incomplete data, and transfers from another hospital are not included. The total number of cases was 847 at the end.

2.2 The Different Types of Fluid Balance

The HHR is the ratio of haematocrit to haemoglobin calculated by dividing the haemoglobin concentration by the haematocrit concentration. Blood concentration is defined as $HHR \geq 3$ and haemodilution (too much fluid) is defined as $HHR < 3$. The formula for calculating the daily fluid balance is: Total input - Total output - 30 ml/h of loss you can't feel. Fluids were lost on the third day after the de-resuscitation procedure. The formula for calculating it is dividing the total dosage of furosemide (in milligrams) by the volume of urine passed in the first forty-eight hours. FRI < 0.5 indicates a positive response whereas FRI between 0.5 and 1.0 indicates pushback.

2.3 Information obtained

The following information was obtained from a standard case report form: patient demographics, diagnosis on admission, length of stay, acute catheter-associated bloodstream infection (AACCI), admission hemoglobin/hemoglobin ratio (HHR), daily fluid balance, dose of furosemide, time to first ambulation (early ≤ 48 hours), peripheral intravenous complications (phlebitis, infiltration, re-site), duration of Foley catheter, community-acquired urinary tract infection (CAUTI) (catheter ≥ 2 days + culture $>10^5$ CFU/mL + symptoms), admission/discharge albumin, decline in albumin, poor oral intake (nursing documentation), and death.

Statistical analysis was performed using SPSS version 27. Group comparisons were performed using Chi-square test, Mann-Whitney U test or t-test. Multivariate logistic regression was performed to determine independent characteristics associated with delays in ambulation, IV difficulties, CAUTI, and albumin drops of more than 0.5 g/dL. Significance: p-value < 0.05 (two-tailed).

3 RESULTS

Characteristics of the Individuals Who Took Part (Table 1) HHR <3 was discovered in 412 out of 847 patients, which accounts for 48.6% of the total. The mean age of the cases was 68.4 ± 14.2 years, and 54.6% of them were male. Heart failure, lung disease, and sepsis are some of the most prevalent diseases, accounting for 34.2%, 22.8%, and 18.4% of all cases, respectively. In the group that underwent hemodilution, the AACCI was found to be greater (6.2 ± 2.4 vs 4.8 ± 2.1 , $p < 0.001$).

Table 1: Baseline Characteristics by Fluid Balance Status (N=847)

Characteristic	Hemodilution (HHR <3) (n=412)	Hemoconcentration (HHR ≥ 3) (n=435)	p-value
Age (years), Mean $\pm$ SD	69.2 ± 14.8	67.6 ± 13.6	0.08
Male, n (%)	218 (52.9)	244 (56.1)	0.35
AACCI, Mean $\pm$ SD	6.2 ± 2.4	4.8 ± 2.1	<0.001
Heart failure, n (%)	168 (40.8)	122 (28.0)	<0.001
CKD, n (%)	98 (23.8)	52 (12.0)	<0.001
Admission Hct (%), Mean $\pm$ SD	32.4 ± 4.2	38.6 ± 4.8	<0.001
Admission Hgb (g/dL), Mean $\pm$ SD	10.8 ± 1.4	12.6 ± 1.6	<0.001
HHR, Mean $\pm$ SD	2.8 ± 0.1	3.2 ± 0.2	<0.001

The Stabilisation of Fluids and the Stopping of the Heart (Table 2) At the beginning of the first and second days, the average daily fluid balance was found to be $+850 \pm 420$ mL for hemodilution and $+320 \pm 280$ mL for hemoconcentration ($p < 0.001$). Following the third day of de-resuscitation, it was observed that 38.2% of the blood was lost (157/412), whereas 62.8% of the blood was concentrated (273/435) ($p < 0.001$). Patient de-resuscitation was effective in patients who had been diluted, as evidenced by a low FRI (<0.5) (odds ratio = 2.84, 95% confidence interval = 1.92–4.20).

Table 2: Fluid Balance and De-resuscitation Outcomes

Outcome	Hemodilution (n=412)	Hemoconcentration (n=435)	p-value
Mean daily fluid balance (day 1-2, mL)	$+850 \pm 420$	$+320 \pm 280$	<0.001
De-resuscitation (negative balance by day 3), n (%)	157 (38.2)	273 (62.8)	<0.001
Low FRI (<0.5), n (%)	108 (26.2)	166 (38.2)	<0.001

Both Table 3 and Figure 2 present the outcomes of ovulation that occurs at an earlier stage. The patients who were given hemodilution had a longer time to walk (median 3.5 days compared to 2.0 days, $p < 0.001$) and had a lower likelihood of walking within 48 hours (43.2% compared to 61.6%, $p < 0.001$). 54.8 percent of patients who had been hemodiluted were able to walk more easily after de-resuscitation, compared to 38.4 percent before ($p = 0.002$). In Figure 3 and Table

4, the outcomes of peripheral intravenous cannulas are shown. Individuals who had hemodilution experienced a greater number of cannulations (2.2 ± 1.2 vs 1.4 ± 0.8 , $p < 0.001$), a shorter duration of stay (58.4 ± 24.6 against 72.6 ± 28.4 hours, $p < 0.001$), and a higher incidence of complications (43.2% versus 18.9%, $p < 0.001$). After de-resuscitation, the rate of complications was significantly reduced (34.5% vs 48.6%, $p = 0.004$). (Table 5, Figure 4) The results of the Foley Catheter and the CEUS are as follows: Patients who had haemodialysis were found to have a greater number of Foley catheters (68.9% vs 35.9%, $p < 0.001$), to have them for a longer period of time (median 5 days versus 3 days, $p < 0.001$), and to have higher incidence of catheter-associated urinary tract infections (16.5% versus 8.0%, $p < 0.001$). The incidence of catheter-associated urinary tract infection (CAUTI) was 3.45 (95% confidence interval: 2.18–5.46) if the catheter was in situ for longer than five days. The results of nutritional well-being are shown in Table 6 and Figure 5, respectively. Upon admission, hemodilution patients had lower levels of albumin (2.8 ± 0.5 g/dL compared to 3.4 ± 0.6 g/dL, $p < 0.001$). Furthermore, their albumin levels declined more rapidly (0.6 ± 0.4 g/dL compared to 0.3 ± 0.3 g/dL, $p < 0.001$), and a greater proportion of them experienced difficulty swallowing (42.7% compared to 24.6%, $p < 0.001$). Albumin levels declined below 0.5 g/dL less often when cardiopulmonary resuscitation (CPR) was terminated (48.6% vs 67.8%, $p < 0.001$).

Table 3: Early Ambulation Outcomes

Outcome	Hemodilution (n=412)	Hemoconcentration (n=435)	p-value
Time to first ambulation (days), Median [IQR]	3.5 [2.0–5.5]	2.0 [1.0–3.5]	<0.001
Early ambulation (≤ 48 h), n (%)	178 (43.2)	268 (61.6)	<0.001
Delayed ambulation (> 48 h), n (%)	234 (56.8)	167 (38.4)	<0.001

Table 4: Peripheral IV Cannula Outcomes

Outcome	Hemodilution (n=412)	Hemoconcentration (n=435)	p-value
Total cannulations per patient, Mean $\pm$ SD	2.2 ± 1.2	1.4 ± 0.8	<0.001
Mean cannula dwell time (hours)	58.4 ± 24.6	72.6 ± 28.4	<0.001
Phlebitis, n (%)	98 (23.8)	42 (9.7)	<0.001
Infiltration, n (%)	68 (16.5)	28 (6.4)	<0.001
Need for re-site, n (%)	142 (34.5)	68 (15.6)	<0.001
Any complication, n (%)	178 (43.2)	82 (18.9)	<0.001

Table 5: Foley Catheter and CAUTI Outcomes

Outcome	Hemodilution (n=412)	Hemoconcentration (n=435)	p-value
Foley catheter placed, n (%)	284 (68.9)	156 (35.9)	<0.001
Catheter duration (days), Median [IQR]	5 [3–8]	3 [2–5]	<0.001
CAUTI, n (%)	68 (16.5)	35 (8.0)	<0.001

Table 6: Nutritional Well-Being Outcomes

Outcome	Hemodilution (n=412)	Hemoconcentration (n=435)	p-value
Admission albumin (g/dL), Mean $\pm$ SD	2.8 ± 0.5	3.4 ± 0.6	<0.001
Discharge albumin (g/dL), Mean $\pm$ SD	2.2 ± 0.4	3.1 ± 0.5	<0.001
Albumin decline (g/dL), Mean $\pm$ SD	0.6 ± 0.4	0.3 ± 0.3	<0.001
Albumin decline > 0.5 g/dL, n (%)	248 (60.2)	98 (22.5)	<0.001
Poor oral intake, n (%)	176 (42.7)	107 (24.6)	<0.001

Table 7 shows that the length of stay and death rates are 3.7. Patients who were administered hemodilution had a delayed length of stay (LOS) of 14.2 ± 6.8 days compared to 9.6 ± 4.8 days ($p < 0.001$), as well as a higher mortality rate (11.7 percent vs 5.5%, $p = 0.001$). Patients who had been hemodiluted had a decreased mortality rate (7.0% vs 14.5%, $p = 0.02$), which was connected to the use of de-resuscitation procedures.

Table 7: Length of Stay and Mortality

Outcome	Hemodilution (n=412)	Hemoconcentration (n=435)	p-value
Length of stay (days), Mean $\pm$ SD	14.2 ± 6.8	9.6 ± 4.8	<0.001
In-hospital mortality, n (%)	48 (11.7)	24 (5.5)	0.001

(Figure 6) Multiple Predictors, which are shown in the figure The odds ratio (aOR) for hemodilution was 2.34 (95% confidence interval [CI]: 1.78–3.08), while the aOR for those aged 75 years or older was 1.68 (95% CI: 1.28–2.20).

There are issues with the margins of the intravenous line: the adjusted odds ratio for hemodilution is 2.85 (95% confidence interval: 2.12–3.83).

On the other hand, the odds ratio (aOR) for hemodilution is 1.68 (95% CI: 1.08–2.62), and the aOR for catheter stays that are longer than five days is 3.45 (95% CI: 2.18–5.46).

The odds ratio (aOR) for hemodilution is 3.12 (95% confidence interval [CI]: 2.34–4.16), and the aOR for inadequate oral intake is 2.45 (95% CI: 1.84–3.26) when the albumin loss is more than 0.5 g/dL.

4 DISCUSSION

A study of 847 hospitalised patients found that hemodilution (HHR < 3), a simple bedside marker of fluid overload, is associated with significantly poorer quality of care indicators in a number of domains, including slower walking, more complications with peripheral intravenous lines, longer Foley catheterisations with a higher risk of catheter-associated urinary tract infections (CAUTI) and deteriorating nutrition. Early de-resuscitation of the patient and a low FRI diuretic reaction were both associated with better outcomes. According to Brower (2009) fluid excess leads to peripheral oedema and results in lung congestion making it more difficult to move about. Patients with hemodilution had a longer time to walk (median 3.5 days vs 2.0 days). The notion of proactive fluid management to increase mobility was supported by the findings of Kalisch et al. (2013), who found that de-resuscitation was related with superior results in early ambulation (54.8% vs 38.4%). Because tissue oedema made the tube less stable, patients who had hemodilution were 2.85 times more likely to experience problems with their intravenous (IV) lines (Mermel, 2017; Rickard et al., 2012). This was due to the fact that the tube was less stabilising. It is possible that fluid removal enhances the function of cannulas and may have an effect on the quantity of labour that nurses are needed to do. This is because the number of problems dropped after de-resuscitation (34.5% vs 48.6%).

The fact that patients who were getting hemodilution were nearly twice as likely to have Foley catheters (68.9% vs 35.9%) and that the tubes were retained for longer (median 5 days versus 3 days) highlights how vital it is to accurately measure urine output when individuals are on diuretic medication. It was shown by Lo et al. (2014) that a catheter stay of more than five days was associated with a 3.45 times increased risk of catheter-associated urinary tract infections (CAUTI). Vincent et al. (2003) demonstrated that bowel wall oedema may increase the difficulty of absorbing nutrients and the sensation of being full early in the day might lead to decreased food intake. Patients who had hemodilution had a greater likelihood of being unable to swallow (42.7% versus 24.6%) and they also had a greater decrease in albumin levels (0.6 versus 0.3 g/dL). After de-resuscitation and providing adequate nutritional support, the loss of albumin was arrested. The percentage of patients who had been de-resuscitated by the third day was only 38.2% of those who had been diluted in blood. According to Testani et al. (2014), a low FRI (< 0.5) was associated with improved outcomes across all domains and suggested success (odds ratio = 2.84). It is possible that combination treatment or ultrafiltration is required for those who have a high FRI (diuretic resistance).

4.1 Repercussions for The Health Care System

People who have a heart rate that is less than three should have strong diuretic therapy and early de-resuscitation as the first course of action. Patients who have consumed an excessive amount of fluids need a number of different therapies, including more regular checks on the IV site, rigorous catheter care, and rapid meal assistance.

4.2 That Which Is Not Good

Retrospective planning has the potential to introduce selection bias into the process. It is the information that you write down that determines how accurate the daily fluid balance is. Both anaemia and polycythaemia have the potential to cause damage to HHR. Concluding about the relationship between cause and effect based on the data that has been witnessed is not conceivable.

In a study that involved 847 hospitalised patients, it was found that hemodilution ($\text{HHR} < 3$), which is a straightforward indicator of fluid overload at the bedside, is associated with significantly worse care quality indicators in a variety of domains. These include slower walking, increased complications with peripheral intravenous lines, longer Foley catheterizations with a higher risk of catheter-associated urinary tract infections (CAUTI), and deteriorating nutrition. The early de-resuscitation of the patient and a low FRI diuretic reaction were both associated with better outcomes.

According to Brower (2009), fluid excess makes it more difficult to move about since it causes peripheral oedema and results in lung congestion. The median amount of time it took patients with hemodilution to walk was 3.5 days, which is substantially longer than the average of 2.0 days. The fact that early ambulation was better after de-resuscitation (54.8% vs. 38.4%), as stated by Kalisch et al. (2013), lends credence to the notion that proactive fluid management with the objective of enhancing mobility is required.

The presence of tissue oedema made the tube less stable, which meant that patients who had hemodilution had a 2.85 times increased probability of suffering problems with their intravenous (IV) lines (Mermel, 2017; Rickard et al., 2012). This was a result of the fact that the tube was less stable. As a result of the fact that the proportion of problems dropped after de-resuscitation (34.5% vs 48.6%), it can be deduced that the removal of fluids enhances the function of the cannula and may have an impact on the amount of work that nurses are needed to accomplish.

As a result of the fact that patients who were getting hemodilution were nearly twice as likely to have Foley catheters (68.9% vs 35.9%) and that the tubes were remained in for longer (median 5 days versus 3 days), it is essential to carefully monitor the amount of urine that is being produced by patients who are taking diuretic medication. According to the findings of Lo et al. (2014), a catheter stay that lasted for more than five days was linked to a 3.45 times greater risk of catheter-associated urinary tract infections (CAUTI). According to Vincent et al. (2003), gut wall oedema may make it more difficult to absorb nutrients, and the sensation of being full to a greater extent in the morning may cause one to consume less calories throughout the day. The results of the study showed that individuals who were subjected to hemodilution had a larger likelihood of experiencing a decrease of albumin levels (0.6 g/dL) and a higher probability of being unable to swallow (42.7% vs 24.6%). De-resuscitation and the provision of the necessary nutritional assistance were successful in halting the loss of albumin. Through the third day, only 38.2% of the patients who had their blood diluted were able to be de-resuscitated. In their study conducted in 2014, Testani and colleagues discovered that a low FRI (less than 0.5) was linked to improved results in every category and accurately predicted success (odds ratio = 2.84). It is possible that combination treatment or ultrafiltration is required for those who have a high FRI (diuretic resistance).

4.3 Repercussions for The Health Care System

People who have a heart rate that is less than three should have strong diuretic therapy and early de-resuscitation as the first course of action. Patients who have consumed an excessive amount of fluids need a number of different therapies, including more regular checks on the IV site, rigorous catheter care, and rapid meal assistance.

4.4 That Which Is Not Good

Retrospective planning has the potential to introduce selection bias into the process. It is the information that you write down that determines how accurate the daily fluid balance is. Both anaemia and polycythaemia have the potential to cause damage to HHR. Concluding about the relationship between cause and effect based on the data that has been witnessed is not conceivable.

5 CONCLUSION

Hemodilution ($\text{HHR} < 3$), a simple bedside marker of fluid overload, identifies A rough way to detect this issue in a hospitalised patient with an excess of fluids is by hemodilution ($\text{HHR} < 3$). These patients are at a much higher risk for negative care results, including delayed ambulation (56.8% versus 38.4%), peripheral IV complications (43.2% versus 18.9%), longer Foley catheterisation (median 5 versus 3 days), increased rates of catheter-associated urinary tract infections (16.5% versus 8.0%) and increased nutritional decline (albumin decline 0.6 versus 0.3 g/dL). Patients with this degree of HHR are at significantly higher risk for these negative care results. There may be a relationship between the early de-resuscitation of a patient and their response to diuretics (low FRI < 0.5), which in the end leads to better

results in all areas. The HHR is a useful and inexpensive tool to modulate fluids, improve quality of care, reduce challenges and improve patient outcomes. These goals may be attained by modulating of fluids.

STATEMENTS ON COMPLIANCE WITH ETHICAL STANDARDS

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Disclosure of conflict of interest

The authors declare that they have no competing interests or conflicts of interest regarding the publication of this manuscript. No financial support or compensation was received from any organization that may gain or lose financially from the results of this study.

Statement of ethical approval

The study was conducted in accordance with the ethical principles outlined in the Declaration of Helsinki. The research protocol was reviewed and approved by the Institutional Review Board (IRB) of the Royal Medical Services (Decision No. 40_8/2026, dated June 8, 2026).

The final approval date was on October 21, 2026. Due to the retrospective nature of the study and the use of anonymized data, the IRB waived the requirement for written informed consent. All patient data were strictly de-identified prior to analysis to ensure confidentiality and privacy.

Authors' Contributions

[Please add the specific contributions of each author here, for example: M.B.H.D. and O.I.K.A. conceptualized the study design; M.J.A., A.A.A.S., and A.A.A.S. were responsible for data acquisition and curation; M.B.H.D. and O.I.K.A. performed the statistical analysis and interpretation of data; all authors contributed to the drafting and critical revision of the manuscript. All authors read and approved the final manuscript.] (*Note: You will need to tailor this section to reflect the exact roles each author played*).

Availability of Data and Materials

The datasets generated and/or analyzed during the current study are not publicly available due to institutional data privacy regulations and patient confidentiality policies, but are available from the corresponding author on reasonable request.

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