Assessment of Electrolyte Disturbances Risk Factors among Traumatic Brain Injury Patients.

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Abstract

Background: Electrolyte disorders are linked to cardiovascular emergencies, such as cardiac dysrhythmias and arrest, complicating resuscitation efforts. Without timely monitoring and management, these issues can lead to severe complications, including death. Traumatic brain injury (TBI) patients frequently experience electrolyte disturbances due to various risk factors, necessitating close monitoring by nurses to detect and prevent life-threatening disorders, thereby improving patient outcomes. **Objective**: This study aimed to assess the risk factors of electrolyte disturbances among TBI patients. **Settings**: Data were collected from five adult ICUs at Alexandria Main University Hospital, ensuring a diverse patient population. **Subjects**: A convenience sample of 140 patients aged 18-65 years with confirmed TBI was selected using power analysis and sample size software (PASS 2020). **Tool**: The "Electrolyte Disturbances Risk Factors Assessment Tool," adopted from Chala Kenenisa Edae et al. (2020), was utilized for systematic data collection, demonstrating validity and reliability (Cronbach's $\alpha = 0.76$). This tool encompassed relevant clinical data, including demographic and laboratory values. **Results**: Significant risk factors for sodium disturbances included: SIADH: P=0.019, Hypervolemia: P=0.038 and Hyperglycemia: P=0. 047.For potassium disturbances, significant associations were found with: SIADH: P=0.029. Hypovolemia a: P=0.033, Acute Renal Failure (ARF): P=0.036 and Hypervolemia: P=0. 038.**Conclusion**: Key risk factors for electrolyte disturbances in TBI patients are SIADH, hyperglycemia, hypovolemia, hypervolemia, and ARF. This underscores the necessity for proactive nursing interventions. **Recommendations**: critical care nurses should enhance monitoring practices and consider assessing additional electrolytes, such as calcium and magnesium, to improve patient outcomes and reduce complications.

Keywords: Electrolyte disturbances, risk factors, Traumatic Brain Injury Patients.

Introduction

Traumatic brain injury (TBI) is a leading cause of morbidity and mortality worldwide, with significant implications for patient care. Electrolyte disturbances are common in TBI patients and can exacerbate neurological outcomes, complicating recovery (Keren et al., 2019). Electrolyte disturbances in TBI patients significantly impact clinical outcomes, often leading to increased mortality, prolonged ICU stays, and additional complications(Timerga et al., 2020). Hypernatremia, for example, is strongly associated with poor prognosis, causing severe dehydration, renal failure, and even death if left untreated. The development of acute kidney injury (AKI) is another common complication in TBI patients, exacerbating fluid and electrolyte disturbances(Ramírez-Guerrero et al., 2023). AKI, which occurs in up to 10% of TBI cases, impairs the kidneys' ability to regulate electrolytes and fluid balance, leading to higher morbidity and the potential need for renal replacement therapy(Z. Y. Huang et al., 2022). Additionally, electrolyte imbalances can cause neuromuscular complications, such as seizures and cardiac arrhythmias, further reducing the likelihood of recovery(Pitt & Rossignol, 2018).

Several factors contribute to the development of electrolyte disturbances in TBI patients. Inappropriate fluid management is one of the most significant, often exacerbated using diuretics or pharmacological interventions designed to control intracranial pressure(Abdelgawad et al., 2020). These imbalances directly impact clinical outcomes, increasing the risk of morbidity and mortality.

Understanding the factors contributing to these disturbances is crucial for developing effective nursing interventions and improving patient management. The significance of this study lies in its potential to enhance nursing practice by providing insights into the risk factors associated with electrolyte disturbances in TBI patients. By identifying these factors, nurses can implement targeted monitoring and intervention strategies that may improve patient outcomes.

Aims of the Study

This study aims to assess the risk factors of electrolyte disturbances among traumatic brain injury patients.

Research question

What are the risk factors of electrolyte of Electrolyte disturbances among Traumatic Brain Injury patients?

Materials and Method Materials

Design: This study utilized a prospective observational design to assess the risk factors of electrolyte disturbances in TBI patients.

Settings: The study was carried out in five

adult ICUs at Alexandria Main University Hospital.

Subjects: A convenience sample of 140 newly admitted critically ill adult patients (18 to 65years Old) who were admitted to the previously mentioned units constituted the subjects for this study. The sample size was calculated by power analysis using (Epi-Info program), Population size = 100, expected frequency=50%, acceptable error=5%, design effect=1, confidence coefficient=95% and power=80%.

Tool:

One tool namely "Electrolyte disturbances risk factors assessment Tool for traumatic brain injury patients (TBI)" was used to collect the data of this study.

This tool was adopted by the researcher from Chala Kenenisa Edae et al., (2020) study that was proven valid and reliable (Cronbach's α = 0.76).

It included two parts:

Part I: Patients profile and clinical data:

It was used to assess traumatic brain injury patients' baseline data before assessing risk factors associated with electrolyte disturbances. This part included patient's bio-sociodemographic data such as Age, gender, occupation and the clinical data such as admission date, diagnosis at the time of admission, level of consciousness using (GCS), comorbidities, severity of illness, Acute physiological and chronic health evaluation using (APACHE Score), duration of ICU Stay, current lab investigations such as complete blood count, blood urea nitrogen (BUN), urine osmolarity, serum creatinine, blood glycose level and electrolyte baselines of serum sodium, potassium, calcium, magnesium and phosphorus ,according to the availability, fluid balance and presence of peripheral edema.

Part II: Risk factors of electrolyte disturbances among TBI Patients:

It was used to assess the factors associated with electrolyte disturbances among traumatic brain injury patients. It includes: Presence of manifestations of Renal failure, Heart failure, syndrome of inappropriate antidiuretic hormone (SIADH) Secretion, cerebral salt wasting syndrome (CSWS), fever, disturbed level of consciousness, prescribed drugs such as laxative diuretics, mannitol, and corticosteroids, and hyperglycemia,

Patients' physiological parameters including hemodynamic such as heart rate (HR), systolic blood pressure (SBP), diastolic blood pressure (DBP), mean arterial pressure (MAP) and central venous pressure (CVP) ventilation such as tidal volume (VT), minute volume (VE); oxygenation Parameters including PH, partial pressure of oxygen (PaO2), partial pressure of Carbone dioxide (PacO2), arterial oxygen saturation (SaO2), peripheral oxygen saturation (SPO2) and

physical examination findings.

Fluid types administered to TBI patients such as hyper-osmolar, hypo-osmolar and iso-osmolar were recorded by the researcher. In addition, the fluid balance was assessed using bar chart (intake/output).

Method

Approval of Research Ethics Committee of the Faculty of Nursing Alexandria University was obtained before conducting the study. An official letter from the faculty of nursing was delivered to the hospital authorities in the main University Hospital and approval to conduct this study was obtained after explanation of the aim of this study. Permission to conduct the study was obtained from the administrative authorities of the previously mentioned settings after an explanation of the aim of the study.

The researcher utilized the "Electrolyte Disturbances Risk Factors Assessment Tool," adopted from Chala Kenenisa Edae et al., (2020) study that was proven valid and reliable (Cronbach's $\alpha = 0.76$).

Data were collected over six months (February to July 2024)

through:

- Review of patient records and admission sheets for demographic data.
- Assessment of laboratory values (CBC, BUN, creatinine, blood glucose, electrolytes).
- Physical examinations to measure physiological parameters.
- Evaluation of symptoms related to fluid overload and deficit.
- Documentation of fluid types and balance, including edema development.
- Investigation of risk factors for electrolyte disturbances (e.g., renal failure, heart failure, SIADH, fever, hyperglycemia, CSWS, hypovolemia, hypervolemia).

Patients were assessed three times: upon admission, during ICU stay, and before discharge.

Ethical considerations:

Written informed consent was obtained from all patients. The study's purpose, potential benefits, risks, and the right to refuse participation were emphasized.

The study participants right to be withdrawn from the study at any time was accepted.

Anonymity, privacy, and confidentiality of the collected data were ensured.

Statistical Analysis

Data were analyzed using SPSS version 24.0.

Descriptive statistics, chi-square tests, and logistic regression were used to identify significant risk factors ($p < 0.05$).

Results

- **Gender**: 67.9% male, 32.1% female.
- **Age**: Mean = 50.81 years (SD = 10.25).
- **Occupation**: Drivers (35.0%) and manual workers (16.4%) were most common.
- **Diagnosis**: common diagnosis included, intracranial hematoma (17.9%), diffuse TBI (16.4%), and diffuse axonal injury (15.7%).
- **Length of Stay**: Mean = 26.29 days (SD = 8.49).
- **Sodium (Na)**: Significant associations with SIADH (p = 0.019), hypervolemia (p = 0.038), and hyperglycemia (p = 0.047). **(see table 14)**
- **Potassium (K+)**: Significant associations with SIADH (p = 0.029), hypovolemia (p = 0.033), and acute renal failure (ARF) (p = 0.036**). (see table15)**

Discussion

In the present study, the gender distribution shows a marked male predominance, with more than a half being male patients compared to female patients that represent about 1/3 of all cases. Diagnostically, the most common conditions include intracranial hematoma, followed closely by diffuse TBI and diffuse axonal injury. The patients' ages range from 26 to 65 years, with a mean of 50.81 years and a standard deviation of 10.25. The length of hospital stay varies between 12 and 40 days, averaging 26.29 days with a standard deviation of 8.49, suggesting a moderate to extended hospitalization period for these cases. Regarding occupation, the majority of patients were drivers, followed by manual workers.

According to Hakim et Apriawan,2023, there is a male predominance in TBI patients, with 63,393 males and 26,408 females. common conditions like intracranial hematoma and drivers are the most frequently affected occupational group among patient (Rahman Hakim & Apriawan, 2023) .

The relationship between sodium (Na) disturbances (normal, hypo-, and hypernatremia) and various risk factors in TBI patients, highlighting significant associations with certain conditions. **Syndrome of Inappropriate Antidiuretic Hormone (SIADH)** shows a strong association with hyponatremia, affecting **75.9%** of hyponatremic patients compared to **21.4%** of those with normal sodium levels (p=0.019p = 0.019p=0.019), indicating that SIADH contributes significantly to low sodium due to excessive water retention. **Hyperglycemia** also has a notable association (p=0.047p = 0.047p=0.047), with a significant number of normonatremic patients experiencing hyperglycemia, suggesting that high glucose levels might interact with sodium imbalances. Additionally, **hypervolemia** correlates

significantly with sodium disturbance (p=0.038p = 0.038p=0.038), with **34.0%** of hypernatremic patients affected, which may reflect a compensatory response to excess sodium. Although **Acute Renal Failure (ARF)**, **Acute Heart Failure (AHF)**, and **fever** lack statistical significance, they still show trends, such as **53.6%** of hypernatremic patients having ARF, hinting at a link between renal impairment and sodium irregularities. **Cerebral Salt Wasting Syndrome (CSWS)** and **disturbed level of consciousness (DLC)** appear across all sodium categories without significant p-values, indicating a more general role in electrolyte issues. These findings emphasize the importance of monitoring SIADH, hyperglycemia, and hypervolemia as they are closely tied to sodium disturbances in TBI patients, underscoring their role in effective electrolyte management. (Shiel,2023) revealed the syndrome of inappropriate antidiuresis (SIADH), emphasizing its significant association with hyponatremia due to excessive water retention. His paper highlights the importance of careful management of sodium levels to prevent complications like osmotic demyelination syndrome(Shiel, 2023).

The relationship between potassium (K+) disturbances (normal, hypo-, and hyperkalemia) and various risk factors in TBI patients, revealing significant associations with several conditions. **Acute Renal Failure (ARF)** is strongly linked to hyperkalemia, with **65.0%** of hyperkalemic patients affected compared to **50.0%** of normokalemic patients (p=0.036p = 0.036p=0.036), highlighting that impaired kidney function significantly raises hyperkalemia risk due to reduced potassium excretion. **Syndrome of Inappropriate Antidiuretic Hormone (SIADH)** also shows a significant relationship with a (p=0.029p = 0.029p=0.029), indicating that SIADH contributes to lower potassium levels through water retention and dilutional effects. **Hypovolemia** correlates with potassium disturbances as well (p=0.033p = 0.033p=0.033), suggesting a complex interaction between fluid balance and potassium levels. **Hypervolemia** is also significantly associated with potassium disturbances (p=0.038p = 0.038p=0.038), as **40.0%** of hyperkalemic patients experienced hypervolemia compared to **20.5%** of normokalemic patients, implying that fluid excess can exacerbate hyperkalemia by altering potassium distribution. Although **Acute Heart Failure (AHF)**, **Cerebral Salt Wasting Syndrome (CSWS)**, and other factors like **fever** and **disturbed level of consciousness (DLC)** did not reach statistical significance, trends such as **70.0%** of hyperkalemic patients with AHF suggest potential links between these factors and potassium balance. Overall, ARF, SIADH, hypovolemia, and hypervolemia emerge as primary influences on potassium disturbances, underscoring the importance of monitoring

these conditions to manage potassium levels effectively and improve outcomes for TBI patients.

Similarly, recently in 2019 it has been proved that acute renal failure significantly raises hyperkalemia risk due to reduced potassium excretion. Additionally, conditions like SIADH, hypovolemia, and hypervolemia also influence potassium disturbances, emphasizing the need for careful monitoring in affected patients(Hunter & Bailey, 2019).

Conclusion

Electrolyte disturbances in TBI patients are influenced by multiple factors, including SIADH, hyperglycemia, ARF, and fluid imbalances. These disturbances significantly impact patient outcomes, necessitating careful monitoring and management to reduce morbidity and mortality.

Recommendations

In light of the findings of this study, the following recommendations are made:

- Nurse Training: Continuous education on electrolyte monitoring and management in TBI patients.
- Clinical Practice: Enhanced monitoring of electrolyte levels and risk factors in ICU settings.
- Investigations: Routine assessment of phosphorus, calcium, and magnesium levels in TBI patients.
- Future Research: Further studies are needed to explore the impact of electrolyte disturbances on TBI outcomes.

Author contributions

Nadia Taha Mohamed Ahmed, Professor: Played a significant role in drafting a thesis protocol, tool of data collection, analysis, and interpretation. Assisted in revising the Thesis and contributed to the methodology used for this study.

Bassem Nashaat Beshay Michael, Assistant professor: Supervised the research and provided expert guidance throughout the study especially during data collection. Contributed to the conceptualization, study design, and final review of the Thesis.

Haitham Mokhtar Mohamed Abdallah, Lecturer: Assisted in drafting protocol and study Tool, offered critical revisions and expertise in the interpretation of the study results and assisted in final revision of the Thesis.

Table 2. Distribution of the studied patients' group regarding their basic demographic data.

	Number "n=140"	Percent
Gender		
Male	95	67.9
Female	45	32.1
Age (years)		
< 35	2	1.4
35-40	26	18.6
40-50	36	25.7
> 50	76	54.3
Range	26.0-65.0	
Mean±S.D.	50.81±10.25	
Occupation		
Driver	49	35.0
Manual worker	23	16.4
Delivery	20	14.3
Employee	15	10.7
Retired	12	8.6
Student	11	7.9
House wife	10	7.1

Table 3. Distribution of TBI Patients regarding initial diagnosis and Length of stay

	Number "n=140"	**Percent**
Diagnosis		
Intracranial hematoma	25	17.9
Diffuse TBI	23	16.4
Diffuse Axonal injury	22	15.7
Subdural hematoma	21	15.0
Intracranial hemorrhage	19	13.6
Extradural hematoma	18	12.9
Subdural hemorrhage	12	8.6
Length of stay		
<14 days	10	7.1
14-30	78	55.7
30-40	52	37.1
Range	12.0-40.0	
Mean±S.D.	26.29±8.49	

Table 1.Relation between Na disturbance and other risk factors of electrolyte disturbances among TBI patients (n=140)

Items	Normal 'N=14"		Hypo 'N=29"		Hyper 'N=97"		X2 P value
	No	%	No	%	No	%	
Acute Renal Failure (ARF)							
No	8	57.1	14	48.3	45	46.4	4.330
Yes	6	42.9	15	51.7	52	53.6	4.363
Acute heart failure (AHF)							
No	10	71.4	13	44.8	59	60.8	3.875
Yes	4	28.6	16	55.2	38	39.2	0.423
Syndrome of inappropriate antidiuretic hormone (SIADH)							
No	11	78.6	7	24.1	40	41.2	11.803
Yes	3	21.4	22	75.9	57	58.8	0.019*
Cerebral salt wasting syndrome (C.S.W.S)							
No	8	57.1	14	48.3	47	48.5	1.178
Yes	6	42.9	15	51.7	50	51.5	0.882
Hyperglycemia							
No	5	35.7	12	41.4	54	55.7	6.306
Yes	9	64.3	17	58.6	43	44.3	0.047*
Fever							
No	4	28.6	16	55.2	51	52.6	5.301
Yes	10	71.4	13	44.8	46	47.4	0.258
Disturbed level of consciousness (D.L.C)							
No	7	50.0	14	48.3	44	45.4	1.256
Yes	7	50.0	15	51.7	53	54.6	0.869
Hypovolemia							
No	6	42.9	15	51.7	61	62.9	3.684
Yes	8	57.1	14	48.3	36	37.1	0.450
Hypervolemia							
No	11	78.6	25	86.2	64	66.0	6.265
Yes	3	21.4	4	13.8	33	34.0	0.038*

Table 2.relation between K+ disturbance and other risk factors of electrolyte disturbances among TBI patients (n=140):

	K+ disturbance						X2 P value
	Normal 'N=44"		Hypo 'N=56"		Hyper 'N=40"		
	No	%	No	%	No	%	
Acute Renal Failure (A.R.F)							
No	22	50.0	31	55.4	14	35.0	3.99
Yes	22	50.0	25	44.6	26	65.0	0.036*
Acute heart Failure (A.H.F)							
No	21	47.7	33	58.9	28	70.0	4.288
Yes	23	52.3	23	41.1	12	30.0	0.117
Syndrome of inappropriate antidiuretic hormone (SIADH)							
No	12	27.3	30	53.6	16	40.0	7.070
Yes	32	72.7	26	46.4	24	60.0	0.029*
Cerebral salt wasting syndrome (C.S.W.S)							
No	23	52.3	25	44.6	21	52.5	0.805
Yes	21	47.7	31	55.4	19	47.5	0.669
Hyperglycemia:							
No	26	59.1	28	50.0	17	42.5	2.326
Yes	18	40.9	28	50.0	23	57.5	0.312
Fever							1.761
No	19	43.2	29	51.8	23	57.5	0.414
Yes	25	56.8	27	48.2	17	42.5	
Disturbed level of consciousness (D.L.C)							
No	17	38.6	28	50.0	20	50.0	1.566
Yes	27	61.4	28	50.0	20	50.0	0.457
Hypovolemia							
No	19	43.2	35	62.5	28	70.0	6.804
Yes	25	56.8	21	37.5	12	30.0	0.033*
Hypervolemia							
No	35	79.5	41	73.2	24	60.0	4.068
Yes	9	20.5	15	26.8	16	40.0	0.038*

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