ORIGINAL ARTICLE OPEN ACCESS

Electrolyte Imbalance in Seizure Patients Presenting to the Emergency Room: A Frequency Analysis

Sadam Hussain[1], Syeda Fatimah Zareen[1], Karim Baksh[1], Muhammad Hamza Rizwan[1], Muhammad Dawood[1], Nayab Chaudhery[1]

[1]Department of Emergency, Combined Military Hospital Rawalpindi, Pakistan.

ABSTRACT

Background: Seizures, caused by abnormal brain electrical activity, are a major neurological issue in children. In Pakistan, pediatric seizure prevalence is significantly higher than in many other countries. Electrolyte imbalance is a known but under-researched cause of seizures, especially in children. The present study aimed to determine the frequency of electrolyte imbalance in patients presenting with seizures.

Methods: This prospective cross-sectional study was conducted at the Emergency Department of a Tertiary Care Hospital in Rawalpindi from January 1st to June 30th,2023. Forty patients under 18 years presenting with seizures were included using non-probability consecutive sampling. Statistical Package for Social Sciences SPSS version 21.0 was used for data analysis. Mean±SD was used for descriptive statistics. An independent samples T-test was applied, with $p \leq 0.05$ considered statistically significant.

Results: Of 40 patients, those with known epilepsy (n=14) had significantly lower serum calcium and magnesium levels (p=0.016 and 0.001) than those with first-time seizures (n=26). Patients on anti-epileptic drugs (n = 7) also showed lower calcium and magnesium levels (p = 0.001 for each) and higher sodium levels (p = 0.029) compared to those not on AEDs (n = 33). Potassium levels remained within normal limits across all groups.

Conclusion: Patients with prior epilepsy and those on AEDs are more likely to have electrolyte imbalances, particularly involving calcium, magnesium, and sodium. These findings highlight the importance of monitoring electrolytes in pediatric seizure patients, especially those with known epilepsy or on medication.

Keywords: Electrolyte, Hyponatremia, Hypernatremia, Hypocalcemia.

Corresponding Author:
Dr. Sadam Hussain,
Department of Emergency,
Combined Military Hospital Rawalpindi, Pakistan.
Email: drshnwazir@gmail.com
Doi: https://doi.org/10.36283/ziun-pjmd14-3/009

How to cite: Hussain S, Zareen SF, Baksh K, Rizwan MH, Dawood M, Chaudhery N Electrolyte Imbalance in Seizure Patients Presenting to the Emergency Room: A Frequency Analysis. Pak J Med Dent. 2025 July ;14(3): 51-57. Doi: https://doi.org/10.36283/ziun-pjmd14-3/009.

Received: Sun, May 11, 2025 **Accepted:** Tue, July 08, 2025 **Published:** Mon, July 21, 2025

INTRODUCTION

An interruption in normal brain functions due to unregulated or abnormal electrical discharge in the brain, which often manifests as an intense involuntary contraction of skeletal muscles, is called a seizure[1]. In Pakistan, as per a cross-sectional study conducted with 600 children in the pediatric ward of Civil Hospital Karachi, the prevalence of seizures was 22% [2]. Generalized tonic-clonic seizures were seen in 52.3% of the children, and the study concluded that there is a high prevalence of epilepsy among the pediatric population in Pakistan[3,4]. In contrast, the incidence of epilepsy in children is 2 - 5 % in Europe & America, 1% in China, and 8 % in Japan[5,6]. The prevalence of non-epileptic seizures in the pediatric population in Pakistan is not documented. A patient with untreated or unrecognized seizure may suffer from a high morbidity or mortality rate due to its quick conversion into generalized convulsive, or more frequently non-convulsive, status epilepticus[7,8].

Depending on the origin of electrical activity, there are two major classes of seizures, i.e., focal, which involves a specific region of the brain, and generalized, which involves both sides of the brain. Depending on the extent of involvement, seizures may be tonic, clonic, tonic-clonic, or myoclonic[9]. Tonic seizures are associated with impaired consciousness due to sudden muscle stiffness, resulting in falls. Clonic seizures correspond to the rhythmic jerky contractions of muscles of the arms, neck, and face. Myoclonic seizures can affect any muscle group, but typically affect the arms with short and sudden muscle contraction [10].

Seizures are mostly caused by disorders of the central nervous system. In general, common etiologies of seizures are intracranial haemorrhage (ICH), brain tumours, cerebrovascular events, infections (the most common cause in critically ill children), and intoxication[11]. However, systemic causes such as uremic encephalopathy, dialysis disequilibrium syndrome, and electrolyte & biochemical disturbances have also been associated with seizures[12,13]. Literature suggests that some of the electrolyte imbalances responsible for triggering seizures are sodium, potassium, calcium, and magnesium[14]. The effects of these electrolyte imbalances are unpredictable and range from non-specific features such as nausea and malaise, to organ-specific presentations such as seizures, and may even cause irreversible end-organ damage[15]. The purpose of this study is to determine the frequency of electrolyte imbalance in patients under the age of 18 years presenting to the emergency department (ED) with seizures.

METHODS

This was a prospective cross-sectional study conducted at the ED of a tertiary care hospital in Rawalpindi over 06 months (1st Jan - 30th June 2023). We obtained ethical approval from the Institutional Review Board (IRB) Committee of Combined Military Hospital Rawalpindi (Approval No: 404 Dated: 4th January, 2023) After a thorough literature search, a sample size of 16 was calculated using a WHO calculator, keeping a 5% margin of error, 95% confidence level, and prevalence of 9.99/1000 in Pakistan[16].

Sampling was done using the non-probability consecutive sampling technique. A maximum number of available participants (40) during the study period were recruited. The inclusion criteria consisted of patients presenting with seizures, under the age of 18 years. Patients with acute head injury, pseudoseizures, intracranial malignancy, and those unwilling to participate in the study were excluded. After receiving informed parental consent, patients were enrolled in the study, and data were collected. Information on demographics (age, gender), pre-existing history of seizures/epilepsy, anti-epileptic drug (AED) use, medication compliance, clinical presentation, and routine laboratory test and toxicology screen was collected.

Lab investigations included renal function tests (RFTs), serum electrolytes (sodium, potassium, calcium, and magnesium), and a complete blood count (CBC). The patient's history, physical examination, and investigation results were analyzed to identify the underlying causes of the seizures.

The precipitating factors for the seizures were classified into three categories: (i) drug withdrawal (AED discontinuation within 48 hours), (ii)systemic infections, and (iii)metabolic/ electrolyte disturbances. Patients with no apparent initial cause of the seizure were labeled as 'unknown etiology' until further workup and final diagnosis at a later stage.

Statistical Package for Social Sciences SPSS version 21.0 was used for data analysis. A calculation of mean and standard deviation was done for age, serum calcium, and magnesium (numerical variables), whereas for categorical variables, including gender, serum calcium, and magnesium (normal, low, high), known epileptics, epileptics on AEDs, and drug withdrawal, percentage and frequency were presented.

The independent samples T-test was applied to determine the statistically significant difference in means of serum electrolytes between groups based on the history of epilepsy, AED usage, and type of epilepsy. A Chi-square test was applied to

determine the cross-tabulation of different levels of serum electrolytes between these three groups. A p-value of ≤0.05 was considered statistically significant.

RESULTS

Out of the total 40 patients included in the study, 23 (57.5%) were male and 17 (42.5%) were female. The mean age of the study participants was 11.08±4.47 years. 16 (40%) patients had a previous history of seizures, while 24 (60%) presented with a first-time seizure. Out of the 16 patients with a known previous history of seizures, 14 were diagnosed with epilepsy, and only 7 were using anti-epileptic medication. The rest of the patients were either non-compliant with medication or their medication had been stopped by the neuro physician due to a seizure-free interval. None of the patients included in the study were on any electrolyte supplements.

Cross-tabulation analysis was performed to evaluate the distribution of serum calcium, sodium, magnesium, and potassium levels among known epileptics and those with first presentation of seizures. The overall significance of the differences in distribution was assessed using p-values. The results are summarized in **Table 1.**

Among known epileptics, 57.1% had low serum calcium levels, 35.7% had normal levels, and 7.1% had high levels. In the previously undiagnosed group, 19.2% had low calcium, 34.6% had normal levels, and 46.1% had high levels. The difference between the groups was statistically significant (p=0.016), indicating low calcium levels in known epileptics and higher calcium levels in first-time seizure patients.

For serum magnesium, 42.9% of known epileptics had normal levels, and 57.1% had low levels. None had high levels. Among the undiagnosed group, none had low magnesium, 84.6% had normal levels, and 15.4% had high levels. This difference was also significant (p=0.001), showing lower magnesium levels in known epileptics and higher levels in first-time seizure presentations.

Regarding serum sodium and potassium, the differences between the two groups were not statistically significant (p=0.222 for sodium and p=0.386 for potassium).

Table 1: Cross-Tabulation of Different Electrolytes in Patients with Diagnosed and Undiagnosed Cases of Epilepsy

	Serum Calcium (Normal range: 2.12 to 2.55 mmol/L) N (%)			p-value
	Low	Normal	High	
Known epileptic (n=14)	8 (57.1%)	5 (35.7%)	1 (7.1%)	0.016*
Previously undiagnosed /First presentation with seizures (n =26)	5 (19.2%)	9 (34.6%)	12 (46.1%)	
Serum Magnesium (Normal range: 0.70 to 0.91 mmol/L)				
Known epileptic (n=14)	8 (57.1%)	6 (42.9%)	0 (0%)	0.001*
Previously undiagnosed /First presentation with seizures (n =26)	0 (0%)	22 (84.6%)	4 (15.4%)	

Serum Sodium (Normal range: 135 to 145 mmol/L)				
Known epileptic (n=14)	2 (14.2%)	5 (35.7%)	7 (50.0%)	0.222
Previously undiagnosed /First presentation with seizures (n =26)	6 (23.1%)	14 (53.8%)	6 (23.1%)	
Serum Potassium (Normal range: 3.5 to 5.0 mmol/L)				
Known epileptic (n=14)	5 (35.7%)	8 (57.1%)	1 (7.1%)	0.386
Previously undiagnosed /First presentation with seizures (n =26)	5 (19.2%)	16 (61.5%)	5 (19.2%)	

Table 2: **Mean Values of Different Serum Electrolyte Levels**

Analytes	Mean Value (± SD)
Sodium **(normal range: 135 to 145 mmol/L)**	141.13 (±9.85) mmol/L
Potassium **(normal range: 3.5 to 5.0 mmol/L)**	4.23 (±0.94) mmol/L
Calcium **(normal range: 2.12 to 2.55 mmol/L)**	2.40 (±0.39) mmol/L
Magnesium **(normal range: 0.70 to 0.91 mmol/L)**	1.83 (±0.28)mmol/L

Table 2 presents the mean values of different serum electrolytes. The mean serum sodium level was 141.13 (±9.85) mEq/L, which falls within the normal range of 135 to 145 mEq/L. The mean serum potassium level was 4.23 (±0.94) mEq/L, within the normal range of 3.5 to 5.5 mEq/L. For serum calcium, the mean value was 2.40 (±0.39) mmol/L, corresponding to the normal range of 8.5 to 10.5 mg/dL. Lastly, the mean serum magnesium level was 1.83 (±0.28) mmol/L, within the normal range of 1.7 to 2.1 mg/dL.

Table 3: Independent samples T-test Between Means of Various Analytes Based on Groups

Analyte	Diagnosed Cases of Epilepsy (Mean ± SD)	Undiagnosed Patients (Mean ± SD)	p-value	H/O Epilepsy (Mean ± SD)	No H/O Epilepsy (Mean ± SD)	p-value	AED Yes (Mean ± SD)	AED No (Mean ± SD)	p-value
Calcium	2.13 ± 0.28	2.5 ± 0.36	0.001*	2.3 ± 0.38	2.47 ± 0.39	0.162	2.0 ± 0.21	2.4 ± 0.38	0.011*
Sodium	143.9 ± 9.34	139.6 ± 9.96	0.190	142.9 ± 9.5	139.9 ± 10.0	0.349	148.4 ± 8.5	139.5 ± 9.5	0.029*
Potassium	3.9 ± 0.88	4.3 ± 0.96	0.193	4.0 ± 0.86	4.3 ± 1.0	0.398	4.3 ± 0.97	4.2 ± 0.95	0.644
Magnesium	1.6 ± 0.23	1.9 ± 0.24	0.001*	1.7 ± 0.29	1.8 ± 0.27	0.236	1.5 ± 0.22	1.8 ± 0.26	0.006*

The overall mean values for serum electrolytes fall within their normal ranges, but independent samples T-tests showed variations within specific patient groups, as shown in **Table 3**. Serum calcium and magnesium levels were significantly lower among the groups. Known epileptic patients (n=14) had lower calcium levels

compared to previously undiagnosed patients (n=26), with p=0.001 for calcium and p=0.001 for magnesium. This supports the results observed in **Table 1.** Low calcium and magnesium levels were also noted in patients using antiepileptic drugs (n=7) compared to those not using AEDs (n=33), with p=0.011 for calcium and p=0.006 for magnesium.

Patients on AEDs have a mean sodium level of 148.4 ± 8.5 mmol/L, which is significantly higher compared to 139.5 ± 9.5 mmol/L in those not on AEDs (p-value: 0.029). This suggests that AED use is associated with hypernatremia, with sodium levels slightly above the normal range. Serum potassium levels did not show significant differences among groups and remained relatively consistent within normal ranges.

Table 4: Frequency of Different Electrolytes about The Use of Anti-Epileptic Drugs

Patient on AED	Serum Calcium N (%)			Total
	Low	Normal	High	
Yes	5 (71.4%)	2 (28.6%)	0 (0%)	7 (17.5%)
No	8 (24.2%)	13 (39.4%)	12 (36.4%)	33 (82.5%)
Total	13 (32.5%)	14 (35.0%)	13 (32.5%)	40 (100%)
Serum Magnesium N (%)				
Yes	4 (57.1%)	3 (42.9%)	0 (0%)	7 (17.5%)
No	2 (6.1%)	27 (81.8%)	4 (12.1%)	33 (82.5%)
Total	6 (15.0%)	30 (75.0%)	4 (10.0%)	40 (100%)
Serum Sodium N (%)				
Yes	0 (0%)	2 (28.6%)	5 (71.4%)	7 (17.5%)
No	8 (24.2%)	17 (51.5%)	8 (24.2%)	33 (82.5%)
Total	8 (20.0%)	19 (47.5%)	13 (32.5%)	40 (100%)
Serum Potassium N (%)				
Yes	1 (14.3%)	5 (71.4%)	1 (14.3%)	7 (17.5%)
No	9 (27.3%)	19 (57.6)	5 (15.1%)	33 (82.5%)
Total	10 (25.0%)	24 (60.0%)	6 (15.0%)	40 (100%)

As shown in **Table 4**, a significantly higher proportion of individuals not using anti-epileptic drugs (AEDs) had normal levels of serum electrolytes compared to those using AEDs. Specifically, 39.4% of non-AED users had normal calcium levels versus 28.6% of AED users. For magnesium, 81.8% of non-AED users had normal levels, compared to 42.9% of AED users. Sodium levels were normal in 51.5% of non-AED users, whereas only 28.6% of AED users had normal sodium levels. 71.4% of patients on AED had high Sodium levels as compared to those having high sodium levels without AED use. Lastly, 57.6% of non-AED users had normal potassium levels, compared to 71.4% of AED users.

DISCUSSION

The results of our study show some degree of association between serum electrolyte imbalances and seizures. The observations can be divided into two groups of patients based on their significance and association with seizures as observed in the present study, i-e, diagnosed and undiagnosed cases of epilepsy, and patients using AEDs and non-AED users. A study conducted on serum calcium and magnesium abnormalities in epileptic patients showed that calcium and magnesium usually follow a similar pattern of low levels in patients with epilepsy, which is also indicated by the results of our study[17].

The results of our study show that patients pre-diagnosed with epilepsy had significant alterations in calcium and magnesium levels, with p-values of 0.016 and 0.001, respectively. 57.1% of the known patients of epilepsy had hypocalcemia and hypomagnesemia, which shows an association between serum levels and seizures. These findings are also supported by a study conducted in Austria and Italy, which focused on acute symptomatic seizures occurring in patients with electrolyte disturbances[18].

The literature also shows that the mean total serum calcium increased in patients after AED withdrawal, suggesting that the use of AED can cause low calcium levels [19,20,21]. Altered levels of electrolytes were particularly common among patients using AED medication. As observed in our study, 71.4% of patients with hypocalcemia and 57.1% of patients with hypomagnesemia were on AED medication.

Similar findings were observed in a study that focused on serum calcium and vitamin D levels in known epileptic patients and patients using AEDs. Serum calcium levels were significantly low in patients using one or more AEDs[22]. These findings support our result that 71.4% of patients using AEDs had lower calcium levels as compared to 24.2% of patients having low calcium levels but not using AEDs.

However, in our observations, imbalances in serum sodium and potassium levels were not found to have any significant association with seizures or history of epilepsy. High serum sodium levels were observed in patients using AEDs. Contrary to these observations, a study conducted in the USA observed low levels of sodium with the use of anti-epileptic drugs. Acute hyponatremia often develops within <48 hours of AED intake[23]. Severe hypernatremia, although less common than hyponatremia, can also trigger seizures[20].

Alterations in potassium levels also showed an association with seizures in some studies[24]. Hypokalemia does not directly cause seizures. However, hyperkalemia directly contributes to seizure activity by altering neuronal excitability[25]. The lack of association between sodium and potassium imbalances with seizures in our study can be attributed to the small sample size and limited population, and resources.

The results of our study show some degree of association between serum electrolyte imbalances and seizures, especially in patients with known epilepsy and those using AEDs. Our findings align with existing studies suggesting lower calcium and magnesium levels in epilepsy patients. However, we also found that sodium and potassium levels did not show a significant association with seizure presentations, possibly due to the limited sample size and population.

Our study offers a unique perspective by specifically investigating pediatric patients presenting with seizures in a Pakistani tertiary care emergency department. Unlike most existing literature that concentrates on adult populations or does not differentiate between first-time seizures and known epilepsy, our work provides updated, region-specific data for the pediatric population. A novel finding of our study is the trend of hypernatremia in patients on AED therapy, which contrasts with previous studies emphasizing hyponatremia as a common complication. Moreover, the significant prevalence of hypocalcemia and hypomagnesemia among known epileptic patients and those using AEDs points to an under-recognized mechanism contributing to seizure exacerbation in this demographic. These insights highlight the importance of careful electrolyte monitoring in pediatric seizure management, particularly in low-resource settings like Pakistan, where such data are sparse. This study focused on patients below 18 years of age. The adult population was not included. Thus, the results cannot be generalized to adults. The study was conducted in a single healthcare facility with a limited sample size. Further large-scale qualitative and quantitative studies are required to validate its results.

CONCLUSION

The study conducted to determine the frequency of electrolyte imbalances in patients presenting with seizures to the emergency department shows significant imbalances in serum calcium and serum magnesium levels. Low calcium and magnesium levels were observed in known epileptic patients and patients using anti-epileptic drugs as compared to patients with first presentation of seizures or those not using AEDs. Significantly high sodium levels were observed in the group of patients using AEDs. Potassium levels did not differ significantly across the groups and remained within normal ranges. A higher proportion of patients not taking AEDs had normal electrolyte levels for calcium, magnesium, sodium, and potassium. Owing to the limitations of this study, including a small sample size and patient age less than 18, further qualitative and quantitative studies are recommended.

LIST OF ABBREVIATIONS

ICH: Intracranial Hemorrhage
ED: Emergency Department
AED: Antiepileptic Drugs
RFT: Renal functional Test
CBS: Complete blood count

ACKNOWLEDGMENTS

None

FUNDING

None

CONFLICT OF INTEREST

None

ETHICAL APPROVAL

The ethical approval was obtained from the Institutional Review Board (IRB) Committee of Combined Military Hospital Rawalpindi (Approval No: 404 Dated: 4th January, 2023).

AUTHORS' CONTRIBUTIONS

SH: conceived the study idea, designed the research protocol, and supervised data collection. **SFZ:** contributed to data analysis and helped in drafting the manuscript. **KB:** assisted with literature review and data interpretation. **MHR:** responsible for patient recruitment and data entry.**MD:** contributed to statistical analysis and result compilation.**NC:** reviewed the final manuscript for intellectual content and ensured accuracy of references.

REFERENCES

1. Wright D. Pediatric Seizures: The Nutritional Aspect. EMjS world. 2020 May 30.
2. Khan J, Ghoto MA, Dayo A, Arain MI, Parveen R, Khan K, Memon AA. Prevalence and clinical

evaluation of epileptic disorders in children at a tertiary care centre in Karachi, Pakistan. Lat Am J Pharm. 2019 Jan 1; 38:1020-3.
3. Fine A, Wirrell EC. Seizures in children. Pediatr Rev. 2020 Jul;41(7):321-47. https://doi.org/10.1542/pir.2019-0134
4. Mohamed ZA, Tang C, Thokerunga E, Jimale AO, Fatima U, Fan J. Serum Glucose and Electrolyte Levels in Children with and without Febrile Seizures: A case-control study. https://doi.org/10.21203/rs.3.rs-2023747/v2
5. Abbasi A, Kazi G, Siddiqui S, Siddiqi Y. Clinical profile & management of children with seizures presenting to pediatric emergency department: A cross-sectional study. Int J Surg Open. 2020 Jan 1;27:188-91. Doi: https://doi.org/10.1016/j.ijso.2020.11.017
6. Sazgar M. Kidney Disease and Epilepsy. J Stroke Cerebrovasc Dis. 2021 Sep 1;30(9):105651 doi:https://doi.org/10.1016/j.jstrokecerebrovasdis.2021.105651
7. Kaminiów K, Kozak S, Paprocka J. Neonatal seizures revisited. Children. 2021 Feb 18;8(2):155. https://doi.org/10.3390/children8020155
8. Zeeshan A, Rajper S, Moazzam M, Abbas Q, Mukhtiar K. P0012/# 731: ACUTE SYMPTOMATIC SEIZURES FREQUENCY, ETIOLOGY AND OUTCOME OF SEIZURES IN CRITICAL ILL CHILDREN–A STUDY FROM PEDIATRIC INTENSIVE CARE UNIT. Pediatr Crit Care Med. 2021 Mar 1;22(Supplement 1 3S):43. DOI: 10.1097/01.pcc.0000738392.42827.26
9. Diringer M. Neurologic manifestations of major electrolyte abnormalities. Handb Clin Neurol. 2017;141:705-713. doi: 10.1016/B978-0-444-63599-0.00038-7. PMID: 28190443
10. Alamin MA, Ahmed A, Suliman AM. Severe electrolyte disturbances complicated by seizures and acute kidney injury within 10 days of starting indapamide. Cureus2020 Nov 2;12(11). DOI: 10.7759/cureus.11303
11. Tehmina SA, Shira G, Sahib Hassan S, ZuhraBano CK, Khan T. Prevalence, Treatment Approaches and Role of Medicinal Plants Towards Epilepsy in Chitral, Pakistan. Hamdard Med. 2020;63(2):13.
12. Rajper SB, Moazzam M, Zeeshan A, Abbas Q. Acute symptomatic seizures in critically ill children: frequency, etiology and outcomes. J Pediatr Neurosci. 2020 Oct;15(4):375. doi: 10.4103/jpn.JPN_140_19
13. Li W, Li P, Fan X, Liu G, Wang Q. Clinical Analysis of the Relationship between Convulsion and Blood Electrolyte in Children. J Behav Brain Sci 2022 Nov 4;12(11):552-68. DOI: 10.4236/jbbs.2022.1211033
14. Gungor O, Aydin Z, Inci A, Oguz EG, Arici M. Seizures in patients with kidney diseases: a neglected problem?. Nephrol Dial Transplant. 2021 Oct 1. https://doi.org/10.1093/ndt/gfab283
15. Pola Santhosh Kumar D, Grover N, Gupta H, Bhardwaj NK. Profile Of Newly Diagnosed Epilepsy In Children Aged 1-Month-18 Years In A Tertiary Care Center In Northern India. J Pharm Negat Results 2022 Dec 7:4573-8. DOI: https://doi.org/10.47750/pnr.2022.13.S09.566
16. Vasavan A, Nair CC, Ammu S, Dharan SS, Shareef A, Roy A, James AJ. A REVIEW ON NEUROLOGIC MANIFESTATIONS IN MAJOR ELECTROLYTIC ABNORMALITIES. DOI: 10.20959/w jpr 20 201519289
17. Chen CY, Chang YJ, Wu HP. New-onset seizures in pediatric emergency. Pediatr Neonatol. 2010 Apr 1;51(2):103-11. Doi: https://doi.org/10.1016/S1875-9572(10)60019-8
18.Castilla-Guerra L, Fernández-Moreno MD, López-Chozas JM, Fernández-Bolaños R. Electrolytes disturbances and seizures. Epilepsia. 2006 Dec;47(12):1990-8.
19. Arslan G, Demir B. Cognitive impairment in epilepsy patients and its correlations. Appl Neuropsychol Adult. 2022 Oct 20:1-6. https://doi.org/10.1080/23279095.2022.2133606
20. Jamil U, Badshah M, Nomani AZ, Irshad M, Janjua J. Serum calcium and magnesium abnormalities in patients with status epilepticus: a single centre tertiary care experience. Pak J Neurol Sci. 2015;10(3) 6. Available at: http://ecommons.aku.edu/pjns/vol10/iss3/6.
21. Nardone R, Brigo F, Trinka E. Acute symptomatic seizures caused by electrolyte disturbances. J Clin Neurol. 2016;12(1):21. doi:10.3988/jcn.2016.12.1.21
22. Dabla PK, Sharma S, Puri V. Disturbed calcium-vitamin D metabolism in patients on anti-epileptic drugs. Oatext. Published 2017. Accessed August 7, 2024. Available at: https://www.oatext.com/disturbed-calcium-vitamin-d-metabolism-in-patients-on-anti-epileptic-drugs.php.
23. Bembenick KN, Mathew J, Heisler M, Siddaiah H, Moore P, Robinson CL, Kaye AM, Shekoohi S, Kaye AD, Varrassi G. Hyponatremia with anticonvulsant medications: a narrative review. Cureus. 2024;16(4) doi:10.7759/cureus.57535. PMID: 38707045; PMCID: PMC11066697.
24. Wang K, Yang J, Xu W, Wang L, Wang Y. Characteristics and treatments of patients with significantly elevated creatine kinase levels induced by seizures: Case report and literature review. Clinical Case Reports. 2023 Aug;11(8):e7788. https://doi.org/10.1002/ccr3.7788
25. Fröhlich F, Bazhenov M, Iragui-Madoz V, Sejnowski TJ. Potassium dynamics in the epileptic cortex: new insights on an old topic. Neuroscientist. 2007;14(5):422-433. doi:10.1177/1073858408317955.