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Original Research Article

Hypokalemic Periodic Paralysis in Adults: Clinical Patterns, Causal Perspectives, Biochemical Spectrum and the Role of Collaborative Team-Based Management at a Tertiary Health Care Centre

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Abstract:

Hypokalemic periodic paralysis predominantly affects males, with the typical age of onset between 18–30 years. Episodes of muscle weakness often begin early in the morning after waking, with paraparesis being the most common presentation, while complete paralysis is bit rare. Respiratory muscle involvement is uncommon, though some patients may experience fatigue and muscle aches before the onset of weakness, or the episodes may occur without warning. High-carbohydrate meals can trigger attacks, although this is not consistently observed. Primary hypokalemic periodic paralysis (HPP), the most common form, primarily affects males and typically begins between 18–26 years of age. Electrocardiographic (ECG) abnormalities indicative of hypokalemia is often detected when serum potassium levels fall below 3.0 mEq/L. Secondary causes include conditions such as renal tubular acidosis, gastrointestinal potassium loss (often with hypomagnesemia), Bartter syndrome, and Gitelman syndrome; in cases involving acid-base disturbances, evaluation for these conditions should be conducted promptly. The primary dangers linked to this condition arise from complications related to hypokalemia, especially irregular Heart Rhythms, and respiratory insufficiency, which could be significant factors in the morbidity and mortality associated with the condition. Genetic testing has limited utility for diagnosing primary HPP. A coordinated, multidisciplinary approach involving neurologists, nephrologists, and dietitians is critical for improving long-term outcomes in hypoPP patients to optimize patient outcomes, minimize complications, and ensure comprehensive care for individuals with hypokalemic periodic paralysis.

Keywords: Hypokalemic Periodic Paralysis, Paraparesis, Healthcare Teams

Introduction

Potassium (K) is a vital chemical element that plays an essential role in maintaining normal cellular function. It is integral to several physiological processes [1]. Acute Hypokalemic Paralysis is a rare but treatable condition characterized by sudden, severe muscle weakness alongside low serum potassium levels. This syndrome is the most well-known form of periodic paralysis. The first reported case was by Hartwig et al in 1874 [2]. Hypokalemic paralysis encompasses a diverse group of disorders that share a common mechanism, resulting in acute muscle weakness accompanied by significant hypokalemia. [3]

Hypokalemic periodic paralysis (hypoPP) is a condition in which affected individuals may experience paralytic episodes with concomitant hypokalemia (serum potassium <3.5 mmol/L). The paralytic attacks are characterized by decreased muscle tone (flaccidity) more marked proximally than distally with normal to decreased deep tendon reflexes. The episodes develop over minutes to hours and last several minutes to several days with spontaneous recovery.

From aetiological perspective, Hypokalemic periodic paralysis (hypoPP) is a rare channelopathy

caused by skeletal muscle ion channel mutations, mainly affecting calcium or sodium channels. Patients with hypoPP experience a sudden onset of generalized or focal flaccid paralysis associated with low blood potassium levels (or hypokalemia), which can last for several hours before resolving spontaneously. Most cases of hypoPP are hereditary or familial. Prompt diagnosis and prophylactic therapy are crucial to managing hypoPP and avoiding associated morbidity. The evaluation for hypoPP includes excluding secondary causes such as hyperthyroidism through thyroid function tests and monitoring for electrocardiogram abnormalities such as prolonged QT interval.

Based on patient response, treatment for hypoPP should follow a stepwise escalation, focusing on relieving acute symptoms, managing complications, and preventing future attacks. This underscores the importance of a coordinated approach to improving patient outcomes. [4]

Ingrid Gamstorp campaigned vigorously for the non-acceptance of the term's "hypo" and "hyper" kalemic, hypopotassemia, and hyperpotassemia. She narrated as "It is likely that the severity of symptoms is better related to the quotient between the intra and extracellular potassium than to the extracellular level alone. "[5]

Gamstorp was advocating for a more nuanced understanding of potassium imbalances in the body, suggesting that the ratio between intracellular and extracellular potassium levels might be a more accurate predictor of symptoms than just the extracellular concentration alone.

She challenged the conventional terminology used, such as "hypokalemia" (low potassium) and "hyperkalemia" (high potassium), as she believes they might oversimplify the condition. The relationship between intracellular and extracellular potassium is indeed critical, as potassium is primarily an intracellular ion, and disturbances in its distribution can have significant physiological effects, especially on cell function and membrane potentials. [5]

Gamstorp's position likely emphasizes the importance of considering the whole potassium balance in the body, rather than focusing solely on one compartment. This perspective could help refine the clinical approach to diagnosing and managing potassium-related disorders, providing a more comprehensive understanding of the underlying pathology. [5]

Therefore, it is crucial for physicians, especially those in acute care environments, to be well-versed in the causes of hypokalemic paralysis. Additionally, it is essential to consider and rule out other potential causes of acute systemic weakness, which may be neurologic, metabolic, or infectious in nature. Prompt action by physicians in emergency situations can help prevent further deterioration of the patient's condition.

Thus, it is vital for doctors, particularly those in emergency care settings, to understand the underlying causes of hypokalemic paralysis. It is equally important to exclude other possible sources of acute systemic weakness, whether they are neurologic, metabolic, or infectious. Timely intervention by physicians in urgent situations can help prevent the patient's condition from worsening.

The majority of cases are attributed to familial hypokalemic paralysis; however, sporadic cases may be linked to a variety of underlying causes, such as thyrotoxic periodic paralysis, barium poisoning, renal tubular acidosis, primary hyperaldosteronism, liquorice consumption, and gastrointestinal potassium losses. It is crucial to recognize that treatment depends on the specific cause of hypokalemia. Therefore, simple diagnostic tests in the emergency room are essential for making an accurate working diagnosis and preventing mismanagement. [6]

The care of a patient with hypokalemic paralysis involves an extensive assessment to identify the underlying cause, along with the administration of potassium replacement therapy. The primary dangers linked to this condition arise from complications related to hypokalemia, especially irregular heart rhythms and respiratory failure, which are significant factors in the morbidity and mortality associated with the condition.

Hence the approach to the patient with hypokalemic paralysis includes a vigorous search for the underlying etiology and potassium replacement therapy. Further therapy depends on the etiology of the hypokalemia. Disposition depends on severity of symptoms, degree of hypokalemia, and chronicity of disease. Collaborative care can be of much value in its treatment. Timely identification and replacement appear to be the key to therapy. [7]

Hypokalemic paralysis has been underreported in neurological practice. The present study was undertaken to assess the clinical profile and metabolic parameters of these patients and to Identify the various etiological, precipitating factors and diagnostic criteria of hypokalemic periodic paralysis to facilitate accurate diagnosis. Also to see can Collaboration with interprofessional healthcare teams improve the clinical outcome for such patients

Aims and Objectives

This study focuses on patients with hypokalemic periodic paralysis, with the goal of exploring their etiological, clinical, and metabolic characteristics along with role of collaborative care in its management The patients were admitted to the medical wards and intensive care unit of a tertiary

care hospital in Mumbai. The study was carried out over a period of 16 months.

1. To assess the clinical profile and metabolic parameters of these patients.
2. Identify the various etiological and precipitating factors and diagnostic criteria of hypokalemic periodic paralysis to facilitate accurate diagnosis.
3. Can Collaboration with interprofessional healthcare teams improve the clinical outcome for such patients.

Materials and Methods

This prospective observational study was conducted in a tertiary health care centre in greater Mumbai over period of 13 months. This study recruited patients who presented to the emergency department with acute-onset paralysis and documented evidence of hypokalemia."

The study included 49 patients. The objectives, protocol, and investigative processes were thoroughly explained to ensure clear understanding and informed participation to both the patients or their legally acceptable representatives. After meeting the eligibility criteria, written informed consent was obtained following a detailed explanation of the study protocol, and the patients were enrolled in the study.

A thorough history was obtained, covering demographic factors such as age, sex, illness duration, current episode of weakness, and other potential precipitating factors like high carbohydrate intake, vigorous exercise, long starvation, severe diarrhea or vomiting, and other medication use. The number of previous episodes, the patient's occupation, and family history were also documented.

Each patient underwent a detailed clinical examination, and other possible causes of muscular weakness were ruled out. Low serum potassium levels were confirmed. All patients had a baseline ECG along with blood gases. A spot urine sample was collected to evaluate urine potassium levels, calculate the urine potassium-to-creatinine (K/C) ratio, and assess the transtubular potassium gradient (TTKG). Serum bicarbonate levels were measured in patients with normal or low blood pressure, and further investigations were performed based on these findings, as necessary.

A subgroup of patients with low serum bicarbonate levels, urine potassium levels greater than 15 mmol/L, hyperchloremic metabolic acidosis with a normal anion gap, and no signs of gastrointestinal losses, along with a fasting urine pH greater than 5.5, underwent additional tests to rule out other causes as renal tubular acidosis.

Inclusion Criteria

1. All Adult patients presenting with paralysis and diagnosed with hypokalemia (i.e., serum potassium levels < 3.5 mEq/L).
2. Patients willing to give informed consent

Exclusion Criteria

1. Patients with weakness but serum potassium levels > 3.5 mmol/L.
2. Patients diagnosed with conditions leading to muscular weakness due to drug induced, neurologic, infectious, or any other metabolic causes.

Statistical Analysis: Data analysis was done by using appropriate statistical methods.

Ethical Clearance: Ethical clearance to proceed was obtained from the IEC of the teaching institute before commencement of the study. Patients who gave valid informed consent were recruited in the study.

Results

Table 1: Demographic characteristics of study participants

Parameters	
No of cases	49
Age in years Range SD Mean	 18-62 yrs 07.17 26.43
BMI (Kg/Sqm) Range SD Mean	 15.4-27.4 02.46 21.41
Sex (%) Male Female	 39(79.5) 10 (20.5)
Residence Rural (Males)	43 (89%)
Urban (Males)	6 (11%)
Residence Rural (Males)	41(86.1)
Urban (Females)	8 (13.9)

In this study, age of the cases ranged from 18-62 years with average age was 26.43 years. Mean BMI was 21.41 kg/sqm and 86 to 89.0% of total cases were male and 14 to 11% were females (Rural and urban resp.)

Table 2: Hypokalemic Periodic Paralysis (HPP) And Its Other Causes

Hypokalemic Periodic Paralysis (HPP)	40
Non-Hypokalemic Periodic Paralysis (NHPP)	
Diarrhoea	1
Hypomagnesemia	2
Distal renal tubular acidosis	2
Sjogren's Syndrome	1
Toluene exposure	1
Bartter's Syndrome	1
Gitelman's Syndrome	1

Table 3: Overview Of Muscle Weakness

Motor Weakness	Total No of Cases (N=49)	Percentage
Paraparesis	33	67.34
Quadriparesis	10	20.4
Quadriparesis + Truncal involvement	04	08.1
Quadriparesis + Truncal weakness + Respiratory Involvement	02	04.0

67.3% of the total cases had paraparesis motor weakness followed by 20.4% quadriparesis, 8.1% quadriparesis + truncal involvement, 4.0% quadriparesis + truncal weakness + respiratory involvement

Overview Of Warning Symptoms.

Total No. of Cases (N = 49),72.4% cases had warning symptoms and 27.6% had no warning symptoms. The cases had an average duration of 14 hrs of warning symptoms.

Overview Of High Carbohydrate Intake History

The data states that 59.4% of the total cases did not have history of high carbohydrate intake followed by 40.6% had history of high carbohydrate intake.

Table 4: ECG changes

ECG Changes	No. of Patients
Sinus bradycardia	19
U waves	26
Sinus bradycardia with ST depression, U waves, and T wave inversion	3
Increased P wave amplitude with Prolongation of PR interval	1

Table 5: Number Of Earlier Attacks with Hypokalemic Paralysis

No. of attacks	Total No. of Cases (N=49)	Percentage
0	31	63.26
1	12	24.49
2	03	06.12
3	01	02.0
4	01	02.0
5	01	02.0

Above table shows that 63.3% patients of the total cases did not have any previous attacks followed by 24.5% one, 6.1% two, 2.0% three and 2.0 % four and five attacks

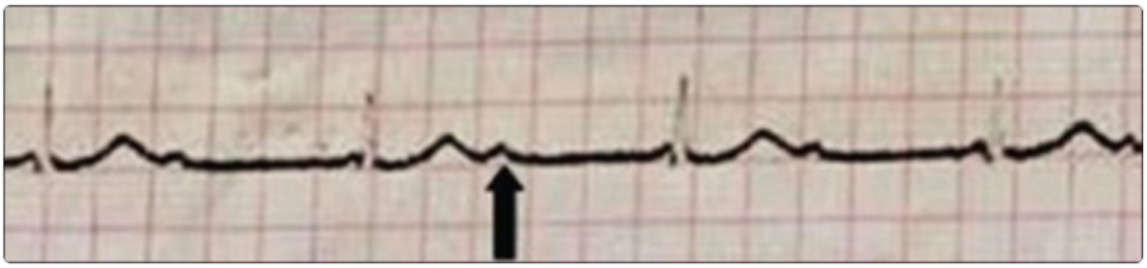

Figure 1: ECG showing bradycardia and U wave (arrow) in a patient with hypothyroidism who had recurrent flaccid quadriplegia with serum potassium of 1.96 mmol/l

Table 6: Comparison Of Changes in Mean Potassium Required Between the Groups

Groups	Mean Potassium (Mean± SD)
HPP (N = 43)	*2.16± 0.43
Non HPP(n=6)	1.43±0.55

By Student 't' Test *P < 0.05 Significant

Mean potassium was 2.16 meql/l among HPP group which was significantly more as compared to 1.43meql/L in non HPP Group

Table 7: Comparison Of Changes in Mean Serum pH Between the Groups

Groups	Mean Serum pH
SPP (N = 41)	7.18 plus/minus 0.07
Non SPP (N = 8)	6.91 plus/minus 0.2

By Student t' Test * P < 0.05 Significant

Mean serum pH was 7.18 among HPP group which was more as compared to 6.91 in Non HPP group and difference was statistically significant.

Table 8: Comparison Of Changes in Mean Urine Potassium Between The Groups

Groups	Mean Urine Potassium (Mean ± SD)
HPP (N=41)	13.19 ±6.48
Non HPP (N = 8)	31.12 ±23.95

By Student 't' Test * P < 0.05 Significant

Mean Urine potassium was 13.19 mmol/L among HPP group which was significantly low as compared to 31.12 mmol/L in Non HPP group.

Table 9: Comparison of change in Mean Bicarbonate between the two groups

Groups	Mean Bicarbonate (Mean ± SD)
HPP (N = 40)	22.91 plus/minus 2.73
Non HPP (N = 9)	16.2 plus/minus 13.53

Student 't' Test P > 0.05 Not Significant

According to this table mean bicarbonate was 22.91 meq/L among HPP group which was more as compared to 17.20 meq/L in Non HPP group, but difference was not statistically significant.

Table 10: Comparison Of Changes in Mean Chloride Between the Groups

Groups	Mean Chloride (Mean ± SD)
HPP (N = 40)	*99.86±04.99
Non HPP (N = 9)	114.21 +08.65

By Student 't' Test *P < 0.05 Significant

This analysis states that mean chloride was 99.86 meql/L among HPP group which was significantly less as compared to 112.11 meql/L in Non HPP group.

Table 11: Comparison of Changes In Mean Urine Potassium Between The Groups

Groups	Mean Urine Potassium (Mean plus/minus S * D) (mmol/L)
HPP (N = 40)	* 13.68 plus/minus 5.99
Non HPP (N = 9)	30.83 plus/minus 24.14

By Student 't' Test * P < 0.05 Significant

Mean Urine potassium was 13.68 mmol/L among HPP group which was significantly low as compared to 30.83 mmol/L in Non HPP group.

Table 12: Comparison Of Changes in Mean Ttkg Between the Groups

Groups	Mean TTKG (Mean ±SD)
HPP (N=40)	2.21 +0.299
Non HPP (N=9)	9.43±8.54

Student 't' Test P>0.05 Not Significant

Above table shows that mean TTKG was 2.21 among HPP group which was low as compared to 9.43 in Non HPP group, but difference was not significant

Table 13: Comparison Of Mean Potassium Required for Treatment Between The Two Groups

Groups	Mean Potassium Required (Mean plus/minus S * D) (meql/L)
HPP (N = 40)	* 57.74 ± 19.32
Non HPP (N = 9)	94 ± 47.38

Student 't' Test *P < 0.05 Significant

Above table shows that mean potassium required was 57.74 meql/L among HPP group which was significantly low as compared to 95.00meql/L in Non HPP group.

Table 15: Comparison Of Changes in Mean Potassium Required with Motor Weakness

Motor Weakness	Mean Potassium Required (Mean plus/minus S * D) (meql/L)
Paraparesis (N = 33) (P)	57.34 ± 19.21
Quadriparesis (N = 10) (Q)	63.8 ± 32.76
Quadriparesis + truncal Involvement (N = 4) (Q + T)	76.5 ± 31.74
Quadriparesis + Truncal +respiratory involvement (N = 2) (Q + T + R)	135 ± 1.2

Table 16: Comparison Of Changes in Mean Recovery Between the Groups

Groups	Mean Recovery (Mean ± SD) (in hours)
HPP (N = 40)	*24.77 +27.56
Non HPP (N = 9)	76.29 +30.73

Student 't' Test *P <0.05 Significant

In this study group mean recovery was 24.77 among HPP group which was less as compared to 76.29 in Non HPP group and difference was statistically significant.

Discussion

This prospective study evaluated patients with hypokalemia presenting with weakness. Individuals with alternative causes of weakness were excluded to focus specifically on manifestations attributable to hypokalemia.

Mild hypokalemia, defined as serum potassium levels between 3 and 3.5 mEq/L, is often asymptomatic. However, as potassium levels drop further, nonspecific symptoms such as generalized weakness, fatigue, and constipation become more prevalent.

In severe cases, hypokalemia may result in critical complications:

- Serum potassium < 2.5 mEq/L: Muscle necrosis may develop.
- Serum potassium < 2.0 mEq/L: Ascending paralysis can occur, potentially leading to respiratory failure.

This study aimed to enhance understanding of the clinical presentation and outcomes associated with hypokalemia, particularly in its more severe forms.

When serum potassium levels drop below 2.5 mEq/L, muscle necrosis may develop. At levels

below 2.0 mEq/L, ascending paralysis can occur, potentially leading to respiratory failure.

The possibility of symptoms may correlate with the rate of decrease in serum potassium, particularly in patients with underlying heart disease. However, cardiac conduction abnormalities are rare, even when serum potassium concentrations fall below 3.5 mEq/L. [8]

In this study, we analysed the clinical features of patients diagnosed with hypokalemic periodic paralysis (HPP), focusing on its underlying causes and precipitating factors.

Among the 49 patients diagnosed with hypokalemic periodic paralysis, we divided them into two groups for clarity and simplicity:

1. Hypokalemic Periodic Paralysis (HPP): Patients with no identifiable cause for hypokalemia.
2. Non-Hypokalemic Periodic Paralysis (Non-HPP): Patients in whom a specific cause for hypokalemia was identified, predominantly due to gastrointestinal or renal potassium losses.

In our study, the mean age of patients was 28 years, with an age range of 17 to 60 years. The mean BMI of the patients was 22.51 kg/m². Of the 49 patients included, 43 were diagnosed with Hypokalemic Periodic Paralysis (HPP).

The remaining 6 patients, classified as non-HPP, had the following diagnoses:

- Distal Renal Tubular Acidosis: 1 patient
- Diarrhea with hypokalemia: 1 patient
- Toluene exposure with secondary distal renal tubular acidosis: 1 patient
- Sjogren's syndrome with distal renal tubular acidosis: 1 patient
- Bartter's syndrome: 1 patient
- Hypomagnesemia: 1 patient

The etiology of Hypokalemic Periodic Paralysis (HPP) varies across different studies:

In our study, the most common cause of Hypokalemic Periodic Paralysis (HPP) was sporadic, with no identifiable cause for hypokalemia in these cases. Similar studies have also found familial or sporadic causes to be the most common [5,6]. The prevalence of specific causes may vary by ethnicity, with thyrotoxic periodic paralysis being the leading cause in China.

In Hypokalemic Periodic Paralysis (HPP), the limb muscles are most commonly affected, particularly the lower limb muscles, with proximal muscles typically involved before distal muscles. Involvement of truncal, bulbar, or respiratory muscles is rare [1]. Deep tendon reflexes may be diminished or absent, while the sensory system and level of consciousness remain unaffected.

Among the patients in our study, 41 experienced warning symptoms, including sensations of heaviness in the legs or back pain. Other reported prodromal symptoms include excessive hunger or thirst, dry mouth, palpitations, sweating, diarrhea, nervousness, and a sense of weariness or fatigue [1,2]. The majority of patients in the HPP group exhibited warning symptoms, which were also noted in a similar study by Lin Sh et al. [9]

The mean duration of these symptoms was approximately 13 hours before patients presented with clinical weakness.

The majority of patients (n=31) presented with attacks early in the morning. The weakness typically began in the lower limbs and then spread to the upper limbs over a mean duration of 13 hours. None of these patients had a family history of similar illness.

In our study, ECGs revealed that 19 patients had sinus bradycardia, 26 exhibited U waves, and 3 showed a combination of sinus bradycardia, ST depression, U waves, and T wave inversion and 1 patient had Increased P wave amplitude with prolongation of PR interval

However, despite serum potassium levels dropping as low as approximately 2 mmol/L, none of the patients developed significant cardiac arrhythmias.

In contrast, Johnsen's study [10] of 106 Danish patients with HPP found that two patients experienced transient diastolic murmurs during paralysis, while another had a transient, partial A-V block. He also noted that some patients developed bradycardia and other unspecified arrhythmias during episodes.

In our study, 41 patients reported warning symptoms, including feelings of heaviness in the legs or back pain. Other prodromal symptoms previously documented include excessive hunger or thirst, dry mouth, palpitations, sweating, diarrhea, nervousness, and fatigue [1,2]. Most patients in the HPP group experienced such early warning signs.

The results were in line with Lin Sh et al. [9], with a mean duration of approximately 13 hours before the onset of clinical weakness.

The majority of patients (n=31) experienced attacks in the early morning. Weakness initially affected the lower limbs and then progressed to the upper limbs, with a mean duration of 13 hours. Notably, none of the patients had a family history of similar conditions.

In our study, a history of high carbohydrate intake was found in only 38% of patients (n=16), all of

whom were in the HPP group. High carbohydrate diets are known to trigger attacks of hypokalemic weakness; however, similar findings were not observed in other studies. Reasons for this dissimilarity has not been analysed.

Regarding ECG findings, 20 patients showed sinus bradycardia, 28 had U waves, and 4 had a combination of sinus bradycardia, ST depression, U waves, and T wave inversion.

Despite serum potassium levels dropping to as low as approximately 2 mmol/L, none of the patients developed cardiac arrhythmias in our study.

Not much studies have correlated the degree of hypokalemia with ECG changes, however a case report by Sagray E et al reported Cardiac arrhythmias in primary hypokalemic periodic paralysis. [10]

Additionally, there is not many studies where ECG findings have been used to diagnose hypokalemia before serum potassium levels are available from lab however in this study, no correlation could be established between ECG changes and the degree of weakness present.

The most common ECG finding in our study was the presence of U waves. Whether ECG changes can aid in the management of patients with HPP remains an area for further research, however certain studies suggest that ECG findings may not correlate with serum potassium levels, and hence it is suggested clinicians not to rely heavily on ECG findings for diagnosis of hypokalemia; it should be used for identifying cardiac rhythm abnormalities and subsequent prognostication and as a supportive diagnostic tool in such patients. [11]

Among all the patients, 16 experienced repeated attacks. Of these, 8 patients had two repeated attacks, 4 had two attacks, 2 had three attacks, and 1 patient had four and five attacks, respectively.

In our study, 36 cases of primary hypokalemic periodic paralysis were identified, with no apparent cause for hypokalemia despite extensive investigations. No antecedent disease was found in these cases. These patients showed complete recovery without any neurological deficits upon potassium replacement.

In our study, two patients with hypokalemic periodic paralysis exhibited secondary hypokalemia due to diarrhea. These patients presented with multiple episodes of diarrhea. Investigations revealed hypokalemia, hyperchloremic metabolic acidosis, and extra-renal potassium loss. Notably, the negative urinary anion gap suggested preserved function of urine acidification, which helped differentiate the condition from a renal cause of acidosis. This finding underscores the role of gastrointestinal losses in potassium depletion, rather than renal dysfunction.

Diarrhea can lead to clinically significant potassium depletion, irrespective of the underlying cause, whether it be infectious diarrhea or side effects of cancer chemotherapy. As stool volume increases, the potassium concentration within the stool decreases. However, substantial quantities of potassium may still be lost due to the volume of stool produced. This loss can result in hypokalemia and its associated symptoms, including quadriparesis.

In a broader cohort of 60 patients presenting with quadriparesis, 70% were found to have hypokalemia, with 58% of those cases attributed to gastroenteritis as the underlying cause of hypokalemia. These findings further reinforce the need to consider gastrointestinal causes of electrolyte imbalances when evaluating patients with hypokalemia, particularly those presenting with gastrointestinal symptoms like diarrhea.

In our study, two patients were diagnosed with distal renal tubular acidosis (dRTA). The clinical presentations included hypokalemia, hyperchloremic metabolic acidosis with a normal anion gap, and alkaline urine despite severe metabolic acidosis, along with a positive urine anion gap. Ultrasonography (USG) of the abdomen was performed to identify nephrocalcinosis.

The second patient also presented with rickets. Additionally, one of the patients was diagnosed with Sjögren's syndrome associated with hypokalemic periodic paralysis. This patient underwent further evaluation, which confirmed dRTA. Given her complaints of dry eyes, Schirmer's test was conducted and was positive (wetting <5 mm). The patient experienced a rapid recovery following correction of the metabolic imbalance with intravenous potassium, which was subsequently transitioned to oral potassium citrate. She was then prescribed oral bicarbonate, potassium supplements, and methylcellulose eye drops for ongoing management.

Two patients in our study were diagnosed with dRTA secondary to toluene exposure, commonly associated with the use of paint thinners [13]. The patient presented with a history of paint thinner ingestion, quadriparesis, and respiratory failure. Laboratory investigations revealed severe hyperchloremia, hypokalemia, and metabolic acidosis. The acidosis was identified as a normal anion gap acidosis with a positive urine anion gap. Further evaluation confirmed a renal potassium-wasting disorder and alkaline urine, despite the presence of severe metabolic acidosis.

Complications of toluene poisoning include a spectrum of electrolyte and acid-base disturbances, gastrointestinal symptoms such as abdominal pain

and hematemesis, and neuropsychiatric manifestations, including altered mental status, cerebellar abnormalities, and peripheral neuropathy [10].

One patient in our study was diagnosed with Bartter's syndrome. The patient presented with hypokalemia and metabolic alkalosis, and investigations revealed renal potassium loss. Additional findings included hypocalcemia and hypercalciuria. Given the presence of normal blood pressure alongside metabolic alkalosis and hypokalemia, and after ruling out diuretic abuse by confirming the absence of chloride wasting, the diagnosis of Bartter's syndrome was established.

Another patient was diagnosed with Gitelman syndrome. This patient presented with hypokalemia and metabolic alkalosis. Investigations revealed renal potassium wasting associated with hypomagnesemia, hypocalcemia, and the absence of calciuria.

All patients in our study underwent thyroid function test but no patients were detected to have thyrotoxic periodic paralysis. However, thyrotoxic periodic paralysis is an important cause of hypokalemic periodic paralysis in South-east Asian region as China.

A study was conducted [14] involving 34 patients who presented to the emergency department with hypokalemic paralysis over a three-year period. None of the patients had a history of hyperthyroidism prior to the attack or a family history of paralysis. All participants demonstrated low potassium excretion rates.

In our study, we observed that severe potassium loss was associated with respiratory muscle involvement. Notably, two patients required ventilatory support due to respiratory failure. Although respiratory failure is a rare occurrence in patients with hypokalemic periodic paralysis (87.88), we found that respiratory muscle weakness correlated with significantly low mean serum potassium levels. These findings were not observed in similar studies.

The rarity of respiratory muscle involvement and its potential relationship with serum potassium levels remain subjects for further research.

Patients with secondary hypokalemic periodic paralysis thus have acid- base disturbances. Thus, patient with hypokalemic periodic paralysis should be investigated for secondary causes for periodic paralysis. It is important at this point to note that the further investigation differ depending on nature of acid-base disorder. Hyperchloremic metabolic acidosis form a major group of patients with non HPP which include (gastrointestinal loss, RTA). Hyperchloremia thus help in differentiation of this disorder from HPP.

Mean Urine potassium was 13.68 mmol/L among HPP group which was significantly low as compared to 30.83 mmol/L in Non HPP group. Thus, Renal and extra renal loss of potassium can safely be differentiated on basis of urinary potassium excretion. In non-HPP group the renal and extra-renal loss can be differentiated by urinary potassium excretion. Random measurement of the urinary potassium concentration is simple to perform but may be less accurate than a 24-h collection, since it is influenced by two independent factors, potassium secretion and water reabsorption in the medulla.

In our study mean TTKG was 2.21 among HPP group which was low as compared to 9.43 in Non HPP group, but difference was not statistically significant.

In study conducted by Joo KW it was found that TTKG is an important predictor to differentiate between renal and extra renal loss of potassium. It was found that higher TTKG correlated well renal potassium loss and high aldosterone levels in serum.

It was noted in our study that the amount of mean potassium required for treatment in HPP group was around 60 meql/L as compared to around 100 meql/L in non-HPP group which was statistically significant. It should be noted that less potassium is required for recovery in primary hypokalemic periodic paralysis

The clinical implication is to be cautious while using potassium in HPP as there are chances of rebound hyperkalaemia.

There was no relation found in amount of potassium required for treating weakness and the degree of neurological weakness that is present.

The attacks in Hypokalemic periodic paralysis usually recovery within few hours but some residual paralysis do remain which may take days to recover. The recovery time required for patients with secondary Hypokalemic periodic paralysis is larger than patients with primary hypokalemic periodic paralysis)

In similar study Maurya noted that recovery time was greater in patients with secondary hypokalemic periodic paralysis. Whether this increase recovery time is related to greater potassium loss (as compared to HPP), greater amount of potassium that is required for correction or ongoing renal loss of potassium is not known.

Two of our patients only had partial recovery on discharge but were of non HPP group. Partial recovery or residual weakness in postulated to occur in patient with primary hypokalemic periodic paralysis

Six patients in our primary hypokalemic periodic paralysis group had more than two repeat attacks of

motor weakness These patients were started on acetazolamide.

In similar study Griggs et al [15] found that in addition to eliminating attacks of weakness, acetazolamide also improved inter attack weakness in 8 of 10 affected patients. Similar findings were noted by Rao et al, and Sushil et al [16]

Although the treatment of choice in periodic paralysis is generally considered to be acetazolamide, there is no standardised treatment regimen and no consensus as to when to start treatment. We do not know if acetazolamide treatment prevents any permanent weakness that may occur. We did not find other randomised or quasi-randomised studies, but only case reports and anecdotal articles using other drugs to reduce paralyses attacks Further more robust research is needed to determine the best treatment for reducing the frequency and severity of attacks and to treat or prevent permanent muscle weakness

The mechanism of action in HPP group is not known. It did not appear to affect serum potassium, total body potassium, total body sodium, blood pH, nor was the agent shown to affect muscle excitability directly) Acetazolamide is kaliuretic but usually prevents precipitation of attacks by induction of mild acidosis. Some patients have worsened on treatment with acetazolamide thus acetazolamide may not work in all patients in such patient's triamterene, spironolactone [1] both of which are potassium sparing diuretics. Dicholorophenamide is potent carbonic anhydrase inhibitor which can be used when acetazolamide does not bring improvement The exact dose of acetazolamide is considered to be but 250 mg thrice daily as optimal, the dose for dicholorophenamide is 50-150mg/day. Acetazolamide should be avoided in patients with Renal tubular acidosis (RTA) as it may worsen RTA associated periodic paralysis due to its kaliopenic effect however disputed evidence are available in literature as one study concludes as there are no consensus statements for the treatment and acetazolamide has been the therapy of choice since five decades. Spironolactone is an important alternative of CAIs; however, androgenic side effects limit its use. If carbonic anhydrase inhibitors are not tolerated or not effective after prolonged use, alternatives include potassium-sparing diuretics such as triamterene, spironolactone, or eplerenone.[17]

An interprofessional healthcare team comprising hospitalists, nurses, dieticians, pharmacists, and geneticists collaborates to provide comprehensive care for managing hypoPP. [18]

This collaborative approach to managing hypoPP through an interprofessional healthcare team can significantly enhance patient outcomes across various healthcare settings. The holistic treatment goals aim to identify and mitigate triggering factors, manage acute manifestations, prevent complications, and reduce the frequency of muscle weakness attacks. [18]

This comprehensive management requires coordinated care involving hospitalists, nursing staff, dieticians, pharmacists, and geneticists. Thus, it is crucial to meticulously identify specific triggers and take proactive measures to avoid them to prevent future episodes of weakness.

Genetic testing is used to identify mutations in primary hypoPP, especially when the likelihood of a genetic cause is high. However, it is noteworthy that not all mutations may be identified through genetic testing, as some remain genetically undetermined. In cases where genetic testing fails to reveal a mutation, provocative testing and EMG can be valuable tools to guide diagnosis and further characterize the condition. [4]

This approach aims to improve patient outcomes by identifying and avoiding triggers, treating manifestations and complications, and reducing future attacks through monitoring for complications, dietary adjustments, medication management, and genetic testing for at-risk individuals.

The nursing staff is critical in closely monitoring patients during hospitalization to prevent life-threatening complications related to hypokalemia or potassium treatment. Dieticians contribute by modifying diets to reduce the risk of future attacks triggered by large carbohydrate meals. Pharmacists are essential for ensuring correct potassium dosing and administration, managing drug interactions, and ensuring medication reconciliation for optimal therapeutic outcomes. Creating a safe environment within patient rooms can prevent secondary complications such as falls during muscle weakness attacks. Couples with a positive family history of hypoPP who plan to conceive may benefit from prenatal genetic testing, which can be offered as part of comprehensive care [4]

Moreover, targeting the primary etiology prevents future complications and is cost effective in the long run. A coordinated, multidisciplinary approach involving neurologists, nephrologists, and dietitians is critical for improving long-term outcomes in hypoPP patients. It highlights the importance of both immediate symptom relief and long-term preventative care. Such collaborative approach can go a long way in better treatment outcome in patients of HPP.

Conclusion

1. **Epidemiology:**
    - Predominantly affects males.
    - Typical age of onset: 18–30 years.

2. **Presentation and Symptoms**:
    - Weakness episodes typically begin early in the morning after waking.
    - Paraparesis is the most frequent presentation; complete paralysis is rarely noted
    - Respiratory muscle involvement is not that commonly seen.
    - Some patients experience fatigue and muscle aches before the onset of weakness, though episodes can occur without warning.
    - High-carbohydrate meals may trigger attacks, but such history is not always found in patients
3. **Primary HPP**:
    - Most prevalent cause of hypokalemic periodic paralysis.
    - Primarily affects males than females.
    - Onset commonly occurs between 18–26 years of age.
4. **Electrocardiographic (ECG) Changes**:
    - ECG abnormalities indicative of hypokalemia is often detected when serum potassium levels fall below 3.0 mEq/L.
    - The ECG is an essential part of the diagnostic toolkit but should be viewed as a complementary, not definitive, method for managing hypokalemia. Proper integration of ECG findings with clinical and laboratory assessments ensures better patient outcomes.
5. **Secondary Causes**:
    - Include conditions such as:
        - Renal tubular acidosis.
        - Gastrointestinal potassium loss (with associated hypomagnesemia).
        - Bartter syndrome and Gitelman syndrome.
    - Hypokalemic paralysis with acid-base disturbances should prompt evaluation for these secondary causes as soon as possible.
6. **Diagnostic Considerations**:
    - Genetic testing may not be helpful for diagnosing primary hypokalemic periodic paralysis (HPP).
7. **Interprofessional collaboration**: Collaborate with interprofessional healthcare teams to optimize patient outcomes, minimize disease-related complications, and provide comprehensive care for patients with hypokalemia periodic paralysis.

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