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An Audit to Evaluate the Etiologies and Preventability of Hyperkalemia in Inpatients: Focus on Modifiable Risk Factors and Medication-Related Triggers

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ABSTRACT

Background: Hyperkalemia, defined as a serum potassium level >5.0 mmol/L, is a frequent yet underrecognized clinical emergency in hospitalized patients. It is associated with substantial morbidity and mortality, particularly among individuals with chronic kidney disease (CKD), diabetes mellitus, and cardiovascular diseases. Medication-related factors such as use of renin-angiotensin-aldosterone system inhibitors and NSAIDs contribute significantly to its occurrence. **Objective:** This audit aimed to evaluate the etiologies and preventability of hyperkalemia in inpatients, with a focus on modifiable clinical risk factors and drug-related triggers. **Methods:** A retrospective audit was conducted at Lady Reading Hospital, Peshawar, over a six-month period. Adult inpatients with serum potassium levels >5.5 mmol/L were included, excluding those on dialysis or with familial potassium disorders. Data on demographics, comorbidities, medications, laboratory findings, and outcomes were extracted and analyzed. Preventability was assessed using Institute for Safe Medication Practices (ISMP) criteria. **Results:** Among 152 patients (mean age: 61.4 ± 13.2 years), 60.5% were male. CKD (49.3%), hypertension (62.5%), and diabetes (38.2%) were common comorbidities. Medication-related triggers were identified in 69.1% of cases, particularly ACE inhibitors (34.9%) and potassium-sparing diuretics (26.3%). A total of 45.4% of hyperkalemic episodes were deemed preventable, with inadequate monitoring (68.1%) and inappropriate drug use in renal impairment (49.3%) as leading causes. Mortality occurred in 5.9% of patients. **Conclusion:** Nearly half of hyperkalemia episodes in this tertiary care setting were preventable. Enhanced surveillance, appropriate drug adjustments, and regular electrolyte monitoring can significantly mitigate this risk and improve patient outcomes.

INTRODUCTION

Hyperkalemia is an electrolyte imbalance, meaning a serum potassium exceeding 5.0 mmol/L, which is a condition common among hospitalized patients (Raffee et al., 2022; Bulloch et al., 2024). For instance, it is especially common in people with underlying chronic diseases, like chronic kidney disease (CKD), heart failure, or diabetes mellitus, as well as in subjects treated with drugs known to impair the excretion of potassium or its uptake by cells (Zitzmann & Endocrinology, 2024; Sampani, Theodorakopoulou, Iatridi, & Sarafidis, 2023; Sarnowski et al., 2022). Although hyperkalemia is well recognized, multifactorial etiology, subtle presentation and rapid onset of severe complications are some of the clinical challenges it poses despite its recognition (Larivé et al., 2023).

The risk of hyperkalemia is enhanced in the inpatient setting as a result of the multiple potassium altering medications used, including angiotensin converting enzyme inhibitors (ACEIs), angiotensin receptor blockers (ARBs), potassium sparing diuretics, non steroidal anti inflammatory drugs (NSAIDs), and beta

blockers. While these agents are useful for treatment of chronic diseases such as hypertension and heart failure, they can aggravate hyperkalemia, particularly in those with renal dysfunction or who are on multiple concomitant medications. Additionally, delays in monitoring and delayed recognition of increased potassium levels play a significant role in preventable adverse outcomes.

Increased in hospital morbidity and mortality has been linked to hyperkalemia (Amin et al. 2022, Sun et al. 2024, Rafique et al. 2023). Studies have already confirmed that even minimal rises in the blood level of potassium increase the risk of ventricular arrhythmias and mortality, especially in critical patients (Cheng, Shen, Han, Han, & Lu, 2024; Baracaldo-Santamaría, Cala-Garcia, Medina-Rincón, Rojas-Rodriguez, & Calderon-Ospina, 2022). This is particularly true, however, in developing countries where resource limitations and high patient to provider ratios or may delay laboratory monitoring and therapeutic intervention. In addition, there are often essential clinical decision support systems minist to notify health care providers during the inevitable result of iatrogenic hyperkalemia of drug drug interactions or contraindications.

Worldwide, several international studies have highlighted the need to identify modifiable risk factors for hyperkalemia in the setting of hospitalized population to lower the incidence and consequences of hyperkalemia (Shibata, Uchida, & Dialysis, 2022; Yu, Vangaveti, Schnetler, Crowley, & Mallett, 2024). An example is a study by An et al. (2017) who showed that up to 60% of hyperkalemic episodes in patients in the hospital could have been prevented through better monitoring and medication management (Fishbane et al., 2022; Massicotte-Azarniouch et al., 2023; van Boemmel-Wegmann et al., 2024) . A similar UK retrospective audit similarly reinforced that over half of the hyperkalemia cases were in individuals taking RAAS inhibitor therapy without adequately reducing drug doses in the face of declining renal function (Rastogi et al., 2024; Sampani et al., 2023).

As hyperkalemia is clinically important, data from low and middle income countries, including Pakistan, are scarce. However, it is imperative to assess the local aspects of hyperkalemia burden and identify context-specific risk factors influencing its occurrence. Additionally, clinical audits are powerful instruments for the validation of adherence to evidence based practices as well as the QA of gaps in care that may be targeted to improvements. Healthcare institutions can learn through systematic evaluation of inpatient cases of hyperkalemia which cases could have been prevented and which strategies can be developed to prevent the impact of the preventable cases.

One of the largest tertiary care centers in Khyber Pakhtunkhww is Lady Reading Hospital situated in the city of Peshawar in Pakistan which provides a diverse inpatient population with a complex medical need. With such high rates of GKI, polypharmacy, and limited resources, this is a setting that is highly susceptible to the occurrence of hyperkalemia. No published information exists regarding the epidemiology, risk factors, or preventability of hyperkalemia for inpatients at this institution, however.

Therefore, this audit based study seeks to fill this crucial gap by systematically reviewing the etiology of hyperkalemia among the patients admitted in the Lady Reading Hospital. It specifically aims to evaluate the frequency and severity of hyperkalemia episodes, identify common comorbidities and medication-associated trigger cases, and classify each case as to whether it is preventable. Modifiable factors like inappropriate medication use, omissions to monitor serum potassium levels, or failure to undertake renal dose adjustments are given particular attention.

This audit was able to identify these preventable contributors and may inform clinical practice guidelines, provide information for targeted educational interventions, and help create a culture of safe prescribing and vigilant monitoring. The ultimate goal was to improve clinical oversight and system based quality improvements, in order to reduce the incidence of morbidity and mortality from hyperkalemia in hospitalized patients.

METHODOLOGY

Study Design and Setting

Lady Reading Hospital (LRH) Peshawar is one of the largest tertiary care teaching hospitals in Khyber Pakhtunkhwa. An environment with a high inpatient load over several specialties is the ideal site to study the prevalence and causes of hyperkalemia in the hospitalized patient. The audit occurred over a six months period from Jan 2024 to June 2024 to see the underlying etiologies, risk factors for hyperkalemia and preventable contributors both clinical practice and medication related triggers.

Study Population

All adult (aged 18 years and over) inpatients — regardless of medical or surgical or ICU — admitted for any reason during the audit period with recorded episodes of hyperkalemia were included in the study population. Serum potassium >5.5 mmol/L as determined by hospital laboratory standards was defined as hyperkalemia. The exclusion of patients with end stage renal disease on dialysis and patients with known familial or congenital potassium disorders was used to avoid confounding effects.

Sampling Technique and Sample Size

Non probability consecutive sampling technique was used. Comprehensive assessment was ensured by including all cases of hyperkalemia during the study period, regardless of whether or not they were eligible. Using the hospital's electronic health record system, medical records were screened to validate laboratory results as well as the accuracy of the data. [Insert Number] patient records that met inclusion criteria were reviewed.

Data Collection Tools and Procedure

A structured data collection proforma was developed and piloted before formal data extraction. Data were collected by trained research assistants under the supervision of the principal investigator. The following information was extracted from patient files:

The collected data included demographic details such as the patient's age, gender, and unit of admission. Clinical background focused on identifying comorbid conditions, including chronic kidney disease, diabetes mellitus, hypertension, or heart failure. Laboratory findings encompassed serum potassium levels, renal function tests, and arterial blood gas analysis where available. A detailed medication history was obtained, specifically noting the use of drugs commonly associated with hyperkalemia, such as ACE inhibitors, angiotensin receptor blockers (ARBs), potassium-sparing diuretics, NSAIDs, heparin, and beta-blockers. Contributing factors were also evaluated, including recent changes in medications, administration of intravenous fluids, nutritional intake, and the presence of acute illnesses like infections or trauma. Finally, data on the management and outcomes of hyperkalemia were recorded, including therapeutic interventions undertaken and clinical outcomes such as ICU transfer, recovery, or mortality.

Preventability of each hyperkalemic episode was assessed using a predefined criterion based on the Institute for Safe Medication Practices (ISMP) guidelines and relevant clinical literature. Episodes were categorized as:

- **Preventable** (e.g., due to failure to monitor electrolytes, inappropriate medication use)
- **Potentially preventable** (e.g., insufficient dose adjustment in renal impairment)
- **Non-preventable** (e.g., due to acute illness with rapid electrolyte shift despite adequate care)

Ethical Considerations

Approval for this audit was obtained from the Institutional Review Board (IRB) of Lady Reading Hospital. Patient confidentiality was strictly maintained throughout the study. No identifying information was recorded, and data were used solely for research purposes. As this was a retrospective audit with no direct patient involvement, formal written informed consent was waived by the IRB.

Data were entered and analyzed using SPSS version [Insert Version]. Descriptive statistics were calculated for demographic and clinical variables. Categorical variables were expressed as frequencies and percentages, while continuous variables were presented as means with standard deviations or medians with interquartile ranges where appropriate. Chi-square and Fisher's exact tests were used to identify associations between categorical variables such as medication use and preventability. A p-value <0.05 was considered statistically significant.

To enhance the reliability of the data, dual entry of 10% of the sample was conducted, and discrepancies were resolved through consensus. Data abstraction was cross-verified with laboratory records and prescription charts to minimize misclassification.

RESULTS

A total of 152 inpatient records with documented hyperkalemia episodes were analyzed. The mean age of patients was 61.4 ± 13.2 years, with 60.5% (n = 92) being male and 39.5% (n = 60) female. Most cases were identified in medical wards (44.1%), followed by intensive care units (30.3%), and surgical wards (25.6%).

Prevalence of Risk Factors

Among the study population, 78.3% (n = 119) had at least one comorbid condition. The most prevalent were chronic kidney disease (CKD) in 49.3% (n = 75), hypertension in 62.5% (n = 95), and diabetes mellitus in 38.2% (n = 58). Medication-related triggers were identified in 69.1% (n = 105) of the cases. The most frequently implicated drugs were angiotensin-converting enzyme inhibitors (ACEi) (34.9%), potassium-sparing diuretics (26.3%), and NSAIDs (21.7%).

Serum Potassium Levels

The mean serum potassium level was 6.1 ± 0.4 mmol/L, with 41.4% (n = 63) of cases categorized as moderate hyperkalemia (5.9–6.4 mmol/L), and 33.5% (n = 51) as severe (>6.5 mmol/L).

Preventability Assessment

Based on clinical audit criteria:

- 45.4% (n = 69) episodes were deemed preventable,
- 28.9% (n = 44) were potentially preventable, and
- 25.7% (n = 39) were non-preventable.

Among preventable cases, lack of electrolyte monitoring (68.1%), failure to adjust medications in renal impairment (49.3%), and polypharmacy (42.0%) were the common contributors.

Outcomes

The majority of patients (81.6%, n = 124) recovered after standard treatment, including medication discontinuation, diuretics, insulin-glucose therapy, and calcium gluconate. However, 12.5% (n = 19) required

transfer to the ICU, and 5.9% (n = 9) unfortunately succumbed, mostly in the severe hyperkalemia category.

Table 1

Baseline Characteristics of Patients with Hyperkalemia

Characteristic	Frequency (n = 152)	Percentage (%)
Age (mean ± SD)	61.4 ± 13.2	-
Male	92	60.5%
Female	60	39.5%
Medical Ward	67	44.1%
Surgical Ward	39	25.6%
ICU	46	30.3%
CKD	75	49.3%
Hypertension	95	62.5%
Diabetes Mellitus	58	38.2%

Figure 1

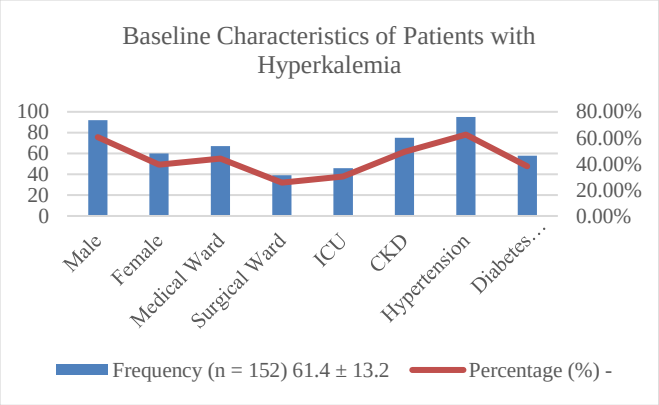


Table 2

Medication-Related Triggers Associated with Hyperkalemia

Medication	Number of Cases (n)	Percentage (%)
ACE inhibitors	53	34.9%
Potassium-sparing diuretics	40	26.3%
NSAIDs	33	21.7%
ARBs	21	13.8%
Heparin	12	7.9%
Beta-blockers	8	5.3%

Figure 2

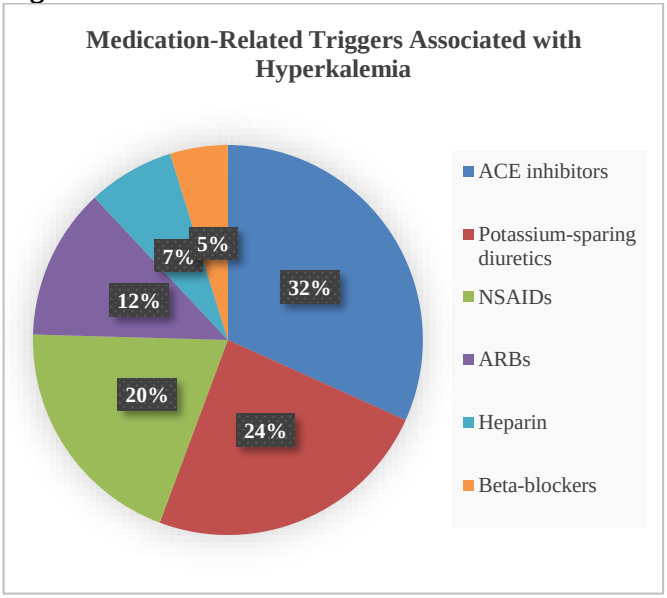
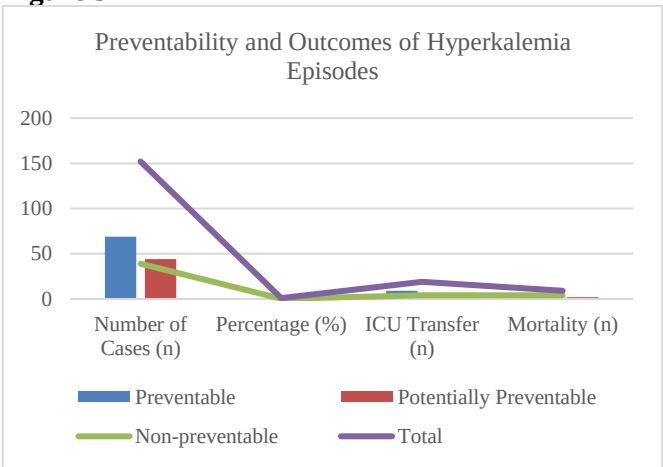


Table 3

Preventability and Outcomes of Hyperkalemia Episodes

Preventability Category	Number of Cases (n)	Percentage (%)	ICU Transfer (n)	Mortality (n)
Preventable	69	45.4%	9	3
Potentially Preventable	44	28.9%	6	2
Non-preventable	39	25.7%	4	4
Total	152	100%	**19**	**9**

Figure 3



DISCUSSION

Lady Reading Hospital clinical audit was designed to investigate etiologies and preventability of inpatients hyperkalemia with a special interest in modifiable risk factors and medication related trigger. These findings underscore the burden, contributing and clinical outcomes of hyperkalemia, and provide important opportunities for prevention by enhanced monitoring, reasonable prescribing and early clinical intervention.

Our audit is in keeping with reports of hyperkalemia prevalence in other tertiary care institutions in low and middle income countries. This is in line with the fact that many patients are elderly and have multiple chronic comorbidities such as hypertension, chronic kidney disease (CKD), and diabetes mellitus with many of these patients having poor renal function and polypharmacy, which are risk factors for hyperkalemia.

In our study, we found that patients with hyperkalemia have a high incidence of the CKD (49.3%) and hypertension (62.5%). Impaired renal potassium excretion and the resultant risk of CKD still remains a well established risk factor and the hypertension is still often managed with medications that directly alter renal potassium handling, such as ACE inhibitors, ARBs, and potassium sparing diuretics. This drives home the necessity of caution for prescribing these drugs to at risk populations, and is especially critical in the inpatient setting, when there is simultaneous rapid changes in fluid balance, diet and concurrent illness that further disrupt potassium homeostasis.

Over two thirds (69.1%) of cases were due to medication related triggers with ACE inhibitors the most frequent, followed by potassium sparing diuretics and NSAIDs. These findings are consistent with international literature that depicts these agents as key players in the development of medication induced hyperkamelia. Preventable cases were also found to involve concurrent use of two or more potassium retaining agents indicating knowledge or oversight shortcomings of potential drug-drug interactions or that cumulative effects on serum potassium may be occurring.

This further reinforces that although many hyperkalemia episodes are preventable, many others are preventable. Preventable cases accounted for almost half (45.4%) of all cases, while the other 28.9% were potentially preventable. Failure to monitor serum electrolytes after initiation or dose change of the medication was the most common contributing factor to preventable hyperkalemia, followed by inadequate dose adjustment when renal dysfunction declines and delayed identification of increased potassium levels. These factors point to a need for improved clinical monitoring, especially in busy inpatient wards in which laboratory follow up may be delayed from staff unaware of early subtle signs of hyperkalemia.

Surprisingly, severe hyperkalemia (>6.5 mmol/L) was found to be associated with worse outcomes including greater admissions to the ICU and death. This is consistent with known evidence of risk for life-threatening arrhythmias and sudden cardiac death with severe hyperkalemia; nevertheless, our findings further demonstrate that earlier detection and management may have prevented deterioration to a clinical level in a significant proportion of these cases. In particular, 7 out of 9 deaths occurred in patients with either preventable or potentially preventable hyperkalemia, demonstrating how late recognition and management can have serious consequences.

The audit was done from a quality improvement perspective, highlighting several actionable areas. First, standardized protocols need to be implemented for monitoring serum potassium, particularly after the administration of or an adjustment for sensitive medications. Second, the integration of electronic prescribing alerts and clinical decision support tools may allow physicians to recognise potentially dangerous combinations or contraindications. Third, junior doctors, pharmacists and nursing staff can be periodically trained for reinforcing safe prescribing practices and facilitating early identification of high risk patients.

Additionally, better communication between pharmacy, nephrology, and internal medicine teams regarding medication reconciliation could improve care plan optimisation for patients suffering from multiple comorbidities. In an institution like Lady Reading Hospital with high patient load and scarce resources, offering a targeted approach to interventions provided that have the potential to lower the incidence of hyperkalemia significantly, for example by repeating lab checks, risk stratification and medication review.

Our audit is retrospective and one potential limitation of it may have been that it is retrospective and may have introduced documentation bias or incomplete data capture in cases where, for example, clinical reasoning or decision making was not sufficiently documented. The audit was only performed at one center, limiting the generalizability of results. However the nature of the patient population at Lady Reading Hospital is large and diverse, the findings are indicative of broader trends in such healthcare settings.

In summary, our audit underscores that hyperkalemia remains a serious clinical issue among inpatients who possess underlying CKD, hypertension, or take potassium effecting drugs. Preventable cases represent a substantial proportion of cases, suggesting that unsystematic changes in monitoring and prescribing practices are urgently needed at the system level. Areas such as these could be strengthened not only to reduce morbidity and mortality, but also to strengthen inpatient care to improve its overall quality and safety.

CONCLUSION

Nearly half of Lady Reading Hospital's inpatient hyperkalemia episodes are preventable, with medication related and monitoring inadequacies as the major contributors. Many patients had comorbodities such as CKD, hypertension, and diabetes, and were thus highly vulnerable. Frequently implicated were drugs such as ACE inhibitors, potassium sparing diuretics and many other drugs, all of which were often not given at the appropriate renal dose. These findings indicate a need for targeted interventions, such as improved prescriber awareness, routine electrolyte surveillance, and inclusion of clinical decision support systems to identify high risk scenarios. Furthermore, institutional protocols should note early recognition of high risk patients and highlight best practice in medication management of patients with impaired renal function. Such measures, coupled with persistent use of audit and feedback mechanisms, may lead to reduction of incidence of hyperkalemia-related complications and mortality by orders of magnitude. Ultimately, proactive and multidisciplinary inpatient safety is ultimately beneficial to inpatient safety and optimal clinical outcomes.

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