The North African Journal of Scientific Publishing (NAJSP)
مجلة شمال إفريقيا للنشر العلمي (NAJSP)
E-ISSN: 2959-4820
Volume 4, Issue 1, 2026
Page No: 133-139
Website: https://najsp.com/index.php/home/index
SJIFactor 2024: 5.49 معامل التأثير العربي (AIF) 0.69 :2025 ISI 2024: 0.696

Assessment of Serum Sodium and Potassium Levels and Their Relationship with Electrolyte Imbalance in Lung Cancer Patients

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تقييم مستويات صوديوم وبوتاسيوم المصل وعلاقتها باختلال الشوارد لدى مرضى سرطان الرئة

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Received: December 27, 2025	Accepted: January 28, 2026	Published: February 07, 2026

Abstract

Lung cancer remains among the most prevalent malignancies and is often accompanied by metabolic derangements, notably electrolyte imbalances, which can compromise patients' overall clinical status and potentially influence disease trajectory. This study sought to (i) quantify serum sodium and potassium concentrations in individuals with lung cancer, (ii) examine their associations with age, and (iii) compare these measures with those observed in an apparently healthy control cohort. The investigation included 43 patients with a confirmed diagnosis of lung cancer (age range: 33–90 years) receiving care at the National Cancer Treatment Center in Misurata, and 24 age-comparable healthy participants. Venous blood specimens were obtained, and serum was isolated in accordance with standard laboratory protocols. Serum sodium and potassium were determined using the ion-selective electrode (ISE) technique. Statistical analyses were performed in SPSS; results were summarized as mean ± standard deviation, between-group comparisons were conducted using the independent-samples t-test, and age-related associations were assessed via Pearson's correlation coefficient, with significance defined as $P < 0.05$. The analyses demonstrated a statistically significant reduction in serum sodium among lung cancer patients relative to controls, whereas serum potassium concentrations did not differ significantly between groups. Moreover, patient age exhibited a significant inverse correlation with serum sodium, while no significant association was identified between age and serum potassium. Collectively, these findings suggest that hyponatremia constitutes a frequent electrolyte disturbance in lung cancer, particularly in older patients, and may serve as a clinically relevant marker for patient assessment, whereas potassium homeostasis appears comparatively preserved in the absence of concomitant conditions.

Keywords: Lung cancer, Hyponatremia, Electrolyte imbalance, Serum sodium and potassium.

الملخص
لا يزال سرطان الرئة يُعد من بين أكثر الأورام الخبيثة شيوعًا، وغالبًا ما يكون مصحوبًا باضطرابات أيضية، ولا سيما اختلال توازن الشوارد، والتي قد تؤثر سلبًا على الحالة السريرية العامة للمرضى وقد تؤثر أيضًا على مسار المرض. هدفت هذه الدراسة إلى (i) :قياس تركيزات الصوديوم والبوتاسيوم في مصل الدم لدى مرضى سرطان الرئة، (ii)دراسة علاقتها بالعمر، و (iii)مقارنة هذه القيم مع تلك المسجلة لدى مجموعة ضابطة من الأفراد الأصحاء ظاهريًا .شملت الدراسة 43 مريضًا تم تشخيصهم مؤكدًا بسرطان الرئة (تراوحت أعمارهم بين 33 و90 عامًا) ويتلقون الرعاية في المركز الوطني لعلاج الأورام بمدينة مصراتة، بالإضافة إلى 24 مشاركًا سليمًا من حيث العمر كمجموعة مقارنة. تم جمع عينات دم وريدية، وتم فصل المصل وفقًا للإجراءات المخبرية القياسية. كما تم تحديد تركيزات الصوديوم والبوتاسيوم في المصل باستخدام تقنية القطب الانتقائي للأيونات(ISE) .أُجريت التحليلات الإحصائية باستخدام برنامجSPSS ، حيث عُرضت النتائج على شكل المتوسط ± الانحراف المعياري، وتمت مقارنة المجموعات باستخدام اختبار (t) للعينات المستقلة، كما تم تقييم العلاقة مع العمر باستخدام معامل ارتباط بيرسون، مع اعتبار القيمة الاحتمالية ($P < 0.05$) ذات دلالة إحصائية . أظهرت النتائج انخفاضًا ذا دلالة إحصائية في تركيز الصوديوم في مصل الدم لدى مرضى سرطان الرئة مقارنةً بالمجموعة الضابطة، في حين لم تُظهر تركيزات البوتاسيوم فروقًا ذات دلالة إحصائية بين المجموعتين. بالإضافة إلى ذلك، أظهر عمر المرضى ارتباطًا عكسيًا ذا دلالة إحصائية مع تركيز الصوديوم في المصل، بينما لم يُسجل أي ارتباط ذو دلالة إحصائية بين العمر وتركيز البوتاسيوم .تشير هذه النتائج مجتمعة إلى أن نقص صوديوم الدم يُعد اضطرابًا شائعًا في توازن الشوارد لدى مرضى سرطان الرئة، خاصة لدى المرضى الأكبر سنًا، وقد يمثل مؤشرًا سريريًا مهمًا لتقييم الحالة الصحية للمرضى، في حين يبدو أن الاتزان الداخلي للبوتاسيوم يظل محفوظًا نسبيًا في غياب حالات مرضية مصاحبة.

الكلمات المفتاحية: سرطان الرئة، نقص صوديوم الدم، اختلال توازن الشوارد، صوديوم وبوتاسيوم المصل.

Introduction

Non-communicable diseases (NCDs), particularly cancer, represent one of the most significant global health challenges, owing to their substantial contribution to morbidity and mortality, as well as the escalating burden they impose on healthcare systems and strategic medical resource planning (World Health Organization [WHO], 2023). Cancer is defined as a heterogeneous group of pathological disorders characterized by the loss of normal cellular regulatory mechanisms governing proliferation and differentiation, resulting in uncontrolled cell growth, local tissue invasion, and the potential for dissemination to distant organs through metastatic processes (National Cancer Institute [NCI], 2022).

Among the various malignancies, lung cancer is recognized as one of the most aggressive and lethal forms, ranking as the leading cause of cancer-related mortality worldwide, with approximately two million new cases reported annually (WHO, 2023). Lung cancer typically arises from genetic damage affecting the epithelial cells lining the respiratory tract, primarily induced by exposure to carcinogenic agents, most notably tobacco smoke, as well as environmental and occupational pollutants and other chemical carcinogens (NCI, 2022). Clinically, lung cancer is broadly classified into two principal subtypes: Small Cell Lung Cancer (SCLC), characterized by rapid proliferation and early metastatic spread, and Non-Small Cell Lung Cancer (NSCLC), which represents the most prevalent form and encompasses several histological subtypes with distinct biological and clinical features (Siegel et al., 2023).

The severity of the disease and the selection of therapeutic interventions are largely determined by cancer staging, which is based on tumor size, extent of local invasion, involvement of regional lymph nodes, and the presence or absence of distant metastases. Accurate staging is essential for prognostic assessment and for guiding evidence-based treatment strategies, thereby optimizing clinical outcomes (American Cancer Society [ACS], 2023). In addition to tumor-related factors, electrolyte disturbances, particularly abnormalities in sodium and potassium homeostasis, constitute clinically significant complications in patients with lung cancer. Hyponatremia is among the most frequently observed electrolyte disorders, especially in patients with SCLC, and is commonly associated with the Syndrome of Inappropriate Antidiuretic Hormone Secretion (SIADH), a paraneoplastic condition resulting from ectopic hormone production (International Agency for Research on Cancer [IARC], 2023). Numerous clinical investigations have demonstrated that hyponatremia is associated with poorer prognosis, reduced survival rates, and deterioration in functional status among affected patients.

Although potassium imbalance is not considered a specific diagnostic marker for lung cancer, hypokalemia may occur in certain patients as a consequence of tumor-related effects or as an adverse outcome of chemotherapy and other systemic treatments that impair renal and endocrine function. Such

disturbances may result in clinically significant neuromuscular and cardiovascular complications if not promptly identified and managed (National Institutes of Health [NIH], 2022). In light of these considerations, investigating alterations in serum sodium and potassium levels in lung cancer patients is of considerable clinical importance. These electrolyte imbalances may serve as valuable prognostic indicators, contributing to improved clinical evaluation, supporting therapeutic decision-making, and ultimately enhancing patient management and health outcomes.

Materials and Methods

This study was conducted on 43 patients diagnosed with lung cancer, aged 33–90 years, who were receiving treatment at the National Cancer Treatment Center in Misurata, including either pharmacological therapy and/or surgical intervention. A control group comprising 24 apparently healthy individuals, matched to the same age range and with no history of malignancy or chronic disease, was also included for comparative purposes. Venous blood samples (5 mL) were collected from all participants into test tubes. Serum was separated by centrifugation at 3000 rpm for 10 minutes and subsequently stored at −20°C until biochemical analysis.

Serum sodium and potassium concentrations were quantified using the ion-selective electrode (ISE) method with an EasyLyte PLUS Na/K/Cl Analyzer (Medica Corporation, USA). The analyzer was calibrated prior to measurements using certified standard reference solutions in accordance with the manufacturer's recommendations. Statistical analyses were performed using the Statistical Package for the Social Sciences (SPSS). Data are presented as mean ± standard deviation (SD). Differences in mean electrolyte concentrations between the lung cancer and control groups were assessed using the independent-samples t-test, and statistical significance was defined as $P < 0.05$.

Results

The collected data were subjected to comprehensive statistical analysis using both descriptive and inferential statistical methods in order to achieve the objectives of the study and evaluate differences between the study groups.

1. Descriptive Statistics

Descriptive statistical analysis was performed to summarize the distribution and central tendency of serum electrolyte concentrations among the study participants. The results are presented in terms of the mean and standard deviation (mean ± SD), providing a quantitative representation of the variability and dispersion of serum sodium and potassium levels within both the lung cancer patient group and the healthy control group.

Table (1): Mean and standard deviation of serum sodium and potassium concentrations in the study and control groups.

Variable	(Mean ± Standard Deviation) Patients	(Mean ± Standard Deviation) Healthy Individuals
Na (mmol/L)	130.35 ± 8.29	140.38 ± 2.33
K (mmol/L)	4.13 ± 0.54	4.17 ± 0.28

The descriptive statistical findings presented in Table (1) demonstrate a marked difference in serum sodium concentrations between lung cancer patients and the healthy control group. Specifically, the mean serum sodium level in patients (130.35 ± 8.29 mmol/L) was substantially lower than that observed in healthy individuals (140.38 ± 2.33 mmol/L). This reduction indicates the presence of hyponatremia among lung cancer patients, which is a well-documented electrolyte disturbance associated with malignancy. The relatively large standard deviation observed in the patient group further suggests increased variability in sodium homeostasis, reflecting heterogeneous disease severity, treatment effects, and possible paraneoplastic syndromes such as the Syndrome of Inappropriate Antidiuretic Hormone Secretion (SIADH), which is particularly prevalent in lung cancer, especially small cell lung cancer.

In contrast, serum potassium concentrations showed minimal variation between the two groups. The mean potassium level in lung cancer patients (4.13 ± 0.54 mmol/L) was comparable to that of the control group (4.17 ± 0.28 mmol/L), and both values remained within the physiologically normal reference range. This finding suggests that potassium homeostasis is relatively preserved in lung cancer patients, particularly in the absence of advanced renal impairment, severe systemic complications, or intensive chemotherapeutic toxicity. However, the slightly higher standard deviation in the patient group may indicate early or subclinical electrolyte instability, potentially attributable to disease progression, metabolic alterations, or treatment-related effects.

2. Inferential Statistics:

The inferential statistical analysis presented in Table (2), based on the independent samples t-test, revealed a statistically significant difference in serum sodium concentrations between lung cancer patients and the healthy control group.

Table (2): Results of the Independent Samples t-test for comparison of serum sodium and potassium levels.

Variable	Value of t	Value of p	Statistical significance	Interpretation
Na (mmol/L)	7.42-	0.001 >	Statistically significant	There is a highly statistically significant difference between patients and healthy individuals, with serum sodium levels significantly decreased in lung cancer patients.
K (mmol/L)	0.44-	0.66	Not statistically significant	There is no statistically significant difference in serum potassium levels between patients and healthy individuals.

The calculated t-value ($t = -7.42$) and the highly significant p-value ($P < 0.001$) confirm that the observed reduction in serum sodium levels among lung cancer patients is not due to random variation but reflects a true physiological alteration associated with the disease. This finding strongly supports the presence of hyponatremia as a common metabolic abnormality in lung cancer patients. The negative t-value further indicates that sodium levels were significantly lower in the patient group compared to the control group. Clinically, this reduction may be attributed to several pathophysiological mechanisms, including paraneoplastic syndromes such as the Syndrome of Inappropriate Antidiuretic Hormone Secretion (SIADH), impaired renal sodium regulation, tumor-induced hormonal imbalances, and the systemic effects of cancer and its treatment. Hyponatremia has been widely recognized as a negative prognostic factor, associated with reduced survival rates, impaired functional capacity, and increased treatment-related complications.

In contrast, the analysis demonstrated no statistically significant difference in serum potassium concentrations between lung cancer patients and healthy individuals, as indicated by the t-value ($t = -0.44$) and the non-significant p-value ($P = 0.66$). This result suggests that potassium homeostasis remains relatively stable in lung cancer patients, particularly in cases where renal function is preserved, and no severe treatment-related toxicity or endocrine dysfunction is present. Although potassium imbalance may occur in certain clinical contexts, such as advanced disease stages, chemotherapy-induced nephrotoxicity, or adrenal dysfunction, the present findings indicate that potassium levels are not significantly affected in the studied population. This stability may reflect the effectiveness of physiological regulatory mechanisms that tightly control potassium balance due to its critical role in maintaining cellular membrane potential and neuromuscular function.

Table (3): Results of the correlation analysis between age and serum sodium and potassium levels in lung cancer patients.

Variable	Value of t	Value of p	Statistical significance	Interpretation
Age x Na (mmol/L)	- 0.47	0.002	Statistically significant	There is a statistically significant inverse correlation, indicating that serum sodium levels decrease with advancing age in lung cancer patients.
Age x K (mmol/L)	- 0.15	0.340	Not statistically significant	There is no statistically significant correlation between age and serum potassium levels.

The correlation analysis presented in Table (3) revealed a statistically significant inverse relationship between age and serum sodium levels in lung cancer patients, as evidenced by the correlation coefficient ($r = -0.47$) and the associated p-value ($P = 0.002$). This finding indicates that serum sodium concentrations tend to decline progressively with advancing age among affected patients. The moderate negative correlation suggests that aging may contribute to increased susceptibility to hyponatremia in lung cancer populations. This age-related decline in sodium levels may be attributed to several physiological and pathological mechanisms, including age-associated deterioration in renal function, impaired sodium reabsorption capacity, altered hormonal regulation, particularly involving antidiuretic hormone (ADH), and the cumulative effects of malignancy and its treatment. Furthermore, older patients are more likely to experience comorbidities and receive multiple pharmacological therapies, which may exacerbate electrolyte imbalances and compromise sodium homeostasis. From a clinical standpoint, this finding underscores the importance of closely monitoring sodium levels in

elderly lung cancer patients, as hyponatremia may contribute to worsened clinical outcomes, reduced functional capacity, and increased morbidity.

In contrast, the analysis demonstrated no statistically significant correlation between age and serum potassium levels ($r = -0.15$, $P = 0.340$), indicating that potassium concentrations remain relatively independent of age in the studied population. This lack of association suggests that potassium homeostasis is maintained through robust physiological regulatory mechanisms, even in the presence of malignancy and aging. Potassium balance is tightly controlled by renal excretion, intracellular–extracellular ion exchange, and hormonal regulation, particularly by aldosterone, which helps preserve stable potassium concentrations under normal and pathological conditions. The absence of a significant age-related effect on potassium levels further supports the notion that potassium disturbances in lung cancer patients may be more strongly influenced by acute clinical factors, such as renal dysfunction, chemotherapy, or metabolic complications, rather than age alone.

Discussion

1. Relationship Between Age and Serum Sodium Levels

The findings of the present study demonstrated a statistically significant decline in serum sodium levels with advancing age among lung cancer patients, representing a clinically meaningful observation. This age-related reduction may be attributed to the increased susceptibility of elderly individuals to electrolyte disturbances due to physiological aging processes, including progressive deterioration in renal function, impaired tubular reabsorption capacity, and dysregulation of hormonal control mechanisms. Furthermore, malignant tumors may exert both direct and indirect effects on electrolyte balance through paraneoplastic syndromes, systemic inflammation, and treatment-related metabolic alterations.

These findings are consistent with the study conducted by Hansen et al. (2018) in Denmark, which identified hyponatremia as one of the most prevalent electrolyte abnormalities among lung cancer patients, particularly in older age groups. Similarly, Cuesta and Thompson (2016) in the United Kingdom reported that the risk of hyponatremia increases with advancing age and is significantly more pronounced in cancer patients compared to healthy individuals. These observations collectively support the hypothesis that aging constitutes an important risk factor for sodium imbalance in lung cancer populations.

2. Sodium as a Prognostic Factor in Lung Cancer

Emerging evidence suggests that hyponatremia is not merely a transient biochemical abnormality but rather a clinically significant prognostic indicator associated with adverse outcomes and reduced survival. Berghmans et al. (2000), in a study conducted in Belgium, demonstrated that lung cancer patients presenting with hyponatremia had significantly lower survival rates compared to those with normal sodium levels. This association highlights the prognostic relevance of sodium imbalance in malignancy.

The present study aligns with these findings, as reduced sodium levels were particularly evident among older patients, potentially reflecting advanced disease progression or the presence of paraneoplastic syndromes such as the Syndrome of Inappropriate Antidiuretic Hormone Secretion (SIADH). SIADH is a well-recognized complication in lung cancer, especially small cell lung cancer, and has been extensively documented in European and Asian clinical investigations. These mechanisms further underscore the importance of sodium monitoring as a valuable component of clinical assessment and prognostic evaluation in lung cancer patients.

3. Relationship Between Age and Serum Potassium Levels

In contrast to sodium, the results of the present study did not reveal a statistically significant relationship between age and serum potassium levels. This finding is consistent with the large-scale population-based study conducted by Kovesdy et al. (2017) in the United States, which reported that potassium levels remain relatively stable across different age groups and are not significantly influenced by aging under normal physiological conditions. This stability may be attributed to the tightly regulated physiological mechanisms controlling potassium homeostasis, including renal excretion, intracellular buffering, and hormonal regulation, particularly via aldosterone. As a result, potassium levels are generally less sensitive to age-related physiological changes or disease processes, unless accompanied by specific pathological conditions such as chronic kidney disease, endocrine dysfunction, or medication-induced electrolyte disturbances.

4. Relationship Between Serum Sodium and Potassium Levels

The present study also demonstrated a weak and statistically non-significant positive correlation between serum sodium and potassium levels, indicating that alterations in one electrolyte do not necessarily correspond to proportional changes in the other. This observation is consistent with established physiological principles, as described by Guyton and Hall (2021), which emphasize that sodium and potassium are regulated through distinct renal and hormonal mechanisms. These findings are further supported by clinical studies conducted in China and Japan involving cancer patients, which reported that sodium disturbances are more prevalent and more strongly associated with disease severity and paraneoplastic syndromes, whereas potassium levels tend to remain relatively stable unless directly affected by renal dysfunction or pharmacological interventions. This consistency across geographically diverse populations suggests a universal physiological pattern in electrolyte regulation, irrespective of regional or demographic differences.

Conclusion

The present study demonstrated significant alterations in electrolyte balance among lung cancer patients, particularly with respect to serum sodium levels. Patients exhibited a statistically significant reduction in sodium concentrations compared to healthy individuals, whereas no significant differences were observed in potassium levels between the two groups. Furthermore, a statistically significant inverse relationship was identified between age and serum sodium levels, indicating that older patients are at increased risk of developing hyponatremia.

These findings confirm that hyponatremia represents a common and clinically significant electrolyte disturbance in lung cancer patients and may serve as a valuable prognostic indicator for disease severity and clinical progression, especially among elderly populations. In contrast, serum potassium levels appeared relatively stable in the absence of comorbid conditions or treatment-related complications, suggesting limited utility as an independent prognostic biomarker in this context.

The results underscore the importance of routine monitoring of serum sodium levels as part of the standard clinical evaluation of lung cancer patients, as early detection and management of electrolyte disturbances may improve therapeutic outcomes and reduce associated complications. Future research involving larger sample sizes, diverse disease stages, and longitudinal follow-up is recommended to further elucidate the prognostic significance of electrolyte imbalances and their relationship with treatment response and survival outcomes in lung cancer patients.

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