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Editorial

Dear Readers,

We are pleased to present the second issue of the eighth volume of the Eurasian Journal of Critical Care, published in August 2026. This issue includes four original research articles, one review article, three letters to the editor, and two case reports, covering a broad range of topics relevant to emergency and critical care medicine.

The original research articles reflect the multidisciplinary nature of our field. They address emergency medicine residents' knowledge of ultrasonography, the differentiation of acute appendicitis from gynecological pathology in women presenting with lower abdominal pain, patient characteristics and outcomes in a pediatric emergency observation unit, and the association between early 25% albumin use and renal outcomes in patients with sepsis.

The review article focuses on modified electrocardiographic criteria for Occlusion Myocardial Infarction, highlighting evolving approaches to the early recognition of acute coronary occlusion. The letters to the editor provide valuable perspectives on methodological challenges in critical care machine learning, the use of standard pulmonary embolism scores for predicting thrombolysis, and basic life support competency in hospital practice.

This issue also includes two instructive case reports addressing indirect rabies exposure following oral suction of a cat bite and non-traumatic spinal shock presenting with acute paraparesis. These cases emphasize the importance of careful clinical assessment and awareness of uncommon but potentially serious conditions in emergency practice.

Together, the contributions in this issue highlight the importance of accurate diagnosis, evidence-based decision-making, continuous medical education, and rigorous research methodology in emergency and critical care medicine.

We sincerely thank our editors, reviewers, and editorial board members for their dedication to maintaining the scientific quality and credibility of our journal. We also thank all authors for their valuable contributions.

As medical knowledge continues to evolve, the Eurasian Journal of Critical Care remains committed to providing high-quality, evidence-based, and clinically relevant publications for clinicians and researchers.

Sincerely,

Başar Cander

Editor

Eurasian Journal of Critical Care

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Ömer Faruk Çakıroğlu

Early Use of 25% Albumin in Sepsis Resuscitation is Not Associated with Worsened Renal Outcomes: A Propensity-Matched Retrospective Cohort Study of MIMIC-IV

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Abstract

Background: The use of hyperoncotic (25%) albumin in sepsis resuscitation remains controversial because of concerns about nephrotoxicity, particularly in patients with pre-existing renal impairment. This study examined whether early administration of 25% albumin in addition to crystalloids increases the risk of acute kidney injury or worsens short-term hemodynamic outcomes compared with crystalloids alone.

Materials and Methods: A retrospective cohort study was performed using a large, publicly available intensive care database. Adult patients with sepsis who received crystalloids alone or crystalloids plus 25% albumin within the first 24 hours of intensive care admission were identified; patients receiving 5% albumin were excluded. Propensity score matching was performed by 1:1 nearest-neighbor matching without replacement, applying a caliper of 0.2 standard deviations of the logit of the propensity score, with demographics, laboratory values, organ-dysfunction sub-scores, and comorbidities as covariates; balance was assessed by standardized mean differences. The primary outcome was acute kidney injury, defined by standardized consensus criteria. Secondary outcomes were renal replacement therapy, intensive care length of stay, and vasopressor-free days.

Results: Among 15,882 patients, 587 matched pairs were analyzed. The incidence of acute kidney injury was similar between groups (albumin, 59.5% versus control, 55.4%; $p = 0.175$), as was the need for renal replacement therapy (23.9% versus 27.8%; $p = 0.142$). Intensive care length of stay and vasopressor-free days did not differ. Despite higher lactate levels, greater hepatic and coagulation dysfunction, and modestly worse baseline renal function in the albumin group, renal outcomes were comparable, and the renal safety profile was consistent across strata of baseline kidney function. Fluid exposure was lower in the albumin group, which received less crystalloid and a less positive net fluid balance.

Conclusions: Early administration of 25% albumin with crystalloids was not associated with worse short-term renal or hemodynamic outcomes. These findings support clinical equipoise and suggest that cautious use of 25% albumin in selected patients confers no additional renal risk.

Keywords: Albumin, Acute kidney injury, Sepsis, Fluid resuscitation, Propensity score matching, Critical care

Introduction

The optimal fluid choice for sepsis resuscitation remains a matter of ongoing debate, particularly regarding the use of hyperoncotic (20–25%) albumin compared with crystalloids^{1–4}. Crystalloids are universally recommended as the first-line fluid in international guidelines; however, albumin has long been considered a potential adjunct because of its oncotic and non-oncotic properties, including improved intravascular volume expansion, antioxidant activity, and endothelial stabilization^{5,6}.

Evidence from randomized controlled trials (RCTs) and meta-analyses suggests that albumin, particularly at higher concentrations, may provide hemodynamic advantages and potentially reduce 90-day mortality in patients with septic shock, although benefits across the broader sepsis population remain inconsistent^{1,3,7,8}. The ALBIOS trial, the largest RCT to date, found no overall survival benefit in patients with severe sepsis but indicated possible improvements in patients with septic shock¹. Observational studies using large critical care datasets, including MIMIC-IV, support the safety of early hyperoncotic al-

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bumin combined with crystalloids, reporting no increase in acute kidney injury (AKI), renal replacement therapy (RRT), or prolonged intensive care unit (ICU) stay^{9,10}.

Renal safety remains a key concern that limits the widespread use of hyperoncotic albumin. Observational data have raised questions about nephrotoxicity in patients with septic shock and pre-existing renal dysfunction¹¹, whereas other studies and systematic reviews have found no evidence of adverse effects^{12,13}. Recent narrative reviews suggest that hypoalbuminemia may act as a moderator of treatment response, with patients in this subgroup potentially experiencing greater hemodynamic benefit and less fluid overload¹⁴.

The heterogeneity of the study findings likely reflects differences in patient populations, timing, dosing strategies, and albumin concentration used. Subgroup analyses indicate that patients with cirrhosis or immunocompromised states may not derive significant benefit from albumin¹⁵⁻¹⁸, whereas trauma patients with sepsis are generally managed with crystalloids given the absence of demonstrated advantages and higher costs^{19,20}.

Cost-effectiveness is another barrier to its use. Albumin is considerably more expensive than crystalloids and has not been shown to be cost-effective in most healthcare settings, particularly in low- and middle-income countries^{21,22}. Although adverse events such as fluid overload or pulmonary edema are rare, they remain important considerations in susceptible patients^{12,23,24}.

Taken together, the available evidence suggests that hyperoncotic albumin is not inherently nephrotoxic and may offer advantages in select sepsis phenotypes, particularly in patients with shock or severe hypoalbuminemia, when administered early. However, the modest and heterogeneous survival benefits, coupled with higher costs, reinforce current guideline recommendations that crystalloids remain the first-line resuscitation fluid, with albumin reserved for individualized scenarios^{25,26}. Despite this body of evidence, a specific gap remains. Randomised trials have predominantly evaluated iso-oncotic (4–5%) albumin or have pooled different albumin concentrations, so that the hyperoncotic preparations used in practice for fluid-restrictive resuscitation have rarely been assessed in isolation. The few observational analyses that addressed renal safety directly either combined 5% and 25% preparations or did not match on baseline renal function, and the single study reporting an increased risk of major adverse kidney events did both. It therefore remains unresolved whether the nephrotoxicity signal attributed to hyperoncotic albumin in septic shock with pre-existing renal impairment reflects a property of the fluid itself or confounding by indication, since sicker patients are preferentially selected to receive it. Resolving this question requires an analysis restricted to 25% albumin, administered early, in

which baseline renal function and illness severity are explicitly balanced between groups. Accordingly, the present study was designed to test the hypothesis that early administration of 25% albumin during sepsis resuscitation does not increase the risk of acute kidney injury or worsen short-term hemodynamic outcomes compared with crystalloids alone. Specifically, this study aimed to determine whether the addition of hyperoncotic albumin within the first 24 hours of ICU admission was associated with adverse renal outcomes in a large propensity score-matched cohort from the MIMIC-IV database.

Materials and Methods

Data source

This retrospective cohort study was conducted using the Medical Information Mart for Intensive Care, version IV (MIMIC-IV v3.1) database, a large, freely accessible critical care dataset derived from Beth Israel Deaconess Medical Center in Boston, Massachusetts, USA²⁷. MIMIC-IV contains de-identified health records of over 70,000 ICU admissions, including demographics, diagnoses, laboratory measurements, medication administration, and detailed clinical observations.

The study is reported in accordance with the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) statement, and the completed checklist is provided as a supplementary file.

Study population

Adult patients (aged ≥ 18 years) admitted to the ICU with a primary or secondary hospital discharge diagnosis of sepsis were eligible. Sepsis was identified using ICD-9 codes 99591, 99592, and 78552, and ICD-10 codes A40 and A41. For patients with multiple ICU stays, only the first ICU admission with documented sepsis was included to avoid repeated measurements per patient.

Two treatment groups were defined based on fluid resuscitation during the first 24 hours of ICU admission: a crystalloid-only group (patients who received intravenous crystalloids without albumin) and an albumin group (patients who received crystalloids in combination with 25% albumin solution [itemid 220862] on ICU day 1). Patients receiving 5% albumin were excluded a priori to isolate the effect of hyperoncotic albumin. Patients with missing identifiers, duplicate entries, or incomplete fluid administration records were excluded.

Data extraction and preprocessing

Data extraction was conducted using Structured Query Language (SQL) queries executed in Google BigQuery (Google LLC, Mountain View, CA, USA). The extract-

Table 1. Selected baseline characteristics of the matched cohort.

Variable	n	Crystalloids + Albumin 25% (Mean ± SD or %)	n	Crystalloids Only (Mean ± SD or %)	p-value
Age, years	587	59.29 ± 14.01	587	61.74 ± 15.49	< 0.001
Female sex, %	587	58.2	587	57.1	0.687
Predictive laboratory values					
Albumin, g/dL	351	2.79 ± 0.82	300	2.71 ± 0.63	0.337
Lactate, mmol/L	526	2.80 ± 2.31	526	2.70 ± 2.49	< 0.001
Organ dysfunction					
SOFA coagulation score	581	1.37 ± 1.19	582	1.23 ± 1.20	0.006
SOFA liver score	498	2.09 ± 1.42	475	1.73 ± 1.43	< 0.001
SOFA renal score	582	1.49 ± 1.21	583	1.48 ± 1.24	0.813
SOFA cardiovascular score	419	3.23 ± 1.44	455	3.29 ± 1.38	0.585
Chronic disease					
Diabetes mellitus, %	587	11.6	587	13.2	0.323
Chronic kidney disease, %	587	9.6	587	10.6	0.513
Liver disease, %	587	22.9	587	18.1	0.016
Heart failure, %	587	9.2	587	12.3	0.045
COPD, %	587	3.7	587	4.8	0.327
Cancer, %	587	9.0	587	11.5	0.099

Data are presented as mean ± standard deviation or percentage. The laboratory variables shown (serum albumin and lactate) are baseline, pre-resuscitation values obtained at or around ICU admission, before the administration of the fluids under study; the low mean serum albumin concentrations are consistent with the hypoalbuminaemia that characterises sepsis and critical illness and do not reflect post-resuscitation dilution. The column headed *n* denotes the number of patients in whom the respective variable was available, as not all variables were measured in every patient; summary statistics and *p*-values refer to patients with available data. *P*-values were derived from Mann–Whitney U tests for continuous variables and chi-square tests for binary variables. Abbreviations: SD, standard deviation; SOFA, Sequential Organ Failure Assessment; COPD, chronic obstructive pulmonary disease.

ed variables included demographic information, admission diagnoses, laboratory values, vasopressor use, and Sequential Organ Failure Assessment (SOFA) score components. Data transformation and statistical analyses were performed in Python v3.9 (Python Software Foundation, Wilmington, DE, USA)²⁸, using the pandas²⁹, NumPy³⁰, SciPy³¹, statsmodels³², and scikit-learn³³ libraries for data wrangling, array operations, nonparametric testing, statistical modeling, and propensity score estimation, respectively.

Raw data were first extracted from MIMIC-IV using SQL queries in BigQuery and then cleaned and harmonized across tables in Python. Propensity scores were estimated and applied for 1:1 nearest-neighbor matching, after which the primary and secondary outcomes were operationalized according to prespecified clinical definitions.

Propensity score matching

Propensity score matching (PSM) was used to reduce treatment selection bias. Propensity scores were estimated using a logistic regression model including the following baseline covariates: demographics (age, sex); laboratory variables (admission lactate, baseline serum albumin); organ dysfunction (individual SOFA sub-scores for coagulation, liver, renal, and cardiovascular function); and comorbidities (diabetes mellitus, chronic kidney disease, liver disease, heart failure, malignancy, and chronic ob-

structive pulmonary disease). The respiratory and central nervous system sub-scores were not incorporated. Derivation of the respiratory sub-score requires temporally paired arterial oxygen tension and fraction of inspired oxygen values, which were not documented concurrently on the first ICU day for a sufficient proportion of the cohort to permit reliable scoring. The central nervous system sub-score was not predominantly missing but non-informative: as reconstructed from the available Glasgow Coma Scale documentation, it took the maximum value of 4 in effectively all patients in whom it could be computed, reflecting documentation practice rather than neurological status. Because a covariate without variance cannot contribute to a propensity score model, its omission leaves the estimated propensity scores and matched pairs unchanged by construction, and a sensitivity analysis re-including it would be uninformative. For the four retained sub-scores, availability within the matched cohort is given in the *n* columns of Table 1: 99.1% for coagulation, 99.2% for renal, 82.9% for liver, and 74.4% for cardiovascular. Matching was conducted using 1:1 nearest-neighbor matching without replacement, applying a caliper width of 0.2 standard deviations of the logit of the propensity score. Patients outside the common support area were excluded to avoid extrapolation. Balance was evaluated using standardized mean differences (SMD), with SMD < 0.1 considered indicative of adequate balance.

Outcomes

The primary outcome was the development of AKI, defined according to the Kidney Disease: Improving Global Outcomes (KDIGO) criteria as an increase in serum creatinine ≥ 0.3 mg/dL within 48 hours or an increase to ≥ 1.5 times the baseline value within 7 days. Baseline creatinine was defined as the lowest value recorded during the first ICU day, from 6 hours before to 24 hours after ICU admission; if unavailable, the earliest creatinine value thereafter was used. KDIGO staging (stages 1–3) was also calculated but was not included as a primary endpoint.

Secondary outcomes included RRT (any receipt of renal replacement therapy in the ICU, identified through structured input events), ICU length of stay (LOS; duration from ICU admission to discharge, in days), and vasopressor-free days (number of days alive and without vasopressor use, including norepinephrine, epinephrine, dopamine, and phenylephrine, during the first 28 days of ICU admission; patients who died before day 28 were assigned zero vasopressor-free days). Ventilator-free days could not be derived because of incomplete documentation of ventilation variables in MIMIC-IV.

Statistical analysis

Continuous variables are expressed as mean $\pm$ standard deviation (SD) or median with interquartile range (IQR), depending on the distribution, and were compared between groups using the Mann–Whitney U test. Categorical variables are presented as counts and percentages and were compared using the chi-square test. All hypothesis tests were two-sided, with a significance threshold of $p < 0.05$. Analyses were performed using Python. No a priori sample size or power calculation was undertaken: as a secondary analysis of an existing database, the study included all patients meeting the prespecified eligibility criteria, and the analysable sample was therefore determined by data availability rather than by a target precision. For orientation, the matched sample of 587 patients per group provided 80% power, at a two-sided alpha of 0.05, to detect an absolute difference in AKI incidence of approximately 8 percentage points relative to an observed control incidence of 55.4%; differences smaller than this could not be excluded and are reflected in the reported confidence intervals. Two additional analyses were performed to address fluid exposure and baseline renal function. The cumulative crystalloid volume, total intravenous fluid input, total recorded output, and net fluid balance were calculated for the first 24 and 72 hours after ICU admission and compared between groups using the Mann–Whitney U test. Baseline kidney function was characterized by the baseline serum creatinine and the estimated glomerular filtration rate (eGFR), calculated with the 2021 race-free Chronic Kidney Disease Epide-

miology Collaboration (CKD-EPI) creatinine equation.³⁴ The incidence of AKI was compared between treatment groups within strata of baseline eGFR (≥ 60 , 30–59, and < 30 mL/min/1.73 m²) and according to chronic kidney disease status using the chi-square test. Effect modification by baseline renal function was assessed by adding a treatment-by-stratum interaction term, and separately a treatment-by-continuous-baseline-creatinine interaction term, to logistic-regression models.

Results

Of the 15,882 patients who received intravenous fluids on ICU day 1, those who received only crystalloids ($n = 14,961$) and those who received crystalloids plus 25% albumin ($n = 921$) were included. Patients who received 5% albumin were excluded from the study.

The matched cohort included 587 patients in each group (Table 1). Patients in the albumin group were marginally younger (59.3 ± 14.0 versus 61.7 ± 15.5 years); although this difference reached statistical significance, a mean difference of approximately 2.5 years is unlikely to be of clinical relevance in a critically ill population of this age range, and it is reported here for completeness rather than as a meaningful imbalance. The proportion of female patients was similar across the groups. Among the laboratory parameters, lactate levels were higher in the albumin group, whereas serum albumin levels did not differ significantly. Organ dysfunction profiles using SOFA sub-scores indicated greater hepatic and coagulation abnormalities in the albumin group. The renal and cardiovascular SOFA components were comparable among the groups.

The prevalence of chronic comorbidities was generally similar between the groups. However, liver disease was more frequent in the albumin group, and heart failure was more frequent in the crystalloid-only group. Other conditions, such as diabetes, chronic kidney disease, chronic obstructive pulmonary disease, and cancer, were evenly distributed. Overall, the baseline characteristics indicated good covariate balance following propensity score matching, with only minor differences remaining between groups.

The clinical outcomes were broadly comparable between matched groups (Table 2). The proportion of patients who developed AKI did not differ significantly between those allocated to crystalloids alone and those allocated to crystalloids plus 25% albumin. The absolute risk difference for AKI was 4.1 percentage points (95% CI, -1.6 to 9.7), corresponding to an odds ratio of 1.18 (95% CI, 0.94 to 1.49). Similarly, the need for RRT was not significantly different between the groups. The duration of ICU stay was nearly identical between the groups. Likewise, vasopressor-free days within the first 28 days

Table 2. Clinical outcomes in the matched cohort (n = 587 per group).

Outcome	Crystalloids + Albumin 25%	Crystalloids Only	p-value
Acute kidney injury (KDIGO), n (%)	349 (59.5)	325 (55.4)	0.175
Renal replacement therapy, n (%)	140 (23.9)	163 (27.8)	0.142
Intensive care unit length of stay, median (IQR), days	4.1 (2.0–9.3)	4.5 (2.0–9.6)	0.525
Vasopressor-free days, median (IQR)	26.8 (24.5–28.0)	26.8 (24.6–28.0)	0.912

Data are presented as n (%) or median (interquartile range). P-values were derived from chi-square tests for categorical variables and Mann–Whitney U tests for continuous variables. Vasopressor-free days were defined as the number of days without vasopressor administration from day 1 to day 28. Abbreviations: IQR, interquartile range; KDIGO, Kidney Disease: Improving Global Outcomes.

of hospitalization showed no difference. These findings suggest no significant association between fluid allocation and short-term renal or hemodynamic outcomes in this propensity score–matched cohort.

Fluid exposure differed between the matched groups (Table 3). Over the first 72 hours, patients in the albumin group received a lower cumulative crystalloid volume (median 5,529 versus 8,476 mL; $p < 0.001$) and a lower total fluid input (10,458 versus 13,396 mL; $p < 0.001$), and had a less positive net fluid balance (6,057 versus 7,871 mL; $p < 0.001$), while additionally receiving 25% albumin (median 200 mL on the first ICU day). Total recorded output did not differ significantly between the groups (3,998 versus 4,499 mL; $p = 0.091$). A comparable pattern was observed over the first 24 hours.

Baseline renal function was modestly worse in the albumin group, which had a higher baseline serum creatinine (median 1.60 versus 1.40 mg/dL; $p = 0.045$) and a lower eGFR (43.8 versus 52.4 mL/min/1.73 m²; $p = 0.037$). When AKI was examined within strata of baseline renal function (Table 4), no significant between-group difference was observed in any eGFR category (≥ 60 : 52.3% versus 49.1%, $p = 0.539$; 30–59: 57.5% versus 59.4%, $p = 0.811$; < 30 : 70.9% versus 61.8%, $p = 0.083$) or according to chronic kidney disease status (absent: 58.7% versus 54.8%, $p = 0.220$; present: 66.7% versus 60.7%, $p = 0.627$). Neither the treatment-by-eGFR-stratum interaction ($p = 0.301$) nor the interaction with continuous baseline creatinine ($p = 0.265$) was significant, and the adjusted odds ratio for AKI with albumin was 1.17 (95% CI, 0.92–1.47; $p = 0.201$).

Table 3. Fluid exposure and fluid balance in the matched cohort (n = 587 per group).

Variable	Crystalloids + Albumin 25%	Crystalloids Only	p-value
Crystalloid volume, 0–24 h	2,815 (1,370–6,017)	5,002 (2,512–7,987)	< 0.001
Crystalloid volume, 0–72 h	5,529 (2,826–10,336)	8,476 (4,600–13,175)	< 0.001
Total fluid input, 0–24 h	5,349 (2,836–8,975)	7,701 (4,638–12,012)	< 0.001
Total fluid input, 0–72 h	10,458 (5,899–16,437)	13,396 (8,006–20,317)	< 0.001
Total output, 0–72 h	3,998 (1,485–6,997)	4,499 (1,569–7,622)	0.091
Net fluid balance, 0–24 h	3,960 (1,421–7,319)	5,952 (2,905–9,536)	< 0.001
Net fluid balance, 0–72 h	6,057 (1,970–11,626)	7,871 (4,075–14,492)	< 0.001
25% albumin, 0–24 h	200 (100–350)	0 (0–0)	< 0.001

Data are median (interquartile range) in millilitres. P-values were derived from Mann–Whitney U tests. Net fluid balance was calculated as total recorded input minus total recorded output. Volumes were measured over the first 24 and 72 hours after ICU admission.

Table 4. Incidence of acute kidney injury by treatment group within strata of baseline renal function.

Subgroup	Crystalloids + Albumin 25%, n/N (%)	Crystalloids Only, n/N (%)	p-value
eGFR ≥ 60	115/220 (52.3)	130/265 (49.1)	0.539
eGFR 30–59	100/174 (57.5)	85/143 (59.4)	0.811
eGFR < 30	134/189 (70.9)	110/178 (61.8)	0.083
Chronic kidney disease absent	311/530 (58.7)	288/526 (54.8)	0.220
Chronic kidney disease present	38/57 (66.7)	37/61 (60.7)	0.627

Data are n/N (%). P-values were derived from chi-square tests within each stratum. The treatment-by-eGFR-stratum interaction was not significant ($p = 0.301$). eGFR is expressed in mL/min/1.73 m² and was estimated with the 2021 race-free CKD-EPI creatinine equation 34. Abbreviations: eGFR, estimated glomerular filtration rate; CKD-EPI, Chronic Kidney Disease Epidemiology Collaboration.

Discussion

In this large propensity score-matched analysis of critically ill adults with sepsis, early administration of 25% albumin with crystalloids was not associated with an increased risk of AKI, need for RRT, prolonged ICU stay, or fewer vasopressor-free days. These findings align with recent MIMIC-IV analyses^{9,10} and meta-analyses suggesting that hyperoncotic albumin does not worsen renal outcomes compared with crystalloids^{3,7,35}. Although the albumin group displayed higher lactate levels and more frequent hepatic and coagulation dysfunction, which are indicators of greater illness severity, their renal outcomes remained comparable to those of the matched controls, reinforcing the internal validity of our findings.

These results contrast with those of Patanwala et al¹¹, who reported an increased adjusted risk of major adverse kidney events with 25% albumin in patients with septic shock and pre-existing renal impairment. Several methodological differences may explain these discrepancies. First, Patanwala et al¹¹ combined 5% and 25% albumin recipients and included patients with baseline renal dysfunction, whereas the present study focused exclusively on 25% albumin administered within 24 hours and matched for chronic kidney disease, comorbidities, and renal SOFA scores. Second, strict 1:1 matching rather than regression adjustment with propensity scores was used, which reduced residual confounding.

The present analysis complements the RCT results. The ALBIOS trial¹ showed no overall survival benefit of albumin in severe sepsis, but subgroup analyses suggested a possible mortality reduction in patients with septic shock. Meta-analyses pooling RCTs have reported improved hemodynamic parameters and lower 90-day mortality with higher-concentration albumin in shock, but not consistently across all sepsis populations^{3,7,8}. The early combination of albumin with crystalloids may confer additional short-term survival benefits^{9,10, 36}; however, high-quality RCTs are still needed to clarify the optimal timing and dosing.

In our cohort, patients in the albumin group presented with higher baseline lactate levels and more frequent hepatic or coagulation dysfunction. These findings suggest that clinicians may preferentially select 25% albumin for patients with more severe illness, reflecting real-world treatment patterns in which hyperoncotic albumin is often reserved for hemodynamic instability, fluid restriction, or hypoalbuminemia^{5,14}. The fact that renal outcomes remained similar between groups despite these unfavorable baseline characteristics underscores the renal safety of early 25% albumin use, even in patients at higher risk of complications.

The higher prevalence of chronic liver disease in the albumin group is noteworthy. Hyperoncotic albumin

is well established as safe in cirrhosis, where it plays a central role in the prevention and treatment of hepatorenal syndrome, spontaneous bacterial peritonitis, and large-volume paracentesis¹⁶⁻¹⁸. Observational studies suggest that, unlike synthetic colloids, albumin does not induce nephrotoxicity in patients with cirrhosis^{37,38}. The present results align with the literature, as even with a higher burden of hepatic dysfunction, the albumin group did not experience worse renal outcomes than the crystalloid-only group. This observation supports the notion that the renal safety profile of hyperoncotic albumin extends beyond cirrhosis to septic critical illness.

Fluid exposure was not identical between the matched groups. The albumin group received less crystalloid and a lower total fluid volume, with a correspondingly less positive net fluid balance, consistent with the volume-sparing effect expected of a hyperoncotic solution. That renal outcomes remained comparable despite this lower fluid exposure, and despite a modestly worse baseline renal function in the albumin group, further supports the renal safety of early 25% albumin. At the same time, the lower positive balance in the albumin group may itself have contributed to the comparable AKI rates by limiting fluid overload; this potential mediating effect, rather than a purely neutral renal profile, should be considered when interpreting the findings and warrants direct evaluation in prospective work.

The renal safety profile was consistent across the spectrum of baseline kidney function. No subgroup defined by baseline eGFR or chronic kidney disease showed a significant excess of AKI with albumin, and formal tests of interaction provided no evidence of effect modification. A non-significant trend toward higher AKI with albumin was confined to the subgroup with the lowest eGFR (< 30 mL/min/1.73 m²), in whom baseline renal function was poorest and indication bias is most likely; the absence of a significant interaction argues against true heterogeneity, although this subgroup deserves specific attention in future prospective evaluation.

Cost-effectiveness is a key barrier to the widespread use of albumin. Analyses have demonstrated that albumin is more expensive than crystalloids and is not cost-effective in diverse settings, especially in low- and middle-income countries^{21,22}.

The magnitude of the differential is considerable rather than incremental: in an international costing study spanning 187 intensive care units, the average acquisition cost was below 1 USD per 100 mL for crystalloids compared with approximately 59 USD per 100 mL for colloids, and after adjustment for equi-effective dosing saline cost approximately 0.6 USD per 100 mL of crystalloid equivalent against approximately 15.8 USD for 20–25% albumin — an approximately 27-fold difference.

A differential of this order is difficult to justify for population-wide use in sepsis, in which no consistent renal or survival benefit has been demonstrated, and it strengthens rather than weakens the argument for selective, indication-driven administration in the specific phenotypes in which a benefit is plausible. Moreover, subgroup analyses of patients with cirrhosis or immunocompromised states showed no significant renal or survival benefits over crystalloids¹⁵⁻¹⁸, further supporting a selective rather than a universal approach. Safety concerns, such as potential fluid overload or pulmonary edema, remain rare but warrant caution in susceptible patients^{12,23,24}.

Study Limitations

Several methodological considerations must be noted. First, although PSM balanced many baseline variables, residual confounding by unmeasured factors cannot be excluded. Indication bias is particularly relevant because clinicians may have chosen albumin based on hemodynamic parameters or perceived severity that were not fully captured in the database. Second, the respiratory and central nervous system SOFA sub-scores could not be incorporated because of incomplete or implausible data, which may have underestimated overall illness severity. Third, AKI was defined solely by serum creatinine criteria because urine output was inconsistently documented, and this constraint deserves emphasis rather than passing mention. Omission of the urine-output criterion is known to underascertain AKI, and the episodes most likely to be missed—early, transient, and oliguric events occurring during resuscitation itself—are precisely those in which fluid strategy might plausibly exert its effect. The incidences reported here should therefore be read as creatinine-defined AKI rather than as complete KDIGO ascertainment, and the absolute rates are likely to be underestimates. Ascertainment could in principle also differ between groups, since creatinine concentrations are sensitive to dilution and the albumin group received a smaller cumulative fluid volume; any such bias would attenuate dilution and thus favour AKI detection in the albumin group, acting against rather than in favour of the neutral result observed. Nonetheless, the possibility that clinically relevant oliguric injury was systematically missed cannot be excluded, and this tempers the strength of the clinical inference that the present data can support. Fourth, no a priori sample size calculation was performed, and the cohort size was fixed by the number of eligible patients in the database. The analysis was therefore adequately powered only for moderate differences in AKI incidence, of the order of 8 percentage points. The absence of a statistically significant difference should accordingly be read as an absence of evidence for a clinically meaningful renal effect, and not as evidence of equivalence; a formal equivalence or

non-inferiority design would require a substantially larger cohort. Fifth, the study design precluded assessment of long-term renal outcomes beyond the ICU stay. In addition, eGFR was derived from the earliest available (day-1) creatinine, which in the setting of acute illness may overestimate the degree of chronic renal impairment; the concordant results obtained with the comorbidity-based chronic-kidney-disease stratification, which does not rely on this assumption, mitigate this concern. Sixth, all data extraction, analysis, and interpretation were performed by a single investigator. Although every extraction step was scripted and is therefore reproducible from the deposited queries, no independent duplicate extraction or adjudication was undertaken, so that the reproducibility of the phenotyping decisions could not be quantified and the possibility of systematic, undetected misclassification cannot be formally excluded. Eighth, MIMIC-IV originates from a single tertiary academic centre in the United States; the prescribing culture, case mix, and fluid practices reflected here may differ from those of other health systems, which constrains the external generalisability of the findings irrespective of internal validity. Finally, although fluid exposure and albumin dosing were previously unmeasured and are now quantified (Table 3), other treatment-related factors could not be captured, including institutional albumin prescribing protocols, the specific clinical trigger that prompted albumin administration in the individual patient, and co-interventions such as diuretic therapy or timing of source control; residual confounding by treatment pathway therefore remains possible. These limitations are inherent to retrospective database studies and highlight the need for prospective validation.

Taken together, the evidence indicates that hyperoncotic albumin is not inherently nephrotoxic in sepsis resuscitation and may offer hemodynamic or survival advantages in select subgroups, particularly in those with septic shock or severe hypoalbuminemia when administered early. However, the overall mortality benefit is modest, and cost-effectiveness remains a concern. Current guidelines recommending crystalloids as the first-line fluid and reserving albumin for individualized scenarios^{25,26} are consistent with these results.

Future studies should move beyond broad population comparisons and aim to identify the patient phenotypes most likely to benefit from early hyperoncotic albumin therapy. Machine learning-based clustering and precision-medicine approaches may help uncover subgroups defined by lactate dynamics, vasopressor dependence, or baseline hypoalbuminemia that respond favorably to albumin. Composite indices derived from routine haemogram parameters, such as the systemic immune-inflammation index, have been evaluated as diagnostic discriminators in other acute presentations, and whether comparable in-

dices could contribute to inflammatory phenotyping in sepsis—for instance in combination with hypoalbuminaemia and lactate dynamics—remains untested. In addition, high-quality randomized trials are needed to determine the optimal timing and dosing of 25% albumin and to establish its cost-effectiveness across diverse healthcare systems. Finally, the integration of cirrhosis-specific evidence into sepsis management frameworks may provide further insight into patient groups for whom hyperoncotic albumin is both safe and potentially advantageous^{41,42}

From a practical standpoint, these findings translate into several considerations for bedside management. They provide no rationale for the routine use of 25% albumin in unselected patients with sepsis, and crystalloids should remain the first-line resuscitation fluid in accordance with current guidelines. Where clinicians nevertheless elect to use hyperoncotic albumin in an individual patient—typically in the setting of persistent haemodynamic instability despite crystalloids, marked hypoalbuminaemia, or a requirement for fluid restriction—the present data offer reassurance that this choice is unlikely to carry additional short-term renal risk, and that this reassurance extends to patients with reduced baseline kidney function. The observation that albumin recipients reached comparable renal outcomes while receiving a lower cumulative crystalloid volume and accumulating a less positive fluid balance suggests that the practical value of hyperoncotic albumin may lie primarily in limiting fluid accumulation rather than in a direct renal benefit; this is a testable and clinically actionable hypothesis. Because the effect on renal outcomes appears neutral rather than beneficial at the population level, implementation should not take the form of protocolised, population-wide administration, but of individualised decisions governed by explicit local indications, documented review of the response, and awareness of cost, pending confirmatory randomised evidence. These findings provide reassurance that the early use of 25% albumin does not worsen short-term renal or hemodynamic outcomes in critically ill adults with sepsis. Together with emerging evidence from observational studies and meta-analyses, these results support ongoing clinical equipoise and highlight the need for prospective randomized evaluations of hyperoncotic albumin in sepsis resuscitation.

Conclusion

In this large propensity score-matched cohort from the MIMIC-IV database, early administration of 25% albumin alongside crystalloids for sepsis resuscitation was not associated with an increased risk of acute kidney injury, the need for renal replacement therapy, or prolonged ICU stay. These findings suggest that, in selected patients, the use of hyperoncotic albumin does not adversely affect

short-term renal or hemodynamic outcomes. Further prospective studies are warranted to clarify the patient subgroups that may benefit from or be harmed by the administration of hyperoncotic albumin in sepsis.

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Ethical Statement: This study was a secondary analysis of the MIMIC-IV database, a publicly available repository of fully de-identified data. Establishment of the database was approved by the institutional review boards of the Massachusetts Institute of Technology and Beth Israel Deaconess Medical Center, with a waiver of informed consent. Database access was granted to the credentialed investigator under the PhysioNet data use agreement after completion of the required human-subjects research training. No additional ethics committee approval was required for this secondary analysis, which was conducted in accordance with the Declaration of Helsinki.

Data Availability: The data underlying this study are derived from the MIMIC-IV database, which is publicly available to credentialed users via PhysioNet (<https://physionet.org/>). No new data were generated in this study.

Author Contributions: The manuscript has a single author, who designed the study, developed the methodology, performed the formal analysis and investigation, and wrote the paper.

References

1. Caironi P, Tognoni G, Masson S, et al. Albumin replacement in patients with severe sepsis or septic shock. *N Engl J Med*. 2014;370:1412-1421. doi:10.1056/NEJMoa1305727
2. Finfer S, Bellomo R, Boyce N, et al. A comparison of albumin and saline for fluid resuscitation in the intensive care unit. *N Engl J Med*. 2004;350:2247-2256. doi:10.1056/NEJMoa040232
3. Geng L, Tian X, Gao Z, et al. Different concentrations of albumin versus crystalloid in patients with sepsis and septic shock: a meta-analysis of randomized clinical trials. *J Intensive Care Med*. 2023;38:679-689. doi:10.1177/08850666231170778
4. Bannard-Smith J, Elrakhawy M, Norman G, et al. The efficacy, safety and effectiveness of hyperoncotic albumin solutions in patients with sepsis: a systematic review and meta-analysis. *J Intensive Care Soc*. Published online 2024. doi:10.1177/17511437241259437
5. Vincent JL, De Backer D, Wiedermann CJ. Fluid management in sepsis: the potential beneficial effects of albumin. *J Crit Care*. 2016;35:161-167. doi:10.1016/j.jccrc.2016.04.019
6. Vincent JL. Fluid management in the critically ill. *Kidney Int*. 2019;96:52-75. doi:10.1016/j.kint.2018.11.047

7. Xu JY, Chen QH, Xie JF, et al. Comparison of the effects of albumin and crystalloid on mortality in adult patients with severe sepsis and septic shock: a meta-analysis of randomized clinical trials. *Crit Care*. 2014;18:702. doi:10.1186/s13054-014-0702-y
8. Vasques F, Duscio E, Romitti F, et al. Septic shock-3 vs 2: an analysis of the ALBIOS study. *Crit Care*. 2018;22:237. doi:10.1186/s13054-018-2169-8
9. Zhou S, Zeng Z, Wei H, et al. Early combination of albumin with crystalloids administration might be beneficial for the survival of septic patients: a retrospective analysis from MIMIC-IV database. *Ann Intensive Care*. 2021;11:42. doi:10.1186/s13613-021-00830-8
10. Yalan Q, Yinzhou L, Binfei T, et al. Early high-volume resuscitation with crystalloid solution combined with albumin improves survival of critically ill patients: a retrospective analysis from MIMIC-IV database. *Burns*. 2024;50:893-902. doi:10.1016/j.burns.2024.01.016
11. Patanwala AE, Flannery AH, Mehta HB, et al. Comparative effectiveness of albumin versus no albumin on renal replacement therapy and mortality in patients with septic shock and renal impairment. *Chest*. 2025;167:1090-1098. doi:10.1016/j.chest.2024.10.012
12. Jiang L, Jiang S, Zhang M, et al. Albumin versus other fluids for fluid resuscitation in patients with sepsis: a meta-analysis. *PLoS One*. 2014;9:e114666. doi:10.1371/journal.pone.0114666
13. Rochwerg B, Alhazzani W, Sindi A, et al. Fluid resuscitation in sepsis: a systematic review and network meta-analysis. *Ann Intern Med*. 2014;161:347-355. doi:10.7326/M14-0178
14. Wiedermann CJ. Moderator effect of hypoalbuminemia in volume resuscitation and plasma expansion with intravenous albumin solution. *Int J Mol Sci*. 2022;23:14175. doi:10.3390/ijms232214175
15. Cortegiani A, Grasselli G, Meessen J, et al. Albumin replacement therapy in immunocompromised patients with sepsis: secondary analysis of the ALBIOS trial. *J Crit Care*. 2021;63:83-91. doi:10.1016/j.jcrc.2021.01.016
16. Brinkman HM, Kashani KB, Gallo de Moraes A, et al. Impact of early albumin use for resuscitation in patients with septic shock and cirrhosis. *Can J Gastroenterol Hepatol*. 2025;2025:8637440. doi:10.1155/cjgh/8637440
17. Angeli P. A step forward in the choice of fluid for early resuscitation of critically ill patients with cirrhosis. *Hepatol Int*. 2021;15:858-859. doi:10.1007/s12072-021-10211-9
18. Durand F, Kellum JA, Nadim MK. Fluid resuscitation in patients with cirrhosis and sepsis: a multidisciplinary perspective. *J Hepatol*. 2023;79:240-246. doi:10.1016/j.jhep.2023.02.024
19. McKee A, Moriber N, Tornwall J. Intravenous fluid therapy choice in trauma patients in the intensive care unit: a scoping review. *Crit Care Nurse*. 2025;45:41-49. doi:10.4037/ccn2025318
20. Amer MAM, Eskander MS, Ryad FM. Comparison between crystalloid versus colloid in septic shock. *QJM*. 2021;114(suppl 1):hcab097.021. doi:10.1093/qjmed/hcab097.021
21. Abedi F, Zarei B, Elyasi S. Albumin: a comprehensive review and practical guideline for clinical use. *Eur J Clin Pharmacol*. 2024;80:1151-1169. doi:10.1007/s00228-024-03664-y
22. Altawalbeh SM, Almestarihi EM, Khasawneh RA. Clinical and economic outcomes associated with intravenous albumin fluid use in the intensive care unit: a retrospective cohort study. *Expert Rev Pharmacoecon Outcomes Res*. 2023;23:789-796. doi:10.1080/14737167.2023.2215431
23. Kakaie F, Hashemzadeh S, Asheghvatan A, et al. Albumin as a resuscitative fluid in patients with severe sepsis: a randomized clinical trial. *Adv Biosci Clin Med*. 2017;5:8-16. doi:10.7575/aiaa.abcm.17.05.04.02
24. Dong L, Wu X, Zhao C, et al. Impact and clinical significance of different types of fluid resuscitation on the glycocalyx in patients with early sepsis and septic shock: a single center, prospective, randomized controlled trial. *Zhonghua Wei Zhong Bing Ji Jiu Yi Xue*. 2025;37:237-244. doi:10.3760/cma.j.cn121430-20240711-00583
25. Wiedermann CJ, Zaboli A, Turcato G. Synthesis of expert opinions on fluid management in severe sepsis: a contextual review of human albumin and crystalloids. *Heart Lung*. 2025;70:339-359. doi:10.1016/j.hrtlng.2025.01.010
26. Arabi YM, Belley-Cote E, Carsetti A, et al. European Society of Intensive Care Medicine clinical practice guideline on fluid therapy in adult critically ill patients. Part 1: the choice of resuscitation fluids. *Intensive Care Med*. 2024;50:813-831. doi:10.1007/s00134-024-07369-9
27. Johnson AEW, Bulgarelli L, Shen L, et al. MIMIC-IV, a freely accessible electronic health record dataset. *Sci Data*. 2023;10:1. doi:10.1038/s41597-022-01899-x
28. Van Rossum G, Drake FL. Python 3 Reference Manual. CreateSpace Independent Publishing Platform; 2009.
29. McKinney W. Data structures for statistical computing in Python. In: *Proceedings of the 9th Python in Science Conference*. 2010:56-61. doi:10.25080/Majora-92bf1922-00a
30. Harris CR, Millman KJ, van der Walt SJ, et al. Array programming with NumPy. *Nature*. 2020;585:357-362. doi:10.1038/s41586-020-2649-2
31. Virtanen P, Gommers R, Oliphant TE, et al. SciPy 1.0: fundamental algorithms for scientific computing in Python. *Nat Methods*. 2020;17:261-272. doi:10.1038/s41592-019-0686-2
32. Seabold S, Perktold J. Statsmodels: econometric and statistical modeling with Python. In: *Proceedings of the 9th Python in Science Conference*. 2010:92-96.
33. Pedregosa F, Varoquaux G, Gramfort A, et al. Scikit-learn: machine learning in Python. *J Mach Learn Res*. 2011;12:2825-2830.
34. Inker LA, Eneanya ND, Coresh J, et al. New creatinine- and cystatin C-based equations to estimate GFR without race. *N Engl J Med*. 2021;385:1737-1749. doi:10.1056/NEJMoa2102953
35. Rochwerg B, Alhazzani W, Gibson A, et al. Fluid type and the use of renal replacement therapy in sepsis: a systematic review and network meta-analysis. *Intensive Care Med*. 2015;41:1561-1571. doi:10.1007/s00134-015-3794-1
36. Qayyum S, Shahid K. Fluid resuscitation in septic patients. *Cureus*. 2023;15:e44317. doi:10.7759/cureus.44317
37. Sort P, Navasa M, Arroyo V, et al. Effect of intravenous albumin on renal impairment and mortality in patients with cirrhosis and spontaneous bacterial peritonitis. *N Engl J Med*. 1999;341:403-409. doi:10.1056/NEJM199908053410603

38. Caraceni P, Riggio O, Angeli P, et al. Long-term albumin administration in decompensated cirrhosis (ANSWER): an open-label randomised trial. *Lancet*. 2018;391:2417-2429. doi:10.1016/S0140-6736(18)30840-7
39. Taylor C, Yang L, Finfer S, et al. An international comparison of the cost of fluid resuscitation therapies. *Aust Crit Care*. 2021;34(1):23-32. doi:10.1016/j.aucc.2020.06.001 (PMID 32828672).
40. Vural N, Duyan M, Saridas A, et al. The predictive value of inflammatory biomarkers in distinguishing testicular torsion and epididymo-orchitis. *Mev Med Sci*. 2024;4:113-118.
41. Maiwall R, Kumar A, Pasupuleti SSR, et al. A randomized controlled trial comparing 20% albumin to plasmalyte in patients with cirrhosis and sepsis-induced hypotension (ALPS trial). *J Hepatol*. 2022;77:670-682. doi:10.1016/j.jhep.2022.03.043
42. Philips CA, Maiwall R, Sharma MK, et al. Comparison of 5% human albumin and normal saline for fluid resuscitation in sepsis induced hypotension among patients with cirrhosis (FRISC study): a randomized controlled trial. *Hepatology Int*. 2021;15:983-994. doi:10.1007/s12072-021-10164-z

Assessment Of Knowledge Level Of Emergency Medicine Residents Regarding The Use Of Ultrasonography

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Abstract

Background: Ultrasonography, a radiological method that has been used in the medical field for diagnostic and therapeutic purposes for a long time, employs sound frequencies. This study aims to examine the use of ultrasonography among emergency medicine residents, investigate the frequency of its usage over the years, and provide recommendations.

Material and Method: In our study, emergency medicine residents currently training at EAH-City hospitals and university hospitals were included. Those who passed the specialty exam were excluded from the study. A comprehensive survey was developed, recording questions regarding the residents' gender, training center, year of residency, availability of ultrasound (USG) equipment in the emergency department, adequacy of the equipment for current diagnoses, USG training, changes in frequency of use after training, frequency of USG use overall, frequency of USG use in resuscitation, for FAST examination, for detecting wall motion abnormalities in myocardial infarction, for measuring optic nerve sheath diameter, for diagnosing deep vein thrombosis (DVT), for the BLUE Protocol, and for diagnosing testicular torsion.

Results: In the study, a total of 190 emergency medicine residents participated, comprising 116 males and 74 females. Among them, 112 were undergoing training at university hospitals, while 78 were at EAH-City hospitals. The distribution of participants based on years of residency showed 47 in the 0-12 month range, 45 in the 12-24 month range, 40 in the 24-36 month range, 31 in the 36-48 month range, and 27 with more than 48 months of current residency. Regarding ultrasound (USG) equipment, 94.7% of participants reported that their training emergency department had at least one USG device. However, 39% of participants felt that these devices were not sufficient for making diagnoses. Two-thirds (67.7%) of participants indicated they had received USG training, and a significant majority (62.9%) reported an increase in the frequency of USG use after receiving training.

Conclusion: In our study, we found that emergency medicine residents training at university hospitals used USG devices more frequently across various types of USG compared to those training at EAH-city hospitals. Additionally, we believe that replacing all devices at the centers with state-of-the-art technology that aids in diagnosis will increase the frequency of use and, over time, reduce examination costs and diagnosis times.

Key words: Ultrasonography, FAST, BLUE Protocol, Emergency Medicine

Introduction

Ultrasonography (US) is a non-invasive, real-time imaging modality that has become an indispensable diagnostic and procedural tool in modern emergency medicine. A fundamental understanding of ultrasound physics is essential for clinicians to obtain and accurately interpret high-quality images. Ultrasound systems generate high-frequency sound waves, typically ranging from 2 to 15 MHz, through piezoelectric crystals embedded within the transducer.

These sound waves propagate through tissues and interact with anatomical structures according to differences in their acoustic impedance (1). During propagation, ultrasound waves undergo attenuation, reflection, refraction, scattering, and absorption, all of which contribute to image formation and influence image quality. The degree of sound wave reflection varies according to tissue composition. Highly dense structures such as bone strongly reflect ultrasound waves and appear hyperechoic (bright white), whereas fluid-filled structures transmit sound with min-

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imal reflection and appear anechoic (black). Soft tissues demonstrate intermediate echogenicity and are visualized in varying shades of gray. Appropriate transducer selection is critical for optimal imaging (2,3). High-frequency probes provide superior spatial resolution but have limited tissue penetration, making them suitable for superficial structures. Conversely, low-frequency probes allow deeper tissue penetration at the expense of image resolution and are preferred for abdominal and cardiac examinations. Probe selection should therefore be tailored to the target organ, imaging depth, and patient characteristics. To eliminate the air interface between the transducer and the skin, a water-based coupling gel is routinely applied, allowing efficient transmission of ultrasound waves into the body (3,4). Ultrasound imaging includes four principal modes: A-mode, B-mode, M-mode, and Doppler imaging. B-mode is the standard two-dimensional grayscale modality used in routine clinical practice. M-mode is primarily used in echocardiography to assess moving cardiac structures with high temporal resolution (4,5). Doppler ultrasonography evaluates the velocity and direction of blood flow by utilizing the Doppler effect, while color Doppler superimposes blood-flow information onto the grayscale image, conventionally displaying flow toward the transducer in red and flow away from the transducer in blue. These imaging principles enable rapid bedside assessment of a wide range of emergency conditions and form the foundation of point-of-care ultrasonography. Ultrasonography has become an indispensable component of emergency medicine because of its rapid, non-invasive, repeatable, and radiation-free nature. As the scope of point-of-care ultrasonography (POCUS) continues to expand, competency in ultrasound has become a core skill expected of emergency medicine residents. Understanding the fundamental principles of ultrasound, selecting the appropriate transducer, and recognizing the capabilities of different imaging modes are essential prerequisites for its effective bedside application. However, the availability of ultrasound equipment alone is insufficient to ensure its optimal clinical use; adequate training and regular practice are equally important. In light of these considerations, the present study was designed to evaluate the current use of ultrasonography among emergency medicine residents in Türkiye, determine the frequency of its use across different clinical applications and stages of residency training, and identify areas where ultrasound education and implementation may be improved.

Materials and Methods

This study included emergency medicine residents who were in training between May 1, 2024, and May 31, 2024, and who agreed to participate in the study. Ethical approval was obtained from the Bezmialem Vakıf Uni-

versity Ethics Committee (Approval No. 2024/80, dated April 1, 2024). The study was conducted in accordance with the principles of the Declaration of Helsinki. This was a prospective, cross-sectional questionnaire-based study. All questionnaires were completed through face-to-face interviews. All participants were emergency medicine residents. Written informed consent was obtained from all participants prior to enrollment, and those who declined to participate were excluded from the study. The questionnaire consisted of a total of 15 items. In addition to demographic characteristics such as sex and the institution where residency training was being completed, the questionnaire included items regarding duration of emergency medicine residency training, availability of an ultrasound device at the training institution, adequacy of the ultrasound equipment for diagnostic purposes, previous ultrasound training, changes in ultrasound utilization following training, frequency of ultrasound use in daily practice, frequency of ultrasound use during resuscitation, frequency of performing the Focused Assessment with Sonography for Trauma (FAST) examination, frequency of echocardiography use, use of optic nerve sheath diameter measurement, use of ultrasound for the diagnosis of deep vein thrombosis (DVT), use of the BLUE protocol, and use of ultrasound in the evaluation of testicular torsion. The questionnaire was developed by the Department of Emergency Medicine based on the current literature and consisted of items rated on a 5-point Likert scale. Considering the study population as all emergency medicine residents in the department, the minimum required sample size was calculated using the Raosoft Sample Size Calculator. The minimum sample size was determined to be 22 participants (margin of error: 5%, confidence level: 95%, population size: 23, $\alpha = 0.05$, power $[1-\beta] = 0.90$).

Statistical Analysis

Statistical analyses were performed using IBM SPSS Statistics version 26.0. The normality of continuous variables was assessed using histogram plots and the Kolmogorov-Smirnov test. Descriptive statistics were presented as mean, standard deviation, median, and minimum-maximum values, as appropriate. Categorical variables in 2×2 contingency tables were compared using the Pearson chi-square test. Continuous variables that did not follow a normal distribution were compared between groups using the Mann-Whitney U test. A p-value < 0.05 was considered statistically significant.

Results

A total of 190 emergency medicine residents participated in the study, including 116 (61.1%) males and 74 (38.9%) females. Of the participants, 112 (58.9%) were training

Table 1. Mean scores of participants' responses

Participant Responses	Mean $\pm$ SE
Residency year	1.71 $\pm$ 0.13*
Monthly frequency of ultrasound use	1.873 $\pm$ 0.09**
Frequency of ultrasound use during resuscitation	1.470 $\pm$ 0.09**
Frequency of FAST examination	1.680 $\pm$ 0.09**
Frequency of ultrasound use for detection of regional wall motion abnormalities in myocardial infarction	1.569 $\pm$ 0.10*
Frequency of ultrasound use for the BLUE protocol	0.718 $\pm$ 0.07*
Frequency of ultrasound use for deep vein thrombosis (DVT) diagnosis	1.275 $\pm$ 0.09*
Frequency of ultrasound use for optic nerve sheath diameter (ONSD) measurement	0.234 $\pm$ 0.02*
Frequency of ultrasound use for the diagnosis of testicular torsion	0.423 $\pm$ 0.04*

*Data are presented as mean $\pm$ standard error (SE). Residency year was categorized according to training duration. Ultrasound use frequency was scored based on the reported monthly frequency of use using a four-point ordinal scale (0 = never, 1 = 1–5 times/month, 2 = 6–10 times/month, 3 = >10 times/month).

at university hospitals, while 78 (41.1%) were training at training and research/city hospitals. Regarding residency duration, 47 (24.7%) participants were in their first 12 months of training, 45 (23.7%) in months 12–24, 40 (21.1%) in months 24–36, 31 (16.3%) in months 36–48, and 27 (14.2%) had been in training for more than 48 months. Among the respondents, 94.7% reported that an ultrasound (US) device was available in their institution, whereas 39.0% stated that the available device was not adequate for emergency department diagnosis and treatment. Of the 189 participants who answered the question regarding previous ultrasound training, 128 (67.7%) reported having received ultrasound training. Among the 178 participants who responded to the question regarding changes in ultrasound use after training, 112 (62.9%) reported an increase in the frequency of ultrasound use. Regarding monthly ultrasound use, 189 participants responded: 24 (12.7%) reported never using ultrasound, 58 (30.7%) reported using it 1–5 times, 25 (13.2%) reported 6–10 times, and 82 (43.4%) reported using ultrasound more than 10 times per month. For ultrasound use during resuscitation, 189 participants responded: 49 (25.9%) reported never using ultrasound, 57 (30.2%) reported using it 1–5 times, 28 (14.8%) reported 6–10 times, and 55 (29.1%) reported more than 10 uses. Regarding FAST examinations, 189 participants responded: 34 (18.1%) reported never performing FAST, 64 (34.0%) reported performing it 1–5 times, 18 (9.6%) reported 6–10 times, and 72 (38.3%) reported more than 10 times. For the assessment of regional wall motion abnormalities in suspected myocardial infarction, 188 participants responded: 45 (23.9%) reported never using ultrasound, 52 (27.7%) reported using it 1–5 times, 30 (16.0%) reported 6–10 times, and 61 (32.4%) reported more than 10 uses. Regarding optic nerve sheath diameter measurement, 188 participants responded: 154 (81.9%) reported never using ultrasound, 27 (14.4%) reported using it 1–5 times, 4 (2.1%) reported 6–10 times, and 3 (1.6%) reported more than 10 uses. For the diagno-

sis of deep vein thrombosis (DVT), 189 participants responded: 62 (32.8%) reported never using ultrasound, 61 (32.3%) reported using it 1–5 times, 18 (9.5%) reported 6–10 times, and 48 (25.4%) reported more than 10 uses. Regarding use of the BLUE protocol, 188 participants responded: 107 (56.9%) reported never using ultrasound, 47 (25.0%) reported using it 1–5 times, 14 (7.4%) reported 6–10 times, and 20 (10.6%) reported more than 10 uses. For the diagnosis of testicular torsion, 189 participants responded: 135 (71.4%) reported never using ultrasound, 37 (19.6%) reported using it 1–5 times, 8 (4.2%) reported 6–10 times, and 9 (4.8%) reported more than 10 uses (Table 1). Diagnostic ultrasound use was significantly more frequent among residents training at university hospitals than among those at training and research/city hospitals ($p = 0.004$). Ultrasound use during resuscitation was also significantly higher in university hospitals ($p = 0.022$). Similarly, ultrasound use for FAST examinations ($p = 0.032$), assessment of regional wall motion abnormalities in myocardial infarction ($p = 0.003$), diagnosis of DVT ($p = 0.003$), and implementation of the BLUE protocol ($p = 0.003$) was significantly more frequent among residents at university hospitals. No statistically significant differences were observed between the two hospital types regarding ultrasound use for the diagnosis of testicular torsion ($p = 0.072$) or optic nerve sheath diameter measurement ($p = 0.644$). Chi-square analysis showed no statistically significant differences between university hospitals and training and research/city hospitals regarding the availability of ultrasound devices in the emergency department, previous ultrasound training, or the adequacy of the available ultrasound equipment (Table 2).

Discussion

Point-of-care ultrasonography (POCUS) has become an essential component of emergency medicine practice and is accepted as a core competency in emergency medicine

Table 2. Comparison of ultrasound utilization between residents training at university hospitals and those training at training and research/city hospitals

Ultrasound Application	P value
Overall ultrasound utilization	0.004
Ultrasound use during resuscitation	0.022
Ultrasound use for FAST examination	0.032
Ultrasound use for detection of regional wall motion abnormalities in myocardial infarction	0.003
Ultrasound use for optic nerve sheath diameter (ONSD) measurement	0.644
Ultrasound use for deep vein thrombosis (DVT) diagnosis	0.003
Ultrasound use for the diagnosis of testicular torsion	0.072
Ultrasound use for the BLUE protocol	0.003

residency training by organizations responsible for emergency medicine education in the United States and Canada (6,7). Although structured ultrasound curricula have been implemented in North America since the early 1990s, a standardized national curriculum has not yet been fully established in Türkiye (8). Therefore, evaluating the current level of ultrasound utilization among emergency medicine residents is important for identifying educational needs. In the present study, 94.7% of participants reported that an ultrasound device was available in their emergency department. This finding is consistent with the survey conducted by Selman et al., who reported an ultrasound availability rate of 96% among emergency medicine residency training centers in Türkiye (9). Similarly, the Turkish Ministry of Health regulation published in 2022 recommends that ultrasonography units should be located within or adjacent to emergency departments (10). Despite this widespread availability, 39% of participants considered the existing ultrasound equipment insufficient for emergency department diagnosis and treatment. These findings indicate that equipment availability alone does not necessarily ensure adequate clinical utilization and that device quality and accessibility remain important issues. Although ultrasound devices were available in nearly all participating institutions, only 43.4% of residents reported using ultrasound more than ten times per month, while 12.7% reported never using ultrasound. Kokulu et al. similarly demonstrated that only approximately 75% of physicians working in emergency departments routinely used ultrasonography despite having access to an ultrasound device (11). Together, these findings suggest that barriers other than equipment availability continue to influence routine POCUS utilization. More than two-thirds of participants had received formal ultrasound training, and 62.9% reported increased ultrasound use after training. This finding supports the importance of structured educational programs in improving resident

confidence and encouraging routine integration of ultrasound into clinical practice. Standardized ultrasound education during residency may therefore increase both competency and frequency of use. One of the major findings of the present study was the significant difference between university hospitals and training and research/city hospitals. Residents training at university hospitals reported significantly higher utilization of ultrasound for diagnostic examinations, FAST, focused cardiac ultrasound, DVT evaluation, the BLUE protocol, and resuscitation. These differences are likely related to the stronger academic environment, greater faculty supervision, and increased opportunities for structured ultrasound education available in university hospitals. Approximately one-quarter of participants reported never using ultrasound during cardiopulmonary resuscitation. Current international resuscitation guidelines emphasize that bedside ultrasound may help identify reversible causes of cardiac arrest and confirm cardiac standstill but should never prolong interruptions in chest compressions (12,13). Therefore, ultrasound training should focus not only on image acquisition but also on appropriate integration into resuscitation algorithms. FAST examination was one of the most frequently performed ultrasound applications in the present study. Nevertheless, 18.1% of residents reported never performing FAST. Özdemir et al. reported a comparable utilization rate for trauma-focused ultrasonography among emergency physicians (14). FAST has been incorporated into the Advanced Trauma Life Support (ATLS) algorithm because of its high specificity and rapid bedside applicability (15). Previous studies have demonstrated sensitivity ranging from 85% to 96% and specificity exceeding 98%, with sensitivity approaching 100% in hypotensive trauma patients (16). These findings support the importance of maintaining adequate FAST competency throughout residency training. Focused cardiac ultrasound for detecting regional wall motion abnormalities in suspected acute myocardial infarction was regularly used by only one-third of participants. Although echocardiography does not replace electrocardiography or cardiac biomarkers, regional wall motion abnormalities remain an important indicator of myocardial ischemia (17,18). Grenne et al. demonstrated that focused cardiac ultrasound could facilitate the early identification of acute coronary occlusion in patients with non-ST-segment elevation myocardial infarction and help identify patients requiring urgent revascularization (19). Increasing resident competency in focused cardiac ultrasound may therefore improve bedside assessment of patients presenting with chest pain. Optic nerve sheath diameter measurement was the least frequently used ultrasound application, with more than 80% of residents reporting that they had never performed the examination. Can et al. demonstrated

that an optic nerve sheath diameter greater than 5 mm was significantly associated with intracranial pathology on computed tomography and elevated intracranial pressure (20). Similarly, Restrepo et al. concluded that optic nerve sheath ultrasonography may represent a valuable bedside method for detecting elevated intracranial pressure in emergency department and intensive care unit patients (21). Despite growing evidence, the present findings suggest that this application has not yet been widely incorporated into emergency medicine training. Only one-quarter of participants reported frequent ultrasound use for the diagnosis of deep vein thrombosis. Compression ultrasonography is widely accepted as a rapid and reliable bedside diagnostic method. Su et al. reported a sensitivity of 100%, specificity of 97%, positive predictive value of 96%, negative predictive value of 100%, and overall diagnostic accuracy of 98% for color Doppler ultrasonography in DVT diagnosis (22). Likewise, Hamper et al. reported sensitivity and specificity approaching 95–100% (23). Despite this strong evidence, DVT ultrasonography appears to remain underutilized in routine emergency practice. Similarly, ultrasound utilization for the BLUE protocol was relatively low, with more than half of residents reporting that they had never applied the protocol. Previous studies have consistently demonstrated that lung ultrasonography is a safe, non-invasive, bedside imaging modality that significantly contributes to the diagnosis and management of critically ill patients (24,25). Furthermore, lung ultrasonography plays an important role in the rapid evaluation of acute respiratory failure by facilitating the diagnosis of pneumothorax, pleural effusion, pulmonary edema, pneumonia, and pulmonary contusion (26). These findings suggest that greater emphasis should be placed on lung ultrasound education during emergency medicine residency. Finally, ultrasound use for the diagnosis of testicular torsion was uncommon, and no significant difference was observed between university hospitals and training and research/city hospitals. Because testicular torsion is a time-critical condition in which prompt diagnosis directly affects testicular salvage, further studies are needed to investigate barriers limiting bedside ultrasound use in this clinical setting. Overall, our findings indicate that although ultrasound equipment is widely available in emergency departments, utilization remains inconsistent across different clinical applications. The significantly higher utilization rates observed in university hospitals suggest that structured education and academic training play a greater role than equipment availability alone. Establishing a standardized national POCUS curriculum and increasing supervised hands-on training may improve competency and promote more consistent ultrasound use among emergency medicine residents in Türkiye.

Conclusion

This study demonstrated that structured ultrasound education is associated with increased utilization of point-of-care ultrasonography (POCUS) among emergency medicine residents in Türkiye. Although ultrasound devices are available in most training centers, variability in equipment quality and the absence of standardized training programs remain important barriers to the widespread and effective use of POCUS. These findings highlight the need to incorporate standardized ultrasound training into the national emergency medicine residency curriculum and to ensure that training centers are equipped with adequate ultrasound devices. Expanding structured POCUS education and improving access to appropriate equipment may increase the use of bedside ultrasonography in emergency departments, facilitate more rapid diagnosis and treatment, and potentially reduce the need for additional imaging modalities and associated healthcare costs. Further multicenter studies are warranted to evaluate the long-term impact of standardized ultrasound education on clinical practice and patient outcomes.

Ethics Committee Approval: Ethical approval was obtained from the Bezmialem Vakıf University Ethics Committee (Approval No. 2024/80, dated April 1, 2024).

Informed Consent: Informed consent was waived due to the retrospective design of the study.

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References

1. G. S. Klinik El Kitabı Ultrason. İstanbul: İstanbul Medikal Yayıncılık. 2011
2. Rose JS BAE. Fundamentals of ultrasound. In: Cosby KS, Kendall JL, editors. Practical guide to Emergency Ultrasound. PA: Lippincott Williams and Wilkins; 2006. pp. 2006. 27–41 s

3. Abu-Zidan FM, Hefny AF CP. doi:10.4103/0974-2700.86646. Clinical ultrasound physics J Emerg Trauma. 2011; 4(4):501-3.
4. Hadzic A. Ultrason Fiziği. Hadzic Periferik Sinir Blokları ve Ultrason Eşliğinde Rejyonel Anestezi İçin Anatomi. 2th ed: Güneş Tıp Kitapevleri; 2013. p. 323-33
5. Hatfield A, Bodenham A. Ultrasound: an emerging role in anaesthesia and intensive care. British journal of anaesthesia. 1999;83(5):789-800.
6. American College of Emergency Physicians. Council resolution on ultrasound. ACEP News. 1990;9(11).
7. Society for Academic Emergency Medicine. Ultrasound position statement. SAEM Newsletter. 1991;summer.
8. Pomero F, Dentali F, Borretta V, Bonzini M, Melchio R, Douketis JD, Fenoglio LM. Accuracy of emergency physician-performed ultrasonography in the diagnosis of deep-vein thrombosis. Thromb Haemost. 2013;109(1):137-45.
9. Selman, F., Günsoy, E., Ünal, A. Y., & Şenol, Y. (2022). Content and Adequacy of Emergency Medicine Point of Care Ultrasound Training: Evaluation of Turkey. Eurasian J Emerg Med 2022;21(4):252-258
10. <https://www.resmigazete.gov.tr/eskiler/2022/09/20220913-5.html>Erişim tarihi: 13 Eylül 2022
11. KokuluK, Sert.ET, Mutlu H. Evaluationof Bedside Ultrasonography Use of Emergency Physicians. Med J West Black Sea. 2021;5(2):182-187
12. Chardoli M, Heidari F, Rabiee H, Sharif-Alhoseini M, Shokoohi H, Rahimi-Movaghar V. Echocardiography integrated ACLS protocol versus conventional cardiopulmonary resuscitation in patients with pulseless electrical activity cardiac arrest. Chin J Traumatol. 2012;15(5):284-287
13. Flato UAP, Paiva EF, Carballo MT, Buehler AM, Marco R, Timerman A. Echocardiography for prognostication during the resuscitation of intensive care unit patients with non-shockable rhythm cardiac arrest. Resuscitation. Published online July 2015:1-6
14. Evaluation of Demographic and Clinical Characteristics of Patients Presenting to the Emergency Department with Traffic Accidents Serdar Özdemir, Ebru Ünal Akoğlu, Taygun Baykal Sayfalar 85 – 89
15. İşcanlı Murat Doğan. Travma (E-FAST). Türkiye Klinikleri Emergency Medicine-Special Topics, 2018, 4.1: 5-10
16. Jang, Timothy, et al. "The technical errors of physicians learning to perform focused assessment with sonography in trauma." Academic Emergency Medicine 19.1 (2012): 98-101
17. Steeds RP, Garbi M, Cardim N, Kasprzak JD, Sade E, Nihoyannopoulos P, et al. EACVI appropriateness criteria for the use of transthoracic echocardiography in adults: a report of literature and current practice review. European Heart Journal - Cardiovascular Imaging. 2017;18(11):1191-204
18. TURAK, Osman. "Akut Koroner Olaylarda Ekokardiyografik Anatomi." Türkiye Klinikleri Cardiology-Special Topics 3.5 (2010): 27-31
19. Grenne, Bjørnar, et al. "Acute coronary occlusion in non-ST-elevation acute coronary syndrome: outcome and early identification by strain echocardiography." Heart 96.19 (2010): 1550-1556
20. Özge C., Ersel M.Y, S, Akarca, F. K. (2023). Acil servise kafa travması ile başvuran hastaların yönetiminde optik sinir kılıf çapı ölçümünün değerlendirilmesi. Ege Tıp Dergisi, 62(1), 112-118
21. Jimenez Restrepo JN, León OJ, Quevedo Florez LA. Ocular Ultrasonography: A Useful Instrument in Patients with Trauma Brain Injury in Emergency Service. Emerg Med Int. 2019;2019:1-6.
22. Sü Ö, Elçin F, Topal U, Savcı G, Tuncel E. Alt ekstremitelerde derin ven trombozlarında renkli Doppler US ve venografi yöntemlerinin karşılaştırılması. Tanısal ve Girişimsel Radyoloji. 1994;1(1):13-20
23. Hamper UM, DeJong MR, Scoutt LM (2007) Alt ekstremitelerde damarlarının ultrason değerlendirmesi. Radiol Clin N Am 45:525-547
24. Eren, G., Hergünel, O., Çukurova, Z., Doğan, Y., & Karakaya, O. (2012). Yoğun Bakımda Kardiyopulmoner Monitorizasyonda Günlük Pratiğimizde "Yeni" Bir Araç: Transtorasik Ekokardiyografi ve Akciğer Ultrasonu. Journal of the Turkish Society of Intensive Care/Türk Yoğun Bakım Derneği Dergisi, 10(1)
25. Çelik, Halime. "Postoperatif dönemde yoğun bakımda takip edilen hastaların akciğer ultrasonografisi ile değerlendirilmesi." (2022).
26. KELEŞ, Ayfer. "Akut Solunum Yetmezliği Olan Acil Servis Hastalarının Tanısında Akciğer Ultrasonografisinin Kullanımı." Türkiye Klinikleri Emergency Medicine-Special Topics 4.1 (2018): 11-16

One-Year Analysis of a Pediatric Emergency Department Observation Unit: Patient Characteristics, Clinical Outcomes, and Disposition Patterns

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Abstract

Background: The aim of our study is to evaluate the reasons for using pediatric emergency services, patient volume, and the rates of admission to intensive care units and inpatient wards in the pediatric emergency department observation unit.

Materials and Methods: Data from 6,846 patients monitored in the pediatric emergency department observation unit at Prof. Dr. Cemil Tascioglu City Hospital were analyzed between January 1, 2023, and December 31, 2023. The data collected included: date and time of application, age, gender, diagnosis, disease group, length of stay in observation, ward admission, intensive care unit admission, referral unit, presence of chronic conditions, medications used, discharge status, treatment refusal, and histories of previous ward and intensive care unit admissions.

Results: Of the 6,846 patients, the most common diseases were respiratory (23.2%) and gastrointestinal (23.1%). Significant differences in observation duration were observed among patients with a history of prior hospitalization ($p=0.004$) and those admitted to the intensive care unit ($p<0.001$). The relationship between younger age and longer observation duration was significant ($p=0.031$). Observation duration was longer in patients with previous ward admission ($p=0.004$). Prior hospitalization was associated with an increased risk of ward admission ($p<0.001$), while chronic illnesses were associated with an increased risk of intensive care unit admission ($p=0.004$).

Conclusion: Infants and males were admitted more frequently, with notable seasonal and hourly peaks. Prior hospitalization strongly predicted intensive care unit or ward admission, underscoring the value of medical history in triage. Observation units play a critical role in improving triage efficiency, reducing unnecessary admissions, and optimizing resource allocation in tertiary pediatric emergency care.

Keywords: Child; Emergency Service, Hospital; Observation Unit; Triage

Introduction

Due to the critical nature of emergencies, operations in these settings must be rapid and error rates must remain minimal. Otherwise, irreversible, life-threatening complications may occur, resulting in substantial expenses for both patients and healthcare providers (1). The evaluation of pediatric emergencies is more complex than that of adults due to age-related presentations and rapid clinical changes. The health of a child arriving at a pediatric emergency department must be promptly assessed to ensure precise preliminary diagnoses and appropriate treatment

strategies to reduce morbidity and mortality (2). The primary factor contributing to increased patient volume is that individuals who would typically qualify for outpatient services are instead seeking care in emergency departments. The number of patients requiring professional emergency intervention has consistently risen. Pediatric emergencies comprise roughly 30% of all emergency cases. In our country, the availability of specialists has been limited compared to other nations, leading to increased workloads at emergency departments (3).

Observation units, referred to as “short-term treatment areas” or “rapid treatment units,” have emerged as im-

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portant components of healthcare services in recent years. Emergency observation units are designed to facilitate a more accurate evaluation of clinical findings through brief patient observation and to prevent unnecessary testing and procedures. In our institution, as in many emergency departments, patients are triaged using a colour-based acuity system. Red indicates critically ill patients requiring immediate life-saving intervention, green identifies patients with minor conditions suitable for routine outpatient management, and yellow represents patients who are clinically stable but require ongoing observation and reassessment before a decision regarding discharge or hospital admission can be made. The pediatric emergency department observation unit primarily manages these yellow-zone patients, who constitute the study population of the present analysis. Dedicated observation units have been associated with fewer hospital admissions and may decrease costs (4). Furthermore, by observing patients' clinical progress over a designated timeframe in observation units, the necessity for critical care and ward services can be assessed more accurately.

This study analyzes patient demographics and clinical outcomes (discharge, ward admission, ICU transfer) in a high-volume pediatric emergency observation unit.

Material and Methods

In our study, we evaluated patients who presented to the Pediatric Emergency Department of the Pediatrics Clinic at Prof. Dr. Cemil Tascioglu City Hospital, from January 1, 2023, to December 31, 2023, and were observed in the observation area. Approximately 500 to 1,500 patients present to our hospital's pediatric emergency department daily. During the study period, a total of 218,231 pediatric patients presented to the emergency department. A total of 6,846 patients from the yellow zone, also called the emergency observation area, were included in the study.

The study was conducted in accordance with the principles of the Declaration of Helsinki. Before the study, written consent was obtained from the University of Health Sciences Hamidiye Scientific Research Ethics Committee (Approval no: 2/53, 2024/2). The patients' histories, clinical data, and laboratory findings were obtained from patient files and hospital automation system records, and subsequently documented on patient information forms created for the study.

At our institution, patients classified as yellow triage and requiring short-term monitoring are placed in the pediatric emergency department observation area. These patients require observation for conditions that are not immediately life-threatening but need monitoring before discharge or admission decisions can be made. Patients under 18 years of age who presented on or after January 1,

2023, were followed in this observation area, had accessible data, and were included in our study. Patients aged 18 or older, those with insufficient data, and those classified as red triage (severe conditions requiring immediate attention) or green triage (minor symptoms not requiring observation) were excluded.

Patient observation records were retrospectively analyzed, and data regarding to the date and time of presentation to the pediatric emergency department, age, gender, diagnosis, disease classification, duration of observation, ward admission, intensive care admission, referral unit, chronic conditions, medication usage, discharge status, treatment refusal, prior ward admissions, and previous intensive care admissions were recorded on the information forms. Respiratory diseases predominantly included lower respiratory tract infections (bronchiolitis, pneumonia, wheezing-associated illness). Gastrointestinal presentations included acute gastroenteritis, vomiting, diarrhea, dehydration, and abdominal pain. Neurological presentations comprised febrile and afebrile seizures, status epilepticus, altered consciousness, headache, and syncope. Infectious presentations included fever without source and viral syndromes. All remaining presentations were categorized according to the primary diagnosis at admission.

Statistical Analysis

Statistical analysis was conducted using IBM SPSS Statistics software (IBM Corp., Armonk, NY, USA). Descriptive statistics: Categorical data were represented as counts and percentages, while numerical variables were expressed as mean, standard deviation, minimum, maximum, and median. Comparisons of numerical variables among groups were conducted using the Kruskal-Wallis test for more than two independent groups and the Mann-Whitney U test for two groups, given the absence of normality. Subgroup analyses were evaluated utilizing the Bonferroni Correction. The Chi-Square Test was employed to compare proportions among groups. The alpha significance level was set at $p < 0.05$.

Results

Our study included 6,846 patients who presented to the Pediatric Emergency Department at Prof. Dr. Cemil Tascioglu City Hospital, University of Health Sciences, and were monitored in the observation area from January 1, 2023, to December 31, 2023. Analysis of gender distribution revealed that 55.5% were male and 44.5% were female. The predominant age group for pediatric emergency observation was infancy (36.9%; 0-2 years), followed by adolescents (23.2%; 12-18 years), early childhood (22.3%; 3-6 years), and late childhood (17.3%; 7-11 years).

Evaluation of hourly variations in pediatric emergency observation visits showed that the busiest hours were between 14:00-15:00, followed by 22:00-23:00. When the distribution of presentations was evaluated by season and month, winter had the highest number of admissions, and the busiest month was January.

When the disease groups of patients under observation were assessed, respiratory diseases constituted 23.2% of all observation indications, mainly lower respiratory tract diseases including bronchiolitis, pneumonia, and wheezing-associated illness, followed by gastrointestinal system diseases including acute gastroenteritis, vomiting/diarrhea (23%), neurological diseases such as seizures, febrile convulsion, headache (17.93%), and infectious diseases (15.99%). The distribution of disease groups by age, sex, and observation duration is summarized in Table 1.

Among the observed patients, 15.8% had a prior admission to a critical care unit, while 31.86% had a prior hospital admission. Among the patients examined, 34.24% were admitted to the hospital, while 1.97% were admitted to an intensive care unit. Of the patients under observation, 5.49% were referred to other hospital units. The pediatric infectious disease unit received the most referrals. A total of 3.61% were referred to an external center. Discharge occurred in 56.24%, and 4.85% refused treatment. Pharmacological management in the observation unit was tailored to each patient's presenting condition. In routine practice, treatment commonly included antipyretics and analgesics, inhaled bronchodilators for

respiratory illnesses, intravenous fluids and antiemetics for gastrointestinal conditions with dehydration, antibiotics for suspected bacterial infections, and antiepileptic medications for neurological disorders. Because medication use was not collected as a predefined study variable, the specific drugs administered during observation were not analyzed. Analysis of age distribution by disease group showed that respiratory system-related observations occurred most frequently in infancy (62.8%), gastrointestinal system-related observations are most frequent during the preschool period (27.9%), neurological-related observations are most frequent in infancy (33.0%), infection-related observations are most frequent in infancy (40.5%), and intoxication-related observations are most frequently in adolescence (46.6%).

The analysis of disease group distribution by gender revealed that intoxication, endocrine disorders, nephrogenic conditions, and psychogenic diseases were predominantly observed in females, whereas other disease categories were more prevalent in males.

When disease groups, history of hospitalization, hospitalization, intensive care unit admission, referral unit, referral to an external center, and discharge treatment refusal rates were evaluated across genders, no significant differences were found between males and females. The mean observation time was 7.43 ± 4.80 hours, with a range of 0.5 to 43 hours. When comparing observation duration by disease group, the longest duration was observed for intoxications (9.1 ± 5.9 hours), followed by neurological diseases (7.8 ± 4.6 hours).

Table 1. Disease group distribution, predominant age group, sex distribution, and median observation duration

Disease Group	n (%)	Predominant Age Group (%)	Female-predominant	Median Obs. Duration (h)
Respiratory	1,580 (23.2%)	Infancy — 0–2 yrs (62.8%)	No	6
Gastrointestinal	1,571 (23.1%)	Preschool — 3–6 yrs (27.9%)	No	7
Neurological	1,220 (17.9%)	Infancy — 0–2 yrs (33.0%)	No	7
Infectious	1,088 (16.0%)	Infancy — 0–2 yrs (40.5%)	No	6
Intoxication	539 (7.9%)	Adolescence — 12–18 yrs (46.6%)	Yes	8
Hematologic	135 (2.0%)	Adolescence — 12–18 yrs (31.9%)	No	5
Surgical	109 (1.6%)	Adolescence — 12–18 yrs (33.9%)	No	4
Allergy	104 (1.5%)	Infancy — 0–2 yrs (30.8%)	No	5
Cardiology	96 (1.4%)	Adolescence — 12–18 yrs (60.4%)	No	5
Endocrine	83 (1.2%)	Preschool — 3–6 yrs (33.7%)	Yes	5
Musculoskeletal	77 (1.1%)	Adolescence — 12–18 yrs (42.9%)	No	6
Rheumatologic	69 (1.0%)	School age — 7–11 yrs (37.7%)	No	5
Trauma	68 (1.0%)	Infancy — 0–2 yrs (30.9%)	No	6
Nephrology	42 (0.6%)	Infancy — 0–2 yrs (28.6%)	Yes	5
Psychogenic	10 (0.1%)	Adolescence — 12–18 yrs (80.0%)	Yes	3.5
Other	55 (0.8%)	—	—	5
Total	6,846 (100%)			

Sex distribution: $p < 0.001$ (Chi-square test). Age group distribution: $p < 0.001$ (Chi-square test). Observation duration: $p < 0.001$ (Kruskal-Wallis test).

Table 2. Comparison of demographic and clinical characteristics according to final disposition

Variable	Discharge (n = 3,835)	Ward Admission (n = 2,344)	ICU Admission (n = 135)	p-value
Median age (years)	6.0	4.0	3.0	< 0.001
Male (%)	29.8%	31.8%	27.4%	0.061
Prior ward admission (%)	30.7%	34.7%	28.1%	< 0.001
Prior ICU admission (%)	13.1%	19.7%	21.5%	< 0.001
Median observation time (hours)	6.0	6.0	4.0	< 0.001

Male (%) values represent the proportion of male patients within each disposition group relative to the total observation cohort (n=6,846), not the within-group sex ratio.

Continuous: median (IQR), Kruskal–Wallis test.

Categorical: %, Chi-square test.

The duration of observation for patients with a history of hospital admission was statistically significantly longer than that of other patients, while the duration of observation for patients with an intensive care unit admission was statistically significantly shorter than that of other patients ($p=0.004$, $p<0.001$).

The duration of the observation stay was weakly correlated with age ($p=0.031$). No statistically significant differences were observed in the rates of ward and critical care unit admissions between genders ($p=0.736$, $p=0.489$).

The comparison of demographic and clinical characteristics according to final disposition is shown in Table 2. Patients admitted to the ICU were significantly younger than those discharged or admitted to the ward (median ages of 3 versus 6 and 4 years, respectively; $p < 0.001$). The observation duration was significantly shorter for patients requiring ICU admission, compared with those who were discharged or admitted to the ward (median 4 hours versus 6 hours; $p < 0.001$).

The rate of ward admission was statistically significantly higher among patients with a prior history of ward admission than among those without ($p < 0.001$). The incidence of ICU admission was statistically significantly higher in patients with chronic disorders compared to those without ($p=0.004$).

Discussion

This study analyzed a large pediatric population observed in the pediatric emergency department observation unit over one year, highlighting the significant demand on tertiary pediatric emergency services. Similar to previous studies, younger children, especially infants, more frequently require monitoring due to their symptoms often nonspecific and progressing rapidly (3,4). The admission time pattern may reflect parental availability in the afternoon and suggest that acute symptoms often emerge in the evening, prompting families to seek medical help right away, even though it's late. Temporal clustering of pre-

sentations emphasizes the need for flexible staffing models in pediatric emergency departments (5). The highest frequency of observation occurred with monthly surges in January and December. These findings may reflect the seasonal increase in viral disorders, particularly respiratory ones, which tend to peak in the winter (6,7). This corresponds with global studies demonstrating a seasonal trend in pediatric emergency visits (8).

Our study revealed that the primary reasons for observation were related to lower respiratory tract infections and gastrointestinal issues. These data are consistent with prior studies that have shown that acute gastroenteritis and respiratory tract infections are the most common causes of pediatric emergency visits (4,6). Similarly, Yusuf et al. (9), who examined pediatric emergency department observation unit data, reported that the most common diagnoses among patients admitted from the observation unit were bronchiolitis, gastroenteritis, and cellulitis/abscess. Collectively, these findings demonstrate that the Pediatric Emergency Department Observation Unit plays a critical clinical role, particularly in the short-term monitoring and decision-making processes for respiratory and gastrointestinal diseases. Our investigation revealed that neurological conditions frequently occurred in infancy, highlighting the necessity for effective triage in this age group and the critical importance of early management of seizures and altered consciousness in emergencies. In a previous study, it was emphasized that neurological emergencies in emergency departments are more common in infancy and that effective recognition and rapid emergency intervention are life-saving for these young patients. Additionally, the WHO's ETAT (Emergency Triage Assessment and Treatment) recommendations emphasize that newborns exhibiting convulsive seizures or significantly altered consciousness necessitate immediate intervention and anticonvulsant treatment, especially in resource-limited environments (10,11).

Current admission was significantly associated with prior hospitalization and ICU history in our study, which supports the adoption of structured triage and observation

protocols to optimize hospital resource utilization (12,13). Prior hospitalization and chronic disease can function as early risk markers and should be integrated into pediatric triage algorithms. The high discharge rate is consistent with prior evidence that short-stay units reduce hospital admissions and healthcare costs, while improving resource utilization in pediatric emergency departments, and supports the utility of observation units in preventing unnecessary hospitalizations (4, 13,14). Similarly, a study evaluating the pediatric observation unit reported that the observation period usually did not exceed 24 hours, and the use of the observation unit reduced the admission rate to pediatric wards by 3.6%; it was also noted that short-term observation prevented unnecessary hospitalizations in cases such as asthma, croup, dehydration, and convulsions (15). These results are consistent with our study, in which a significant proportion of patients were safely discharged after observation.

Clinical presentations differed according to developmental stage, underscoring the importance of age-specific assessment methods. This aligns with developmental trends: newborns possess underdeveloped immune systems, whereas adolescents have a heightened propensity for risk-taking behavior and intentional ingestion (16,17). In accordance with prior studies, girls in our pediatric emergency sample demonstrated a greater prevalence of psychogenic (functional), endocrine, and nephrological disorders, indicating gender-related differences in health-seeking behaviors (18). Patients with complex medical histories require longer clinical reassessment intervals. In contrast, shorter durations in surgical and psychogenic cases indicate expedited decision-making (19).

The duration of observation was significantly longer in patients with previous hospitalizations and shorter in those needing ICU admission. This is likely due to the rapid escalation of treatment. The nonverbal symptom presentation and diagnostic uncertainty of younger children may require extended observation, as evidenced by a weak correlation between age and observation duration. The prolonged emergency department stays that pediatric patients under the age of 11 required have been linked to the increased diagnostic workup and communication challenges that are common in younger age groups, as reported by Zeleke et al. (20). Similarly, Singhal et al. demonstrated that a significant proportion of children transferred to the ICU within 24 hours of emergency department admission required critical interventions, underscoring the importance of timely escalation to critical care (21). No significant difference was observed in the rates of ward admission or ICU admission by gender, despite the disparities in disease patterns. This underscores that gender is not the primary factor in the determination of triage and clinical decision-making in emergency settings (22).

In our study, 4.85% of patients or caregivers declined additional treatment following observation. Although this number is relatively modest, it highlights the significance of effective communication, collaborative decision-making, and fostering trust between healthcare providers and families. Previous studies have shown that treatment refusal in pediatric emergency contexts may be affected by cultural attitudes, perceived severity of illness, and prior healthcare experiences (23,24).

Our findings indicate that consistently obtaining information on previous hospitalization history and chronic disease status could facilitate earlier risk stratification in the observation unit. Patients with previous ward admissions had a significantly higher likelihood of subsequent admissions, whereas chronic illness remained a predictor of ICU admission. Incorporating these characteristics into disposition algorithms may assist clinicians in identifying high-risk patients more promptly, initiating necessary interventions earlier, and avoiding extended or unnecessary observation. Prior ward admission may signal underlying clinical complexity, explaining the need for longer observation.

Real-time observational data more accurately represent the clinical process and improve relevance to clinical practice (25). The use of real-time observation data allowed the analysis of patient flow, discharge decision-making, and escalation to the ward/ICU. Our design, in contrast to studies that focus on diagnosis, reflects real clinical practice and demonstrates how useful the pediatric emergency department observation unit is in practice. The large sample size and complete data set minimize selection bias and enhance generalizability to high-volume tertiary hospitals.

Future research should focus on developing predictive clinical tools that can identify which patients benefit most from observation (26, 27) and evaluate long-term post-discharge outcomes, not only short-term pediatric emergency department observation unit outcomes. Additionally, multicenter prospective studies should examine whether implementing structured risk-guided disposition protocols leads to shorter length of stay and reduced health-care costs.

Study Limitations

This study has several limitations. First, the retrospective, single-center design conducted in a tertiary pediatric emergency department may limit generalizability to other hospitals. Second, electronic medical records may have documentation variability. Third, the medications administered during the observation period were not systematically recorded as a predefined study variable. Consequently, quantitative analysis of treatment patterns

within the observation unit was not possible. Future prospective studies should include standardized documentation of pharmacological management to better evaluate its association with patient outcomes. Finally, the study only examined short-term outcomes during monitoring, not after discharge.

Conclusion

This study highlights the demographic, clinical, and temporal features of pediatric patients in a tertiary emergency department's observation unit. It provides guidance for the functional role of pediatric emergency observation units, the development of future structured triage systems, and the establishment of risk-based patient management models. These results can inform efforts to improve pediatric emergency care, and additional prospective, multi-center studies are necessary.

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References

1. Soni P, Agrawal A. Pediatric emergency care: Determinants and systematic barriers. *World J Clin Pediatr.* 2025;14(3):108140. doi:10.5409/wjcp.v14.i3.108140.
2. Yüksel A, İşler A. Characteristics of pediatric emergency patients in a Turkish tertiary-level hospital: A 1-year cross-sectional study. *SageOpenMed.* 2022;10:20503121221135401. doi:10.1177/20503121221135401.
3. Kayipmaz AE, Sözüer EM, Sarıtaş A, Kandış H. Emergency department overcrowding in Turkey: Reasons, facts and solutions. *Turk J Emerg Med.* 2014;14(2):56-61. doi:10.5505/1304.7361.2014.62723.
4. Leggett E, Haan S, Mendoza C, Tran Q. Are there benefits to observation units in the emergency departments: A narrative review. *J Clin Med.* 2025;14(12):4333.
5. Byczkowski TL, Fitzgerald M, Miller T, Kachelmeyer A. Comparison of presenting complaint vs. discharge diagnosis for identifying emergency department visits for pediatric fever. *Acad Emerg Med.* 2010;17(2):157-162. doi:10.1111/j.1553-2712.2009.00636.x.
6. Demiröz O, Tunaoğlu FS. Use of pediatric emergency observation units. *Turk Arch Pediatr.* 2007;42:61-4.
7. Khashayar P, Haghpahan S, Zakeri H. Seasonal variations in pediatric emergency department visits: An Iranian experience. *Iran J Pediatr.* 2014;24(2):119-24.
8. Pomerantz A, De Souza HG, Hall M, Bucholz EM, Morgenshtern J, Goodman DC, et al. Racial and ethnic differences in insurer classification of nonemergent pediatric emergency department visits. *JAMA Netw Open.* 2023;6(5):e2311752. doi:10.1001/jamanetworkopen.2023.11752.
9. Yusuf S, Camp EA, Adekunle-Ojo AO. Characteristics of admissions from the pediatric emergency department observation unit. *South Med J.* 2024;117(9):543-548. doi:10.14423/SMJ.0000000000001734.
10. Falsaperla R, Ferrara P, Corsello G, Pavone P, Parisi P. Neonatal neurologic emergencies requiring access to pediatric emergency units: a multicentre study. *Sci Rep.* 2022;12:13703. doi:10.1038/s41598-022-13703-2.
11. World Health Organization. Pediatric Emergency Triage, Assessment and Treatment: Care of Critically-Ill Children (ETAT). Geneva: WHO; 2016.
12. Chan M, Meckler GD, Doan Q, Kissoon N. The impact of short-stay observation units on hospitalization rates in pediatric emergency care: A systematic review. *Pediatr Emerg Care.* 2016;32(5):287-94.
13. Lyons TW, Stack AM, Monuteaux MC. Effectiveness of a pediatric observation unit for children with nonurgent conditions. *Pediatr Emerg Care.* 2013;29(8):851-6.
14. Potts BK, Pelletier JH, Rawdon L, Forbes ML. Short-stay unit led by pediatric hospital medicine advanced practice providers. *J Hosp Med.* 2024;19(2):83-91.
15. Gatto A, Rivetti S, Capossela L, Pata D, Covino M, Chiaretti A. Utility of a pediatric observation unit for the management of children admitted to the emergency department. *Ital J Pediatr.* 2021;47(1):11. doi:10.1186/s13052-020-00953-5.
16. Chien WC, Huang WH, Chang YC, Lin CH, Chung CH, Lu CL. Clinical spectrum of acute poisoning in children admitted to the pediatric emergency department. *Pediatr Neonatol.* 2018;59(4):373-9. doi:10.1016/j.pedneo.2017.11.010.
17. Simon AK, Hollander GA, McMichael A. Evolution of the immune system in humans from infancy to old age. *Proc Biol Sci.* 2015;282(1821):20143085. doi:10.1098/rspb.2014.3085.
18. Al-Beltagi M, Saeed NK, Bediwy AS, Bediwy EA, Elbeltagi R. Unraveling functional neurological disorder in pediatric populations: A systematic review of diagnosis, treatment, and outcomes. *World J Clin Pediatr.* 2025;14(3):105290. doi:10.5409/wjcp.v14.i3.105290.
19. Goldstein AM, Madell TW, Hardy DG, Glick PL. Pediatric emergency department observation units. *Curr Opin Pediatr.* 2005;17(3):294-9.

20. Zeleke EG, Assefa MK, Girma AM, Ayele MG. Determinants of prolonged length of stay in the emergency department among pediatric patients in Ethiopia: A cross-sectional study. *BMC Emerg Med*. 2024;24(1):89. doi:10.1186/s12873-024-01089-5.
21. Singhal N, Kumar M, Siddiqui W. Pediatric ICU transfers within 24 hours of admission from the emergency department: rate of transfer, outcomes, and clinical characteristics. *Hosp Pediatr*. 2019;9(5):393-400. doi:10.1542/hpeds.2018-0275.
22. Green CA, Banks M. Gender differences in emergency department care and clinical outcomes. *Acad Emerg Med*. 2012;19(12):1412-9.
23. Henderson DP, O'Connor RE, Muniak MA. Refusal of care in the pediatric emergency department. *Pediatr Emerg Care*. 2008;24(8):524-528. doi:10.1097/PEC.0b013e318180dc80.
24. Mittal V, Sigrest T, Ottolini MC, Landrigan CP, Horwitz LI. Family-centered rounds and medical student education: A randomized controlled trial. *Pediatrics*. 2014;134(4):807-814. doi:10.1542/peds.2014-0329.
25. Sherman RE, Anderson SA, Dal Pan GJ, Gray GW, Gross T, Hunter NL, et al. Real-world evidence—what is it and what can it tell us? *N Engl J Med*. 2016;375(23):2293–2297. doi:10.1056/NEJMs1609216.
26. Barak-Corren Y, Fine AM, Reis BY. Early prediction model of patient hospitalization from the pediatric emergency department. *Pediatrics*. 2017;139(5):e20162785. doi:10.1542/peds.2016-2785.
27. Bradman K, Borland M, Pascoe E. Predicting patient disposition in a paediatric emergency department. *J Paediatr Child Health*. 2014;50(10):E39–E44. doi:10.1111/jpc.12011.

Distinguishing Acute Appendicitis from Gynecological Pathology in Female Patients Presenting with Acute Lower Abdominal Pain

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Abstract

Background: Acute lower abdominal pain is a common reason for emergency department presentation, and differentiating surgical from gynecological conditions in female patients remains a major diagnostic challenge because of substantial clinical overlap. This study aimed to evaluate the demographic, clinical, physical examination, and laboratory characteristics of female patients presenting with acute lower abdominal pain and to identify independent clinical predictors that may facilitate the differential diagnosis.

Methods: This retrospective observational study included 300 female patients presenting to the emergency department with acute lower abdominal pain between January 2019 and December 2023. Patients were classified into acute appendicitis, gynecological pathology, or nonspecific abdominal pain according to their final diagnosis. Demographic characteristics, clinical symptoms, physical examination findings, and laboratory results were compared among groups. Binary logistic regression was performed to identify independent predictors of appendicitis among patients with appendicitis and gynecological pathology. Model discrimination was assessed using receiver operating characteristic (ROC) analysis.

Results: Of the 300 patients, 99 (33.0%) were diagnosed with acute appendicitis, 81 (27.0%) with gynecological pathology, and 120 (40.0%) with nonspecific abdominal pain. Patients with appendicitis were significantly younger than those in the other groups ($p < 0.001$). Rebound tenderness, muscular defense, anorexia, fever, leukocytosis, and positive Psoas and Rovsing signs were significantly more common in appendicitis, whereas nausea and normal urine microscopy did not differ significantly between appendicitis and gynecological disorders. Multivariable logistic regression identified younger age, leukocytosis, muscular defense, Rovsing sign, and fever as independent predictors of appendicitis. The final diagnostic model demonstrated excellent performance, with an area under the ROC curve of 0.98 (95% CI 0.97–1.00), a sensitivity of 93.9%, and a specificity of 96.3%.

Conclusion: Female patients with acute lower abdominal pain exhibit considerable clinical overlap between appendicitis and gynecological disorders. Nevertheless, younger age, leukocytosis, muscular defense, Rovsing sign, and fever independently distinguish acute appendicitis. The proposed multivariable model demonstrated excellent diagnostic accuracy but requires internal and external validation before routine clinical implementation.

Introduction

Acute lower abdominal pain is a common reason for emergency department presentation and remains a major diagnostic challenge. Acute appendicitis is one of the most frequent abdominal surgical emergencies, and timely diagnosis is essential to reduce the risk of perforation and other complications. However, its clinical presentation is variable, and no individual symptom, physical examination finding, or laboratory test can reliably confirm or exclude the diagnosis in isolation [1]. Diagnostic evaluation is particularly difficult in female patients because gynecological conditions, including pelvic inflammatory disease, ecto-

pic pregnancy, ruptured ovarian cyst, and adnexal torsion, may closely mimic acute appendicitis. Nonspecific abdominal pain is also common and may initially resemble a surgical or gynecological emergency. This clinical overlap can lead to delayed treatment, unnecessary hospitalization or imaging, negative appendectomy, and inappropriate referral between surgical and gynecological services [2,3]. Right lower quadrant tenderness, rebound tenderness, muscular guarding, anorexia, fever, leukocytosis, and positive Psoas or Rovsing signs are traditionally associated with acute appendicitis. Nevertheless, these findings may also occur in gynecological disorders, particularly in the presence of pelvic inflammation or peritoneal irritation.

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Pregnancy testing, pelvic examination, urinalysis, inflammatory markers, and imaging can improve diagnostic accuracy, but their availability and performance vary across clinical settings. Current guidelines therefore recommend an integrated approach combining demographic characteristics, clinical assessment, laboratory findings, validated risk scores, and selective imaging [1]. Several clinical scoring systems have been developed to estimate the probability of appendicitis. Most, however, were derived from general populations and may be less reliable in women because of the broader range of competing diagnoses. Previous studies of women with acute lower abdominal or right iliac fossa pain have demonstrated considerable overlap among appendicitis, obstetric–gynecological disorders, and nonspecific abdominal pain [2–5]. Moreover, findings that appear important in univariable comparisons may lose significance after adjustment for correlated clinical factors. The independent diagnostic value of routinely available variables in distinguishing appendicitis from gynecological pathology therefore remains uncertain.

This study aimed to compare the demographic, clinical, physical examination, and laboratory characteristics of female patients with acute appendicitis, gynecological pathology, or nonspecific abdominal pain. A secondary aim was to identify independent predictors of appendicitis among patients with appendicitis or gynecological pathology and to evaluate the discrimination of a multivariable diagnostic model. We hypothesized that younger age, systemic inflammatory findings, and signs of localized peritoneal irritation would independently help distinguish acute appendicitis from gynecological disorders.

Materials and Methods

This retrospective observational study was conducted in the Emergency Department of Bezmialem Vakıf University. The electronic medical records of female patients evaluated with suspected acute abdomen over a five-year period between 01.01.2019 and 31.12. 2023 were reviewed. Ethical approval was obtained from the Bezmialem Vakıf University Ethics Committee (Approval No. 2025/42, dated 02.07.2025). The study was designed and reported in accordance with the principles applicable to retrospective observational studies. Female patients presenting to the emergency department with acute lower abdominal pain and initially evaluated for a possible surgical or gynecological acute abdominal condition were eligible. Patients were included if they had sufficient clinical, physical examination, laboratory, imaging, consultation, operative, or follow-up information to establish a final diagnosis. Patients were excluded if they were younger than 18 years, had a history of appendectomy, presented primarily because of trauma, had chronic or recurrent abdominal pain without an acute component, were transferred after receiving definitive treatment at another

institution, or had incomplete records preventing diagnostic classification or analysis of the principal study variables. When a patient had multiple presentations during the study period, only the first eligible presentation was included. Demographic, clinical, physical examination, laboratory, imaging, consultation, operative, and histopathological data were obtained from the hospital's electronic medical records. The collected variables included age, abdominal pain, right lower quadrant tenderness, rebound tenderness, anorexia, vomiting, nausea, muscular defense, Dunphy sign, obturator sign, Psoas sign, Rovsing sign, body temperature, white blood cell count, urine microscopy findings, and radiographic evidence of localized ileus. Patients were classified into three groups according to their final diagnosis: Acute appendicitis: Diagnosis confirmed through operative findings and histopathological examination of the appendectomy specimen. Gynecological pathology: Diagnosis of pelvic inflammatory disease, ovarian cyst rupture, adnexal torsion, or ectopic pregnancy based on gynecological consultation, laboratory findings, ultrasonography or other imaging, operative findings, and pathological examination when available. Nonspecific abdominal pain: Acute lower abdominal pain for which no specific surgical, gynecological, urological, or other etiological diagnosis was established after emergency department evaluation, observation, consultation, imaging, or clinical follow-up. The primary analysis compared demographic, clinical, examination, and laboratory findings among the three diagnostic groups. A secondary analysis was restricted to patients with acute appendicitis or gynecological pathology to identify variables independently associated with acute appendicitis.

Statistical analysis

Data distribution was assessed using the Shapiro–Wilk test. Continuous variables were compared using one-way ANOVA or the Kruskal–Wallis test, as appropriate, while categorical variables were compared using the chi-square or Fisher's exact test. Variables with clinical relevance or $p < 0.10$ in univariable analysis were entered into a multivariable logistic regression model to identify independent predictors of acute appendicitis.

Results

A total of 300 female patients evaluated for acute lower abdominal pain were included in the study. Final diagnoses were acute appendicitis in 99 (33.0%) patients, gynecological pathology in 81 (27.0%), and nonspecific abdominal pain in 120 (40.0%). Patients with acute appendicitis were significantly younger than those with gynecological pathology or nonspecific abdominal pain ($p < 0.001$). Right lower quadrant tenderness was common in both appendicitis and gynecological pathology, whereas rebound tenderness and muscular defense were

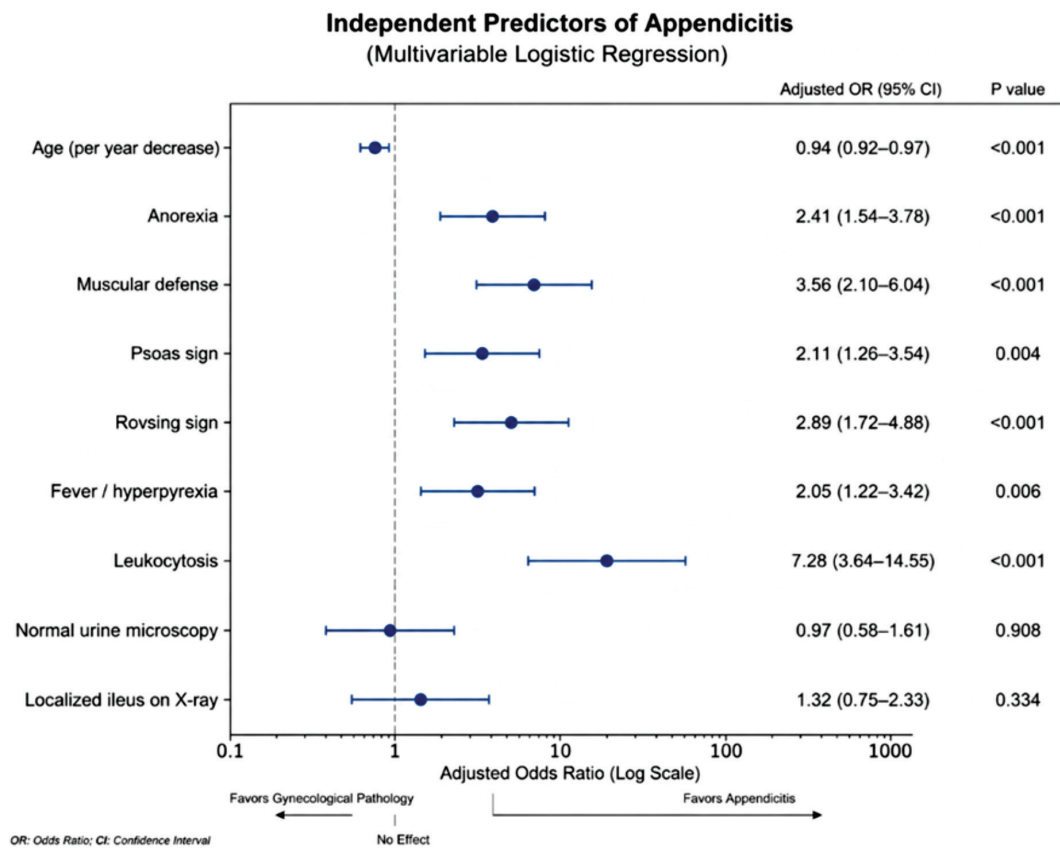


Figure 1. Forest plot of adjusted odds ratios for acute appendicitis versus gynecological pathology

observed more frequently in patients with appendicitis (both $p < 0.01$). Similarly, anorexia, fever, leukocytosis, and positive Psoas and Rovsing signs were significantly associated with appendicitis. In contrast, nausea and normal urine microscopy did not differ significantly between appendicitis and gynecological disorders (both $p > 0.05$). When only appendicitis and gynecological pathologies were compared, multivariable logistic regression demonstrated that younger age, leukocytosis, muscular defense, Rovsing sign, and fever remained independent predictors of appendicitis, whereas several other clinical findings lost statistical significance after adjustment for confound-

ing factors. The final multivariable model showed excellent discrimination for differentiating appendicitis from gynecological pathology, with an area under the ROC curve of 0.98 (95% CI 0.97–1.00). At the optimal probability threshold, the model achieved a sensitivity of 93.9% and a specificity of 96.3% (Figure 1), (Table 1).

Discussion

In this study, acute appendicitis accounted for one-third of diagnoses among female patients presenting with acute

Table 1. Comparison of Clinical Characteristics According to Final Diagnosis

Variable	Acute Appendicitis	Gynecological Pathology	Nonspecific Abdominal Pain	P value
Age (years), mean $\pm$ SD	28.6 $\pm$ 8.7	35.8 $\pm$ 10.4	34.9 $\pm$ 11.2	<0.001
Right lower quadrant tenderness, n (%)	92 (92.9)	60 (74.1)	48 (40.0)	<0.001
Rebound tenderness, n (%)	76 (76.8)	24 (29.6)	18 (15.0)	<0.001
Muscular defense, n (%)	70 (70.7)	18 (22.2)	12 (10.0)	<0.001
Anorexia, n (%)	68 (68.7)	29 (35.8)	34 (28.3)	<0.001
Fever, n (%)	37 (37.4)	12 (14.8)	10 (8.3)	<0.001
Leukocytosis, n (%)	82 (82.8)	33 (40.7)	28 (23.3)	<0.001
Positive Psoas sign, n (%)	49 (49.5)	8 (9.9)	4 (3.3)	<0.001
Positive Rovsing sign, n (%)	61 (61.6)	10 (12.3)	6 (5.0)	<0.001
Nausea, n (%)	58 (58.6)	45 (55.6)	64 (53.3)	0.72
Normal urine microscopy, n (%)	72 (72.7)	55 (67.9)	88 (73.3)	0.63

lower abdominal pain, whereas gynecological pathology and nonspecific abdominal pain comprised 27.0% and 40.0%, respectively. Patients with appendicitis were younger and more frequently exhibited signs of localized peritoneal irritation and systemic inflammation. Multivariable analysis identified younger age, leukocytosis, muscular defense, Rovsing sign, and fever as independent predictors of appendicitis, and the resulting model demonstrated excellent discrimination between appendicitis and gynecological pathology. The diagnostic distribution in our cohort reflects the inclusion of all eligible emergency department patients rather than only surgical cases. Similar findings have been reported by Rennie et al., whereas studies restricted to patients undergoing surgery demonstrated substantially higher appendicitis rates [6–8]. These differences emphasize the influence of patient selection and referral pathways on reported disease prevalence. Consistent with previous studies, right lower quadrant tenderness was common in both appendicitis and gynecological disorders, limiting its diagnostic value. In contrast, rebound tenderness, muscular defense, leukocytosis, fever, and positive Rovsing and Psoas signs were significantly associated with appendicitis in univariable analyses [4,7–9]. However, after adjustment for confounding, only younger age, leukocytosis, muscular defense, Rovsing sign, and fever remained independent predictors, suggesting that several physical examination findings represent overlapping manifestations of localized peritoneal irritation rather than independent diagnostic factors. Nausea and normal urine microscopy did not distinguish appendicitis from gynecological pathology, supporting their role as nonspecific adjunctive findings rather than reliable diagnostic markers. The final multivariable model achieved excellent discrimination (AUC 0.98), with a sensitivity of 93.9% and specificity of 96.3%, exceeding the performance reported for previously published female-specific clinical prediction models [10]. Nevertheless, because the model was developed and evaluated in the same retrospective cohort, its performance may be overestimated. Internal and external validation are therefore required before clinical implementation. Furthermore, the model should complement, rather than replace, clinical assessment, gynecological examination, pregnancy testing, and appropriate imaging, consistent with current guideline recommendations [6].

This study has several limitations. Its retrospective, single-center design creates a risk of selection and information bias. Clinical findings may not have been documented consistently by different emergency physicians. Combining several gynecological diagnoses into one group may obscure clinically important differences between inflammatory, hemorrhagic, ischemic, and pregnancy-related disorders. Variables such as pregnancy status, β -hCG, cervical motion tenderness, vaginal bleeding, C-reactive protein, and imaging findings were not included in the final model. In addition, the optimal probability threshold was derived from the same cohort and may not

perform similarly in other populations. Finally, changes in diagnostic and imaging practices during the five-year study period may have influenced patient classification.

In conclusion, acute appendicitis, gynecological disorders, and nonspecific abdominal pain demonstrated considerable clinical overlap in female patients presenting with acute lower abdominal pain. Younger age, leukocytosis, muscular defense, Rovsing sign, and fever independently favored acute appendicitis over gynecological pathology. The multivariable model demonstrated excellent diagnostic discrimination, but internal and external validation are necessary before it can be recommended for routine clinical decision-making.

Ethics Committee Approval: Ethical approval was obtained from the Bezmialem Vakıf University Ethics Committee (Approval No. 2025/42, dated 02.07.2025).

Informed Consent: Informed consent was waived due to the retrospective design of the study.

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References

1. Podda M, Ceresoli M, De Simone B, Fugazzola P, Pata F, Balla A, et al. Diagnosis and treatment of acute appendicitis: 2025 edition of the World Society of Emergency Surgery Jerusalem guidelines. *JAMA Surg.* 2026;161(3):283-295. doi:10.1001/jamasurg.2025.6218.
2. Rennie AT, Tytherleigh MG, Theodoropoulou K, Farouk R. A prospective audit of 300 consecutive young women with an acute presentation of right iliac fossa pain. *Ann R Coll Surg Engl.* 2006;88(2):140-143. doi:10.1308/003588406X94887.
3. Hatipoglu S, Hatipoglu F, Abdullayev R. Acute right lower abdominal pain in women of reproductive age: clinical clues. *World J Gastroenterol.* 2014;20(14):4043-4049. doi:10.3748/wjg.v20.i14.4043.
4. Jearwattananok K, Yamada S, Suntornlamsiri W, Smuth-tai W, Patumanond J. Clinical scoring for diagnosis of acute lower abdominal pain in female of reproductive age. *Emerg Med Int.* 2013;2013:730167. doi:10.1155/2013/730167.
5. Jearwattananok K, Yamada S, Suntornlamsiri W, Smuth-tai W, Patumanond J. Validation of the diagnostic score for acute lower abdominal pain in women of reproductive age. *Emerg Med Int.* 2014;2014:320926. doi:10.1155/2014/320926.
6. Podda M, Ceresoli M, De Simone B, Fugazzola P, Pata F, Balla A, et al. Diagnosis and treatment of acute appendicitis: 2025 edition of the World Society of Emergency Surgery Jerusalem guidelines. *JAMA Surg.* 2026;161(3):283-295. doi:10.1001/jamasurg.2025.6218.

7. Rennie AT, Tytherleigh MG, Theodoropolou K, Farouk R. A prospective audit of 300 consecutive young women with an acute presentation of right iliac fossa pain. *Ann R Coll Surg Engl.* 2006;88(2):140-143. doi:10.1308/003588406X94887.
8. Hatipoglu S, Hatipoglu F, Abdullayev R. Acute right lower abdominal pain in women of reproductive age: clinical clues. *World J Gastroenterol.* 2014;20(14):4043-4049. doi:10.3748/wjg.v20.i14.4043.
9. Jearwattanakanok K, Yamada S, Suntornlimsiri W, Smuthtai W, Patumanond J. Clinical scoring for diagnosis of acute lower abdominal pain in female of reproductive age. *Emerg Med Int.* 2013;2013:730167. doi:10.1155/2013/730167.
10. Jearwattanakanok K, Yamada S, Suntornlimsiri W, Smuthtai W, Patumanond J. Validation of the diagnostic score for acute lower abdominal pain in women of reproductive age. *Emerg Med Int.* 2014;2014:320926. doi:10.1155/2014/320926.

Modified Occlusion Myocardial Infarction Electrocardiographic Criteria

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Abstract

The electrocardiogram (ECG) is a useful diagnostic tool that allows clinicians to rapidly evaluate patients for acute coronary syndrome. The ECG is crucial in the evaluation of chest pain and diagnosis of ischemia. It is critical for clinicians to be able to accurately recognize these ischemic patterns to allow timely and appropriate cardiovascular care. The classic ST-segment elevation myocardial infarction (STEMI) with rapid reperfusion within less than 60 minutes of acute coronary occlusion improve morbidity and decreases mortality. According to the Fourth Universal Definition of Myocardial Infarction, the STEMI criteria consist of (1) 1 mm ST-segment elevation in any 2 consecutive leads at the J point, excluding V2 and V3; and (2) age- and sex-specific ST-segment elevation thresholds in V2 and V3 (1.5 mm elevation in women regardless of age, 2.5 mm in men <40 years, and 2mm in men aged 40 years), in the absence of left ventricular hypertrophy and bundle branch block (1), but despite that approximately half of high-risk patients with occlusion myocardial infarction fail to meet STEMI criteria, resulting in delays in urgent revascularization (2,3). Definition of occlusion myocardial infarction representing near or total occlusion of a culprit epicardial coronary artery with insufficient collateral circulation causing active infarction, thus necessitating emergency reperfusion (4) In this review we detail the high-risk ECG occlusion myocardial infarction patterns indicative of acute myocardial ischemia resulting from active totally or near totally occlusion of coronary artery

Keywords: Electrocardiographic, Myocardial infarction, New pattern

Introduction

The electrocardiogram (ECG) is a useful diagnostic tool that allows clinicians to rapidly evaluate patients for acute coronary syndrome. The ECG is crucial in the evaluation of chest pain and diagnosis of ischemia. It is critical for clinicians to be able to accurately recognize these ischemic patterns to allow timely and appropriate cardiovascular care. The classic ST-segment elevation myocardial infarction (STEMI) with rapid reperfusion within less than 60 minutes of acute coronary occlusion improve morbidity and decreases mortality. According to the Fourth Universal Definition of Myocardial Infarction, the STEMI criteria consist of (1) ≥ 1 mm ST-segment elevation in any 2 consecutive leads at the J point, excluding V2 and V3; and (2) age- and sex-specific ST-segment elevation thresholds in V2 and V3 (≥ 1.5 mm elevation in women regardless of age, ≥ 2.5 mm in men <40 years,

and ≥ 2 mm in men aged 40 years), in the absence of left ventricular hypertrophy and bundle branch block (1), but despite that approximately half of high-risk patients with occlusion myocardial infarction fail to meet STEMI criteria, resulting in delays in urgent revascularization (2,3) Definition of occlusion myocardial infarction representing near or total occlusion of a culprit epicardial coronary artery with insufficient collateral circulation causing active infarction, thus necessitating emergency reperfusion (4) In this review we detail the high-risk ECG occlusion myocardial infarction patterns indicative of acute myocardial ischemia resulting from active totally or near totally occlusion of coronary artery

Hyperacute T waves (HATW)

The T waves (TW) in the affected leads are both more symmetric and enlarged in terms of overall area under

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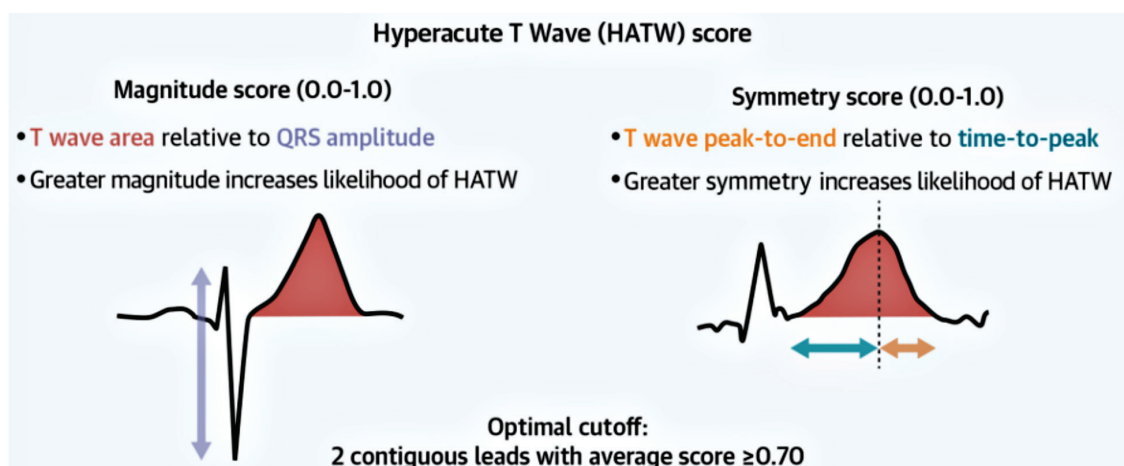


Figure 1. The T-wave magnitude (T-wave area/QRS amplitude) and T wave symmetry score

the curve relative to both their baseline size and to their QRS complex amplitude. T-wave with both magnitude (T-wave area / QRS amplitude) and T wave symmetry score more than 0.70 (Figure 1). ECG leads are only eligible for the HATW score if they satisfy the following requirements: (5)

1. Not lead aVR or V1
2. Narrow QRS: QRS duration less than 110 ms
3. Well-defined QRS complex: Total QRS amplitude more than 1.0 mm (0.1 mV)
4. Well-defined and positive T-wave:
 - a. Positive T-wave amplitude more than 1.0 mm (0.1 mV)
 - b. TW start-to-peak and TW peak-to-end each ≥ 40 ms
5. T-wave neither inverted nor biphasic

Figure 1 the T-wave magnitude (T-wave area/QRS amplitude) and T wave symmetry score

Left Bundle Branch Block

Diagnostic criteria of myocardial infarction in patient with LBBB.

The Sgarbossa criteria (6)

1. The confirm diagnosis of MI must be need at least 3 or more points from the following criteria. Figure 1. ST-elevation of ≥ 1 mm and concordant with the QRS complex (5 points)
2. ST-segment depression ≥ 1 mm in lead V1-3 (3 points)

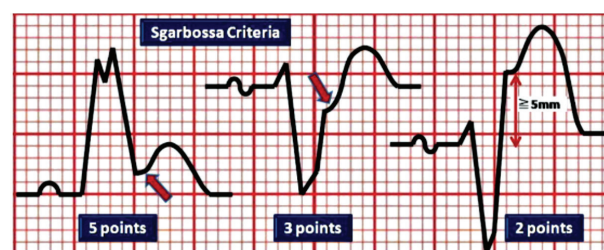


Figure 3. Sgarbossa criteria for myocardial infarction.

Simple calculation for HATW

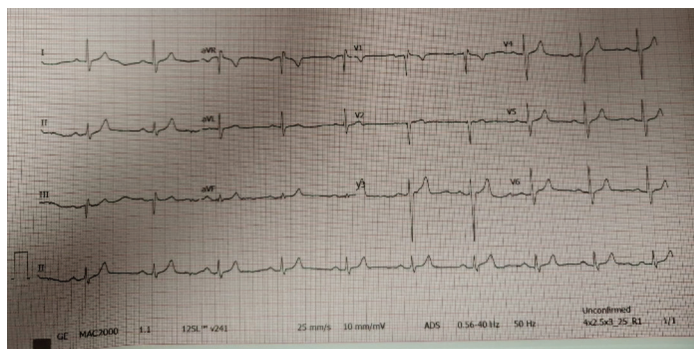


Figure 2. Calculation of T-wave magnitude (T-wave area/QRS amplitude) = 1 and T wave symmetry 0.60 (from III ve aVF), coronary angiography suggested tight stenosis in mid RCA.

Two Contiguous Leads (excluding aVR and V1) with both:

1) Increased T-wave area relative to QRS amplitude

$$\frac{\text{Area under T-wave}}{\text{Net Absolute QRS Amplitude}} > \text{Lead-specific threshold}$$

(60 for limb leads, 80 for V2-3, 60 for V4-6)

2) Increased T wave Symmetry

T-Wave Peak Position $\leq 67\%$ of the T-P Interval

$$\frac{J\text{-point to } T_{\text{peak}} \text{ interval}}{J\text{-point to } T_{\text{end}} \text{ interval}} < 0.67$$

3. ST elevation ≥ 5 mm and discordant with the QRS complex (2 points)

The specificity of 98%, but poorer sensitivity of 20%. The third criteria have only 2 point so that no add any significant value as it alone does not confirm diagnosis of acute myocardial infarction. (Figure 3)

Modified Sgarbossa (Smith-Sgarbossa) Criteria (7)

Because of the third criteria of Sgarbossa have only 2 point and does not confirm diagnosis of acute myocardial infarction. The modified Sgarbossa criteria was used to modified and support the third criteria by calculation the ratio of ST segment elevation to the depth S wave. The discordant ST/S ratio ≥ 0.25 mm in any lead suggested acute MI. Figure 4.

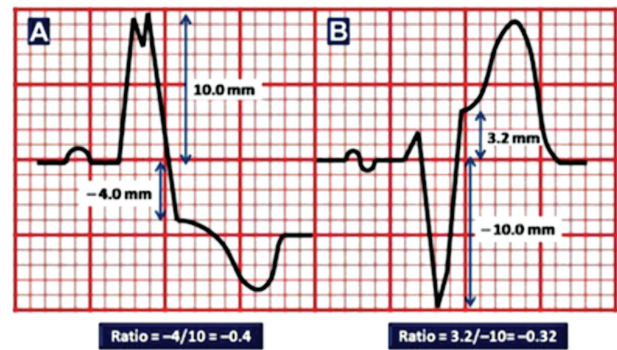


Figure 4. Modified Sgarbossa Criteria for myocardial infarction

2. Concordant with QRS complex and ST elevation ≥ 1 mm
- B. Discordant ST deviation ≥ 1 mm with QRS complex in any lead where the R or S is ≤ 6 mm. (Figure 5)

The Barcelona Criteria (8)

Barcelona Criteria contains of 3 criteria, As with the prior Sgarbossa criteria, criteria 1 is the same. Criteria 2 is expanded to all leads (but in Sgarbossa just in V1-3).

Criteria 3 is specific for the Barcelona criteria and suggested that discordance deviation of ≥ 1 mm in any lead with a dominant R or S wave ≤ 6 mm.

- A. ST deviation ≥ 1 mm concordant with QRS complex in any lead;
1. Concordant with QRS complex and ST depression ≥ 1 mm

Summary of electrocardiographic criteria; (9)

This is simple 6 steps for diagnosis Patients with Left Bundle Branch Block and suspected occlusion acute myocardial infarction

1. Confirm diagnosis of LBBB. If yes go to 2nd step
2. Calculate ST segment deviation ≥ 1 mm in any lead If
 1. Confirm diagnosis of LBBB. If yes go to 2nd step
 - yes go to 3rd step
3. Concordant or Discordant with QRS complex?

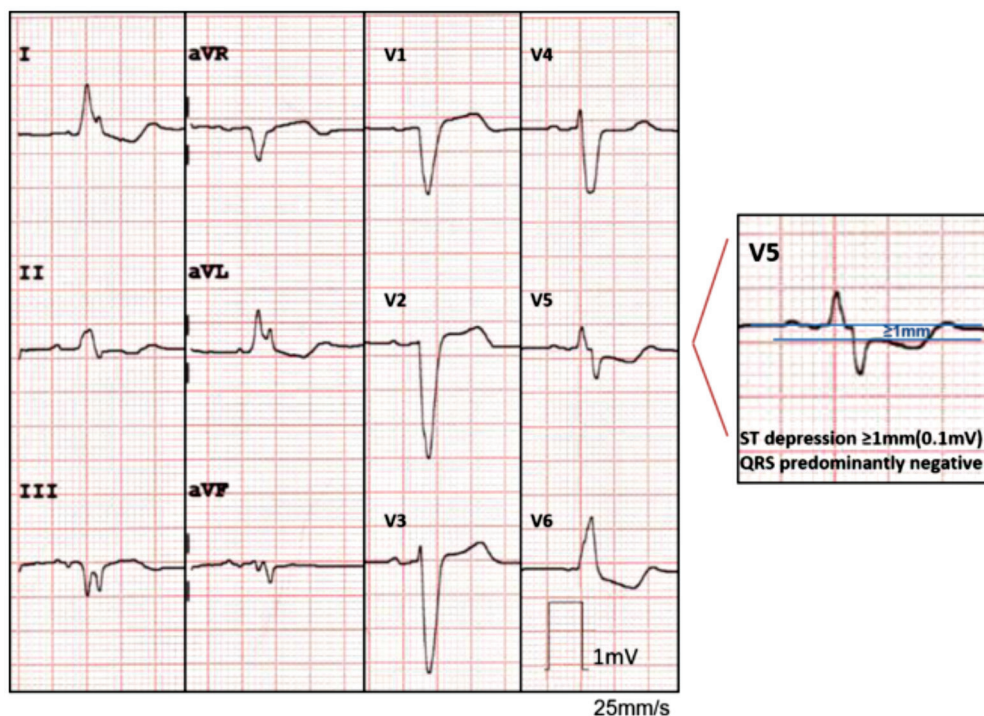


Figure 5. ECG from a patient with acute myocardial infarction and culprit lesion in the right coronary artery, showing ST-segment depression ≥ 1 mm (0.1 mV) concordant with negative QRS polarity in lead V5.

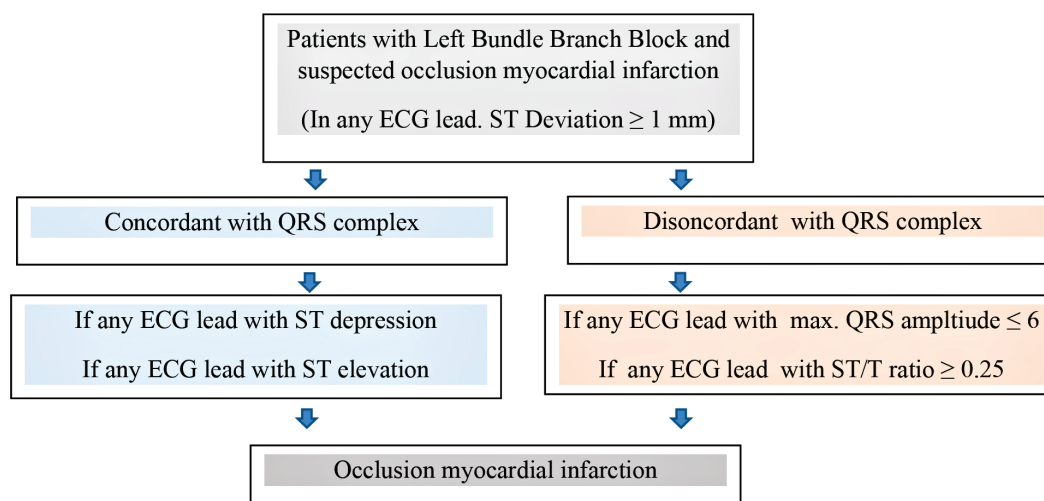


Figure 6. Summary of electrocardiographic criteria; ECG; Electrocardiogram.

4. If concordant and ≥ 1 mm ST segment deviation in any lead; Acute MI
4. If concordant and ≥ 1 mm ST segment deviation in any lead; Acute MI
5. If discordant in any lead with R or S is ≤ 6 mm; Acute MI
5. If discordant in any lead with R or S is ≤ 6 mm; Acute MI
6. If discordant in any lead with R or S is ≥ 6 mm; calculate the ratio of ST segment elevation to the depth S wave. If $\geq 25\%$; Acute MI

Summary of electrocardiographic criteria among patients with Left Bundle Branch Block and suspected occlusion myocardial infarction. Figure 6

Wellens syndrome

Wellens syndrome was described by Wellens, and colleagues, who identified a subset of patients with unstable angina who had specific precordial T-wave changes and subsequently developed anterior myocardial infarction (10). Wellens syndrome refers abnormalities in the precordial T waves (V2-4), which are associated with moderate to severe stenosis of the proximal left anterior descending (LAD) coronary artery.

Syndrome criteria include the following:

Criteria for Wellens' syndrome (11-12)

- Biphasic or deeply inverted symmetric T waves in leads V2 -3 during pain-free state (May be in leads V1, V4, V5 and V6)
- No pathologic precordial Q waves
- Preserved precordial R wave progression
- Isoelectric or minimally elevated (<1 mm) ST-segment
- Recent history of chest pain
- Normal or slightly elevated serum cardiac markers

Wellens syndrome is characterized by biphasic (pattern A) or deeply inverted (pattern B) T wave in leads V2-V3 and the absence of Q waves (Figure 7).

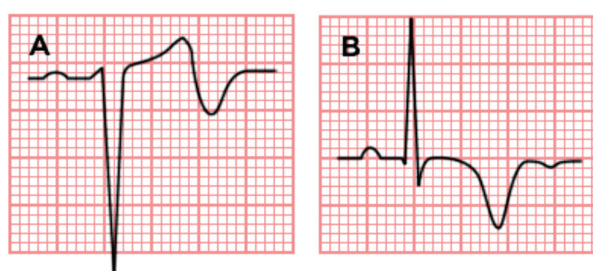


Figure 7. Wellens syndrome is characterized by biphasic (A) or deeply inverted (B).

De-Winter syndrome

The diagnostic criteria for de Winter syndrome include (figure 8)

- A 1 to 3 mm upsloping ST-segment depression at the J point in leads V1 to V6 that continues in total, positive symmetrical T waves
- QRS complex usually not wide or only slightly widened
- In some patients, a loss of precordial R wave progression
- A 1 to 2 mm ST-segment elevation in aVR.

The underlying mechanism of this ECG pattern in acute myocardial infarctions is unknown but probable mechanisms that lack of activation of sarcolemmal adenosine triphosphate (ATP) sensitive potassium channels that cause the absence of ST-segment elevation.(13)

Left ventricle aneurysm

Persistent ST segment elevation after previous myocardial infarction (MI). This is clinically and pathologically manifested as left ventricular aneurysm (LVA) and is found in up to 60% of completed anterior STEMI when there is no spontaneous or therapeutic reperfusion. (14)

The association between persistent STE on the ECG after prior MI and LVA has been well documented over the years, confirmed with autopsy studies (15).

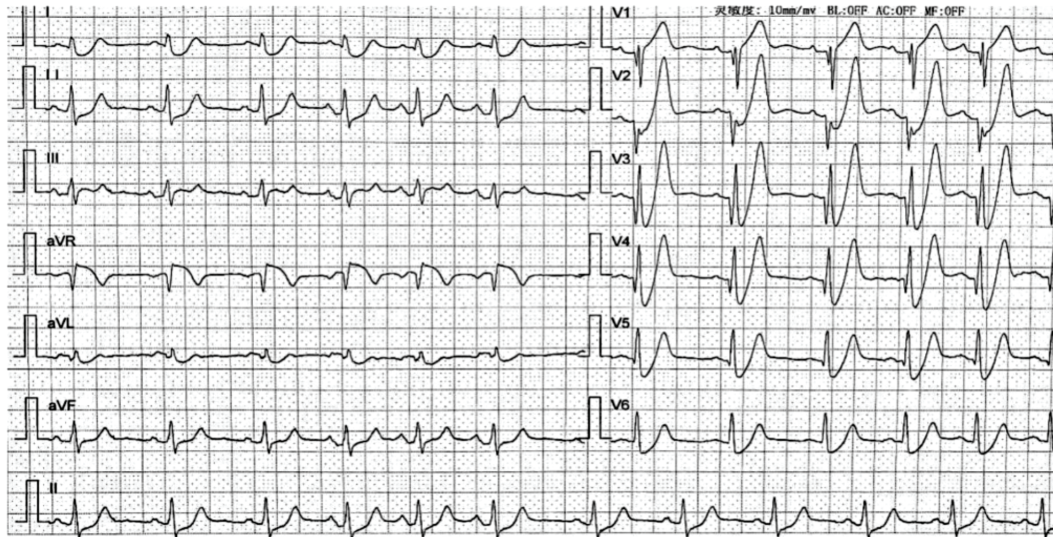


Figure 8. The electrocardiogram shows upsloping ST-segment depression at the J-point with tall and symmetrical T waves from V2 to V6 leads, as well as ST-segment elevation in the aVR lead.

Rule 1: Acute STEMI is predicted if:	
$\frac{\text{sum of T wave amplitudes V1 + V2 + V3 + V4}}{\text{sum of QRS amplitudes V1 + V2 + V3 + V4}} > 0.22$	
Rule 2: Acute STEMI is predicted if:	
$\frac{\text{T wave amplitude}}{\text{QRS amplitude}} \text{ In any lead V1, V2, V3 or V4} \geq 0.36$	

Figure 9. Two ECG rules for predicting acute myocardial infarction vs Left ventricular aneurysm.

Accoedint to Lauren R. Klein, suggested 2 rules among patients who present with ischemic symptoms and acute occlusion MI in previous LVAon ECG (16).

Left ventricle hypertrophy (LVH)

Algorithm to identify anterior STEMI in the presence of LVH: (17)

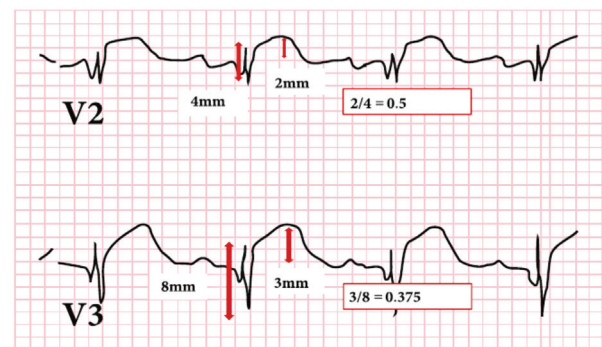
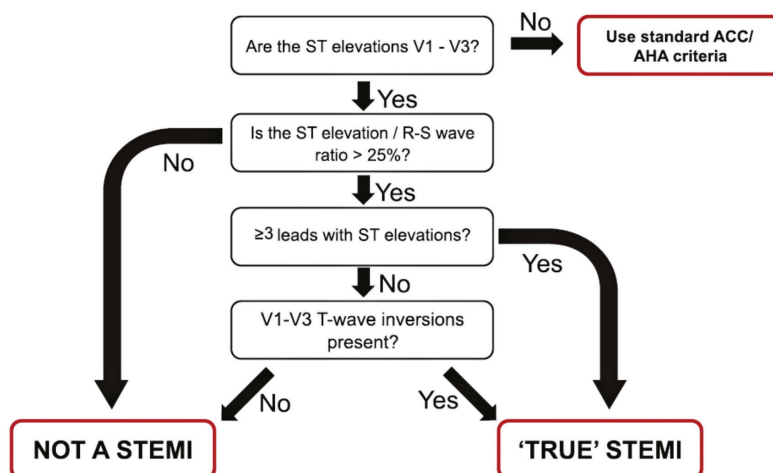


Figure 10. T wave amplitude/QRS amplitude for predicting acute myocardial infarction in patient with left ventricular aneurysm.

- If the ST segment to R-S-wave magnitude was 25%, presence of STE in 3 contiguous leads
- or presence of T-wave inversions in the anterior leads classified patients as having a 'true' OMI. (Figure 11)

In patients with STE in leads V1 to V3, an ST segment to R-S-wave magnitude < 25% excluded the diagnosis of a STEMI. If the ST segment to R-S-wave magnitude was

Figure 11. Occlusive anterior MI in the presence of LVH.

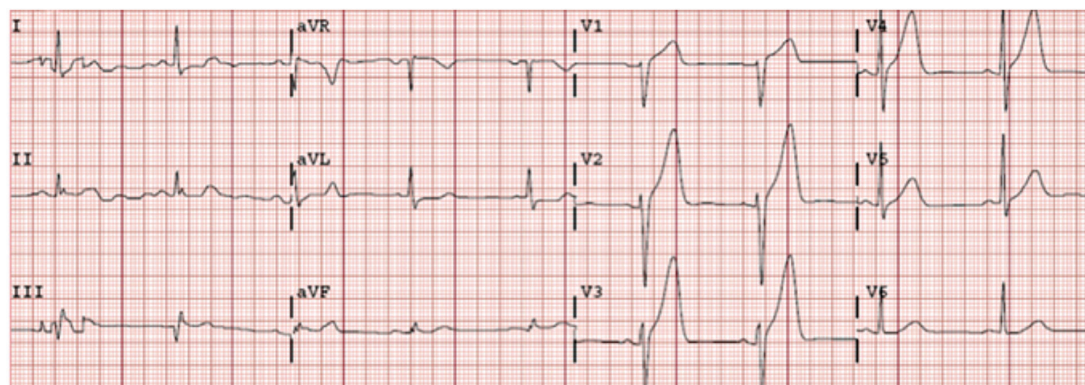


Figure 12. Occlusive anterior MI in the presence of LVH.

$\geq 25\%$, presence of STE in 3 contiguous leads or presence of T-wave inversions in the anterior leads classified patients as having a “true” STEMI. Increasing the cutoff of “significant” STEs to 2.5 mm in leads V1 to V3 increased the specificity of the electrocardiogram to 74%, but sensitivity was decrease to 68% (18)

Aslanger pattern

ECG pattern indicating inferior MI in patients with concomitant critical lesion (s) in coronary arteries other than the infarct-related artery.(19)

ECG pattern consisting of three criteria:

- Any STE in DIII but not in other inferior leads,
- STD in any of leads V4 to V6 but not in V2,
- STin lead V1 higher than ST in V2 (Figure 13)

The South African Flag Sign

It is typically reflective of “high lateral” myocardial infarction (MI) due to the occlusion of the first diagonal (D_1) branch of the left anterior descending (LAD) coronary artery.

there is ST-segment elevation (STE) in leads I, aVL, V_2 , and ST-segment depression in lead III (20) (Figure 14).

New-Onset Bifascicular Block

A necropsy study disclosed that blood supply to the right bundle branch and left anterior fascicle is predominantly provided by septal perforators of the proximal left anterior or descending coronary artery in 90% of the cases examined (21).The diagnostic particulars of the ECG include; (Figure 15)

- New-onset RBBB
- New-onset LAFB
- Concordant STE in any of the anterior and/or lateral leads; concordant ST-depression in the inferior

Precordial swirl sign

In this pattern the ECG manifests abnormal ST elevation (STE) in V1-V2, with reciprocal ST depression (STD)

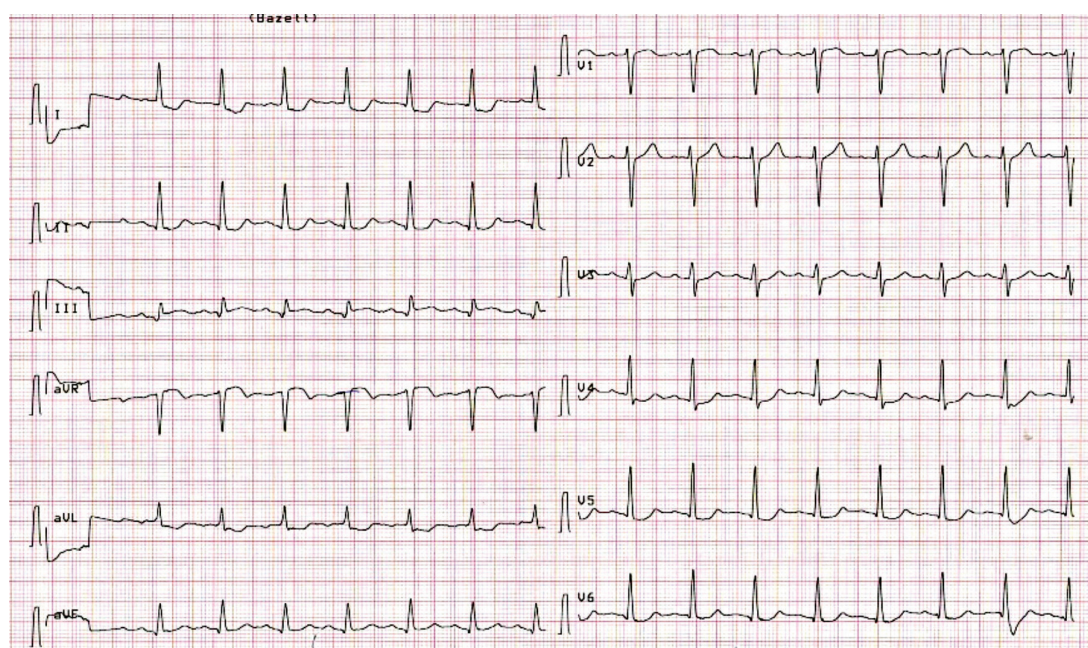


Figure 13. Alsanger pattern STE in DIII but not in other inferior leads, STD in leads V4 to V6 and STE in lead V1 higher than ST in V2.

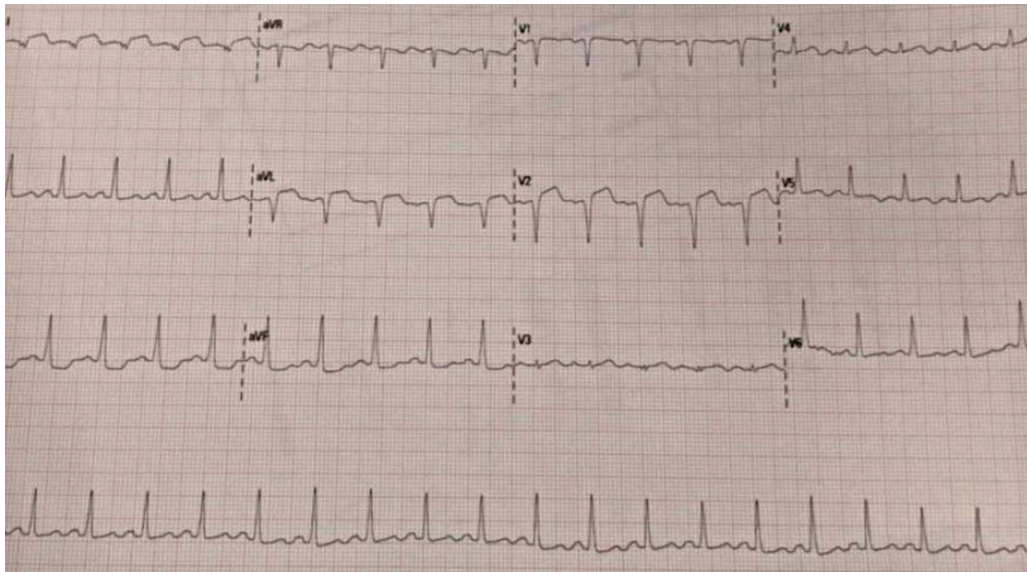


Figure 14. ST-segment elevation (STE) in leads I, aVL, V2, and ST-segment depression in lead III .

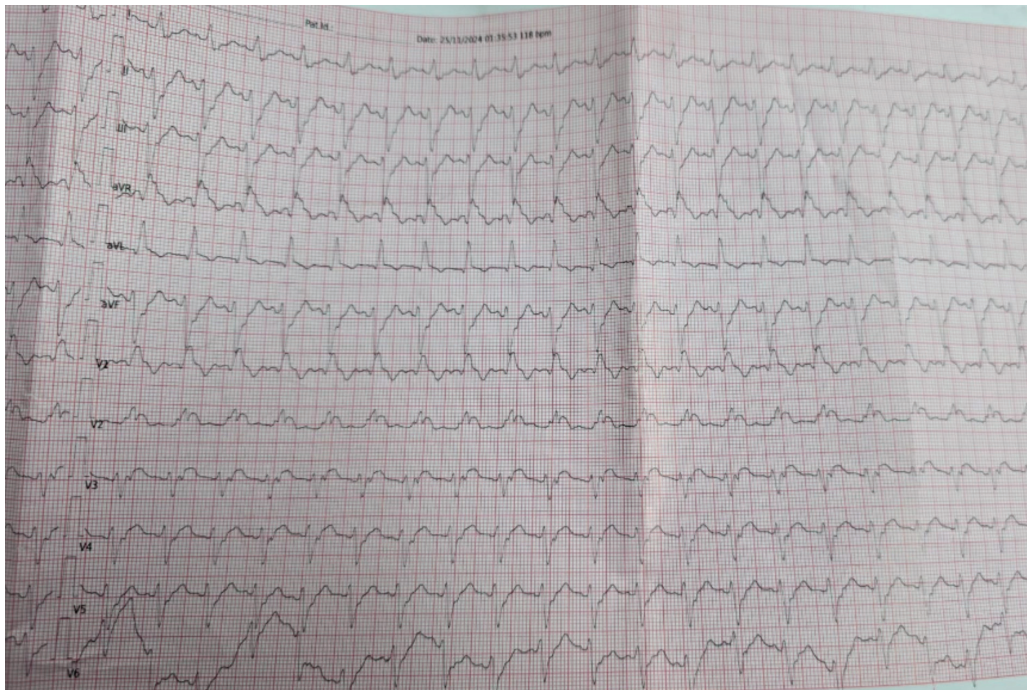


Figure 15. Right bundle branch and left anterior fascicle .

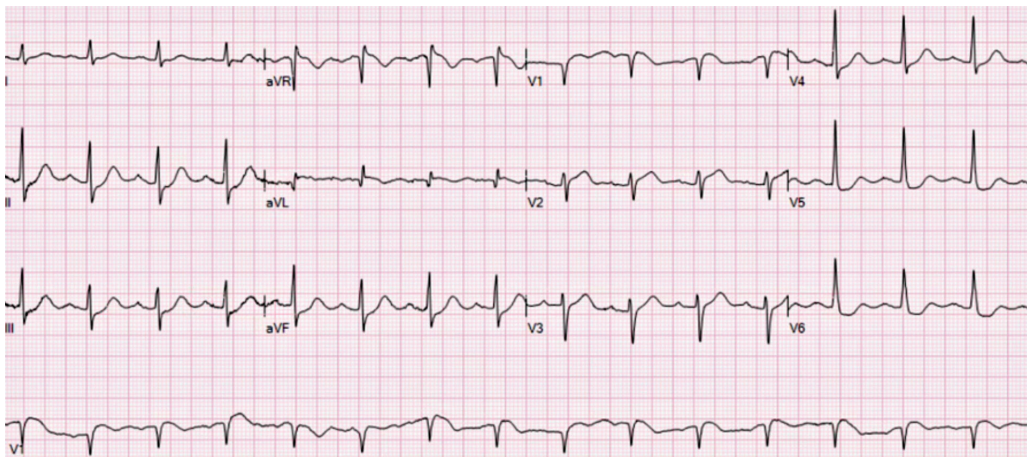


Figure 16. Case example from derivation group of an elderly male with chest pain .

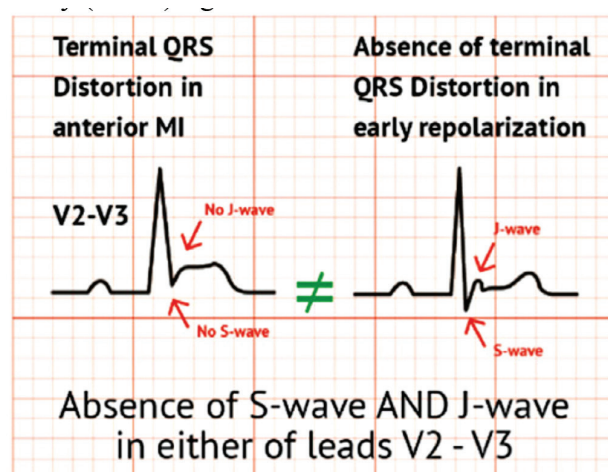


Figure 17. Terminal QRS distortion.

in V5-V6, creating a clockwise “swirl” pattern in the ST shifts of the precordial leads specificity for LAD Occlusion MI.

The derived rules for precordial swirl sign (22)

1. Narrow QRS with STD in V5-V6 and STE V1-V2
2. Normal QRS (narrow QRS and no LVH) with STD in V5-V6 and STE V1-V2
3. Narrow QRS with STD V5-V6 and T/S ratio ≥ 0.40 in V2

Terminal QRS Distortion

Terminal QRS distortion is defined as a decrease in S-wave amplitude in leads with a terminal S wave and an elevation of the J point $> 50\%$ of the height of the R wave amplitude in leads with qR configuration (23). Terminal QRS distortion is not observed in early repolarization, and thus it can be useful in distinguishing STEMI from early repolarization (24). The presence of terminal QRS distortion in STEMI has been associated with a larger infarct size, impaired myocardial salvage, lower epicardial reperfusion success, low left ventricular ejection fraction (LVEF), reperfusion injury, anterior location of myocardial infarction, higher risk of re-infarction, and mortality (25-26) (Figure 17).

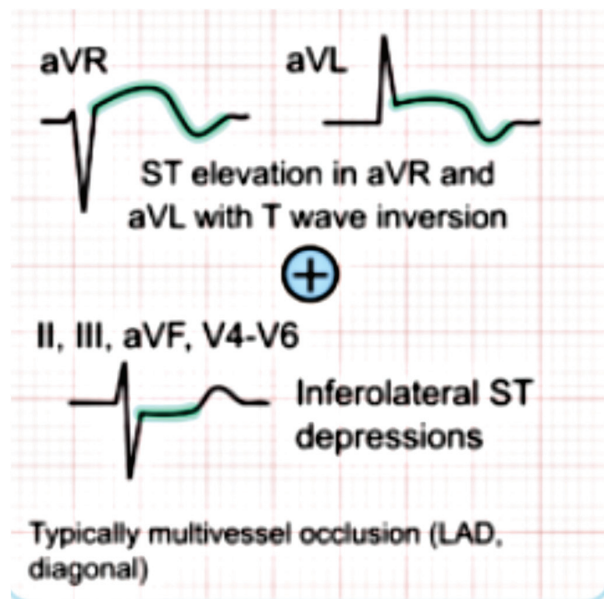


Figure 18. STsegment elevation in aVR and aVL with negative T wave and any ST-depression in inferolateral leads.

Northern Occlusion Myocardial Infarction

Is defined by any STsegment elevation in aVR and aVL with negative T wave and any ST-depression in inferior and lateral precordial leads with positive or biphasic T waves. figure 18

ST Elevation in AVR Lead (LMCA/ Proximal LAD Occlusion)

Isolated STE in the augmented vector right (aVR) lead, accompanied by multilead ST depression, as a potential indicator of STEMI due to left main coronary artery (LMCA) or proximal LAD occlusion (Figure 19).

Shark fin sign

is an ECG pattern with a giant R wave (amplitude ≥ 1 mV) and a QRS complex fused with the ST segment and the T wave (Figure 20).

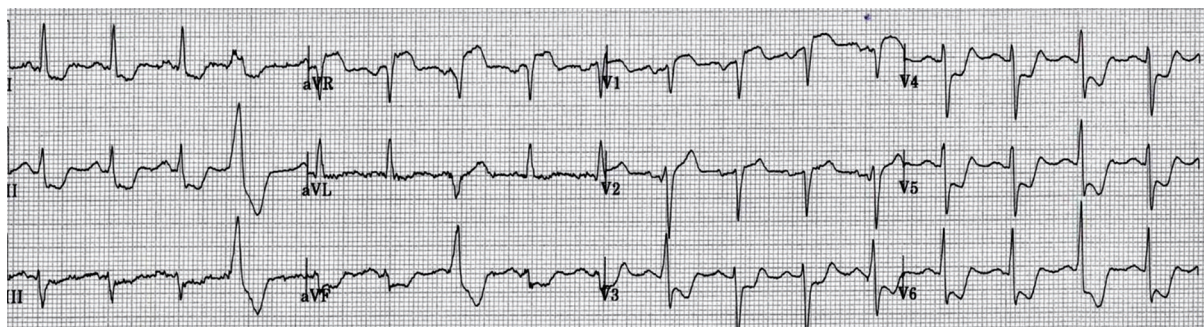


Figure 19. aVR ST elevation and inferolateral ST depression.

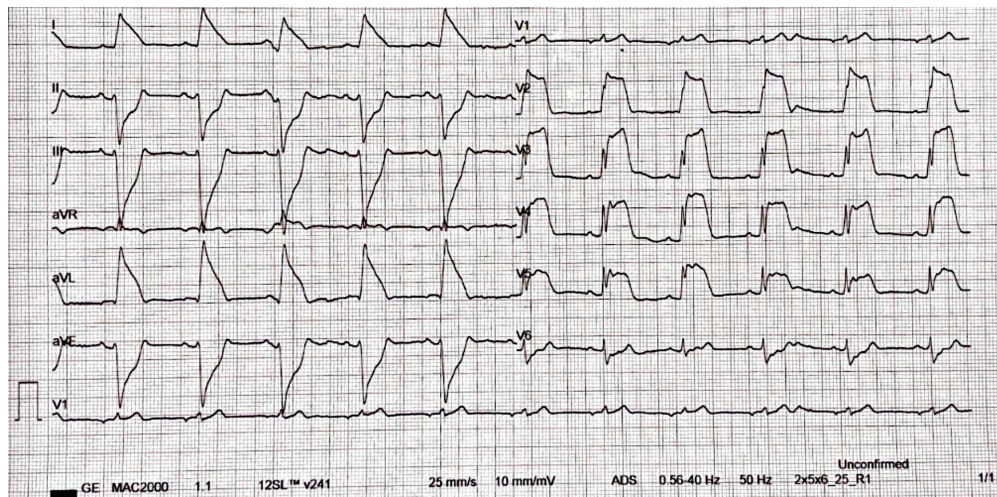


Figure 20. The electrocardiogram demonstrated a sinus rhythm with 'shark fin' morphology in leads I, aVL and in the V 2-5 leads (shark fin sign).

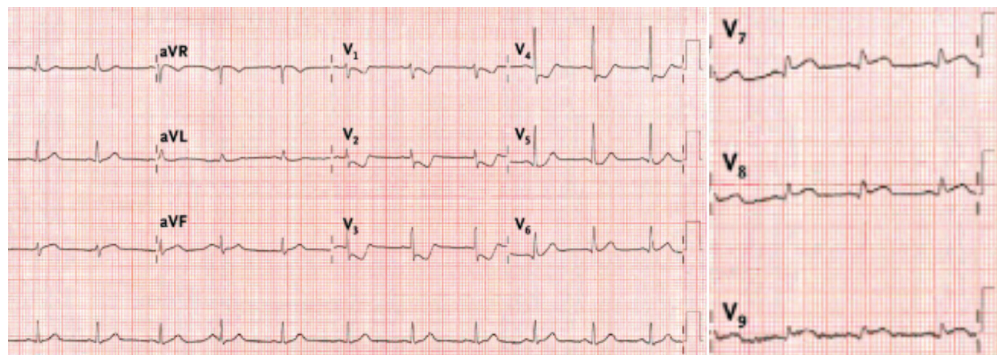


Figure 21. Electrocardiogram showing normal sinus rhythm with ST depression in v1-4 and ST elevation in V7-9.

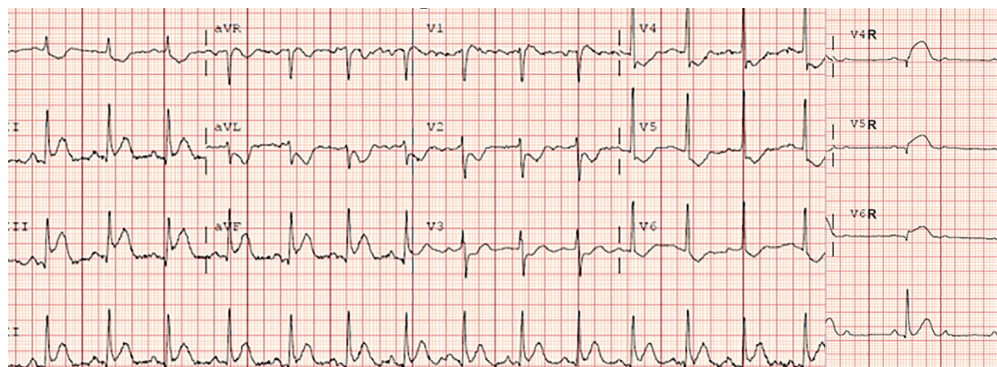


Figure 22. Electrocardiogram showing normal sinus rhythm with STElevations in II,III,aVFandV1 and STElevations in leadsV3R–V6R.

Posterior MI

ECG findings include ST-segment depressions ≥ 0.5 mm in leads V_1 – V_3 , upright T waves, and tall R waves in V_1 – V_2 (Figure 21) (27).

Right ventricular infarction (RVI)

Isolated RVI occurs seldom; approximately only 2% cases are reported on autopsy. Around one-third of patients with acute inferoposterior ST-segment elevation MI, will present with concomitant RVIST-segment elevation in V_1 and V_3R – V_6R confirms RVI (28-29) (Figure 22).

References

1. Thygesen K, Alpert JS, Jaffe AS, et al. Fourth universal definition of myocardial infarction (2018). *Circulation*. 2018;138:e618-e651.
2. de Alencar Neto JN, Scheffer MK, Correia BP, et al. Systematic review and meta-analysis of diagnostic test accuracy of ST-segment elevation for acute coronary occlusion. *Int J Cardiol*. 2024;402: 131889.
3. Meyers HP, Bracey A, Lee D, et al. Comparison of the ST-elevation myocardial infarction (STEMI) vs. NSTEMI and occlusion MI (OMI) vs. NOMI paradigms of acute MI. *J Emerg Med*. 2021;60:273-284.

4. Meyers HP, Bracey A, Lee D, et al. Accuracy of OMI ECG findings versus STEMI criteria for diagnosis of acute coronary occlusion myocardial infarction. *Int J Cardiol Heart Vasc.* 2021;33:100767.
5. H. Pendell Meyers, Franti sek Siman, Robert Herman. Et al. Hyperacute T Waves Are Specific for Occlusion Myocardial Infarction, Even Without Diagnostic ST-Segment Elevation. *JACC Adv.* 2025;4:102120.
6. Sgarbossa EB, Pinski SL, Barbagelata A, et al. Electrocardiographic diagnosis of evolving acute myocardial infarction in the presence of left bundle-branch block. GUSTO-1 (Global Utilization of Streptokinase and Tissue Plasminogen Activator for Occluded Coronary Arteries) Investigators. *N Engl J Med* 1996;334:481-7. 3.
7. Smith SW, Dodd KW, Henry TD, Dvorak DM, Pearce LA. Diagnosis of ST-elevation myocardial infarction in the presence of left bundle branch block with the ST-elevation to S-wave ratio in a modified Sgarbossa rule. *Ann Emerg Med* 2012;60:766-76
8. Andrea Di Marco, Marcos Rodriguez, Juan Cinca et al. New Electrocardiographic Algorithm for the Diagnosis of Acute Myocardial Infarction in Patients With Left Bundle Branch Block. *J Am Heart Assoc.* 2020;9:e015573.
9. Mohammed Habib. Electrocardiographic Criteria for Diagnosis of Acute Myocardial Infarction in Patients with Left Bundle Branch Block. *Eurasian Journal of Critical Care.* 2024;6(2): 88-90
10. de Zwaan C, Bar FW, Wellens HJ. Characteristic electrocardiographic pattern indicating a critical stenosis high in left anterior descending coronary artery in patients admitted because of impending myocardial infarction. *Am Heart J.* 1982 Apr. 103(4 Pt 2):730-6
11. Rhinehardt J, Brady WJ, Perron AD, Mattu A. Electrocardiographic manifestations of Wellens' syndrome. *Am J Emerg Med* 2002;20(7):638-43. [5]
12. Nisbet BC, Zlupko G. Repeat Wellens' syndrome: case report of critical proximal left anterior descending artery restenosis. *J Emerg Med* 2010;39(3):305-8.
13. de Winter RJ, Verouden NJ, Wellens HJ, Wilde AA, Interventional Cardiology Group of The Academic Medical Center. A new ECG sign of proximal LAD occlusion. *N Engl J Med.* 2008;359:207 1-3.
14. Mills RM, Young E, Gorlin R, Lesch M. Natural history of S-T segment elevation after acute myocardial infarction. *Am J Cardiol* 1975;35:609-14.
15. Berger AK, Radford MJ, Wang Y, Krumholz HM. Thrombolytic therapy in older patients. *J Am Coll Cardiol* 2000;36:366-74.
16. Lauren R. Klein, Gautam R. Shroff, William Beeman, Stephen W. Smith, Electrocardiographic criteria to differentiate acute anterior ST-elevation myocardial infarction from left ventricular aneurysm. *American Journal of Emergency Medicine* 33 (2015) 786-790
17. Miranda DF, Lobo AS, Walsh B, et al. New insights into the use of the 12-lead electrocardiogram for diagnosing acute myocardial infarction in the emergency department. *Can J Cardiol* 2018 Feb;34(2):132-145
18. Ehrin J. Armstrong, MSca, Ameya R. Kulkarni, Electrocardiographic Criteria for ST-Elevation Myocardial Infarction in Patients With Left Ventricular Hypertrophy. *Am J Cardiol* 2012;110:977-983
19. Emre Aslanger, Ozlem Yildirimtürk, Barış Şimşek, et al. A new electrocardiographic pattern indicating inferior myocardial infarction. *Journal of Electrocardiology* 61 (2020) 41-46
20. Steven Swarath, Nicole Maharaj, Andrew Hall, Jean Marie Frederick. The South African Flag Sign: An Electrocardiographic Flag for All Coronary Territories? *J Investig Med High Impact Case Rep* 2023 Aug 9;11:23247096231192861.
21. Frink RJ, James TN. Normal blood supply to the human his bundle and proximal bundle branches. *Circulation.* 1973;47:8-18.
22. Lucas Goss, Pendell Meyers, Alexander Bracey, et al. Preordial swirl sign: A new ECG pattern of left anterior descending artery occlusion myocardial infarction. *Journal of Electrocardiology* 91 (2025) 153931
23. Nikus K, Birnbaum Y, Eskola M, et al. Updated electrocardiographic classification of acute coronary syndromes. *Curr Cardiol Rev.* 2014;10:229-236.
24. Lee DH, Walsh B, Smith SW. Terminal QRS distortion is present in anterior myocardial infarction but absent in early repolarization. *Am J Emerg Med.* 2016;34:2182-2185.
25. Mulay DV, Mukhedkar SM. Prognostic significance of the distortion of terminal portion of QRS complex on admission electrocardiogram in ST segment elevation myocardial infarction. *Indian Heart J.* 2013;65:671-677. doi: 10.1016/j.ihj.2013.10.012.
26. Birnbaum Y, Herz I, Sclarovsky S, et al. Prognostic significance of the admission electrocardiogram in acute myocardial infarction. *J Am Coll Cardiol.* 1996;27:1128-1132.
27. Agarwal J, Khaw K, Aurignac F, et al. Importance of posterior chest leads in patients with suspected myocardial infarction, but nondiagnostic, routine 12-lead electrocardiogram. *Am J Cardiol* 1999;83:323-6.
28. Namana V, Balasubramanian R, Hollander G. A 71-Year-Old Man With Complicated Myocardial Infarction. *JAMA Cardiol* 2016;1(6):735-6.
29. Carroll R, Sharma N, Butt A, Hussain KM. Unusual electrocardiographic presentation of an isolated right ventricular myocardial infarction secondary to thrombotic occlusion of a non-dominant right coronary artery. *Angiology* 2003;54(1):119-24.

Indirect Rabies Exposure via Oral Suction of a Cat Bite: A Case Report

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Abstract

Introduction: Rabies is almost invariably fatal after the onset of clinical disease. Although bites and scratches are the usual routes of transmission, mucosal contact with potentially infectious saliva is also considered a severe exposure requiring post-exposure prophylaxis.

Case Presentation: A 19-year-old woman presented to the emergency department after being bitten on the right hand by an unowned stray cat that could not be located for observation. During history taking, it was learned that her father had immediately performed oral suction on the bite wound as a traditional first-aid attempt. The patient was managed for a Category III exposure. Because the father's oral mucosa had directly contacted a wound potentially contaminated with cat saliva, he was also evaluated as having a secondary mucosal exposure. Rabies post-exposure prophylaxis was initiated for both individuals after infectious diseases consultation. No complications were observed during follow-up.

Conclusion: This case highlights that unconventional wound interventions may create secondary rabies exposure. Emergency physicians should specifically ask about prehospital first-aid practices and should recognize mucosal contamination as a potential indication for prophylaxis when the source animal is unavailable.

Keywords: Rabies; Post-exposure prophylaxis; Cat bite; Mucosal exposure; Emergency department.

Introduction

Rabies is an acute, progressive encephalomyelitis caused by neurotropic lyssaviruses and remains one of the most fatal zoonotic infections worldwide. Although most human cases follow the bite of an infected mammal, transmission may also occur when infectious saliva or neural tissue contacts broken skin or mucous membranes [1-4]. Therefore, accurate exposure classification is central to emergency department management. The World Health Organization classifies transdermal bites or scratches, contamination of mucous membranes with saliva, and licks on broken skin as Category III exposures, for which immediate wound care and post-exposure prophylaxis (PEP) are indicated [2]. In practice, however, non-bite or secondary exposures may be missed, particularly when patients or caregivers perform traditional first-aid practices before arrival. Oral

suction of an animal bite wound is one such unsafe intervention, because it may expose the rescuer's oral mucosa to saliva present in the wound. We present a rare dual-exposure scenario in which a young woman sustained a stray cat bite and her father subsequently performed oral suction of the wound. The case emphasizes the need to question prehospital interventions and to manage mucosal exposure with the same urgency as direct animal exposure when rabies risk cannot be excluded.

Case Presentation

A 19-year-old woman presented to the emergency department after being bitten on the dorsal aspect of the right hand by an unowned stray cat. The animal fled immediately after the incident and could not be captured, observed, or tested. The patient had no relevant medical

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history or immunosuppressive condition. Her vital signs were within normal limits. Physical examination revealed superficial puncture wounds on the dorsum of the right hand, without active bleeding, tendon injury, limitation of movement, or neurovascular compromise. The wound was managed with extensive irrigation and local wound care. Tetanus prophylaxis was administered according to the patient's immunization status. During detailed history taking, the patient reported that, immediately after the bite, her father had placed his mouth over the wound and attempted to suck out presumed contaminated saliva. The father had not been bitten or scratched by the animal, and no visible oral lesion was reported; however, his oral mucosa had directly contacted the fresh bite wound. Rabies PEP was initiated according to national recommendations and local infectious diseases guidance, using the local Essen intramuscular vaccination regimen. Because the father's oral mucosa had directly contacted a wound potentially contaminated with animal saliva, his exposure was also evaluated as a Category III mucosal exposure after infectious diseases consultation, and rabies PEP was initiated. Both individuals received amoxicillin/clavulanate for bacterial prophylaxis. No adverse events or infectious complications were observed during follow-up.

Discussion

This case is clinically relevant because it illustrates an unusual secondary rabies exposure mechanism created by an unsafe prehospital intervention. In the emergency department, rabies risk assessment often focuses on the person who sustained the bite. However, additional individuals may be exposed during wound manipulation, particularly when saliva-contaminated tissue contacts mucous membranes or broken skin. Guidelines emphasize that mucosal contamination with saliva from a potentially rabid animal is a severe exposure and should prompt PEP when the source animal cannot be evaluated [2,3]. The oral mucosa is highly vascular and may contain microabrasions that are not visible during routine examination. For this reason, absence of a visible lesion does not necessarily exclude risk when direct mucosal contact with potentially infectious material has occurred. A fatal rabies case reported from China described a father who developed rabies after sucking the wounds of his son, who had been bitten by a stray dog; the father had declined PEP [5]. Although such events are extremely rare, this previous report supports the biological plausibility and clinical importance of mucosal exposure during oral suction. Our case differs in that the exposure

was recognized at the emergency department, the source animal was unavailable, and prophylaxis was initiated for both exposed individuals. The case also highlights a practical pitfall: patients may not volunteer unconventional first-aid practices unless specifically asked. Emergency physicians should therefore ask targeted questions about wound washing, application of substances, oral contact with the wound, and assistance provided by family members or bystanders. Such details can change exposure classification and PEP indications. Public education should also emphasize that animal bite wounds should be washed with soap and water and that oral suction should not be performed.

Conclusion

Oral suction of an animal bite wound may create preventable secondary rabies exposure through mucosal contact with potentially contaminated saliva. When the source animal is unavailable, this exposure should be considered during Category III risk assessment. Emergency clinicians should actively question prehospital first-aid practices and initiate rabies PEP without delay when indicated.

Declarations

Ethics approval: Ethics committee approval was not required for this single case report according to local institutional policy. The report was prepared in accordance with the principles of the Declaration of Helsinki.

Consent for publication: Written informed consent was obtained from the patient and her father for publication of this case report.

Conflict of interest: The authors declare that they have no conflict of interest.

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Author contributions: All authors contributed to patient management, literature review, manuscript drafting, and critical revision. All authors read and approved the final version of the manuscript. (Not: "All Author" yazımını "All authors" olarak düzelttim).

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Data availability: Data sharing is not applicable to this article because no datasets were generated or analyzed.

References

1. Fooks AR, Banyard AC, Horton DL, Johnson N, McElhinney LM, Jackson AC. Current status of rabies and prospects for elimination. *Lancet*. 2014;384:1389-99.
2. World Health Organization. Rabies vaccines: WHO position paper, April 2018. *Wkly Epidemiol Rec*. 2018;93:201-20.
3. Manning SE, Rupprecht CE, Fishbein D, Hanlon CA, Lumlertdacha B, Guerra M, et al. Human rabies prevention--United States, 2008: recommendations of the Advisory Committee on Immunization Practices. *MMWR Recomm Rep*. 2008;57:1-28.
4. Hemachudha T, Ugolini G, Wacharapluesadee S, Sungkarat W, Shuangshoti S, Laothamatas J. Human rabies: neuropathogenesis, diagnosis, and management. *Lancet Neurol*. 2013;12:498-513.
5. Zhao H, Zhang J, Cheng C, Zhou YH. Rabies acquired through mucosal exposure, China, 2013. *Emerg Infect Dis*. 2019;25:1028-9

Non-traumatic Spinal Cord Compression Presenting with Concomitant Spinal and Neurogenic Shock: A Case Report

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Abstract

Background: Spinal shock is typically associated with high-energy trauma, while non-traumatic causes are exceptionally rare.

Case: We report the case of an 85-year-old male who presented with sudden-onset back pain and lower extremity weakness; hemodynamic collapse developed during emergency department follow-up. Thoracic computed tomography (CT) revealed acute spinal cord compression secondary to a T3 vertebral hemangioma and osteoporotic collapse. The patient developed neurogenic shock with bradycardia, hypotension, and respiratory failure in the emergency department. Immediate resuscitation with atropine, intravenous fluids, and dopamine infusion achieved stabilization. Thoracic computed tomography revealed a T3 vertebral hemangioma with osteoporotic collapse causing acute spinal canal narrowing. High-dose corticosteroid therapy was administered, followed by urgent neurosurgical intervention.

Conclusion: This case highlights the importance of recognizing non-traumatic spinal shock in elderly patients with acute paraparesis and hypotension, even without a history of trauma. Early diagnosis and multidisciplinary management are essential to prevent irreversible neurological deficits.

Keywords: Spinal shock, Paraparesis, Vertebral hemangioma, Osteoporosis, Non-traumatic compression.

Introduction

Spinal shock refers to a transient loss of all neurological activity below the level of spinal cord injury, characterized by areflexia, flaccid paralysis, and autonomic dysfunction (1). It is most often observed following high-energy trauma. However, non-traumatic spinal shock remains an extremely rare clinical entity and is frequently associated with diagnostic delays and poor outcomes.

Vertebral hemangiomas occur in approximately 10–12% of the population, yet fewer than 1% become symptomatic. Only a small subset cause acute spinal cord compression. When combined with osteoporosis, the risk of pathological fracture and sudden canal narrowing increases significantly (2).

We present an unusual case of acute paraparesis and progressive spinal shock secondary to spontaneous vertebral collapse due to coexisting osteoporosis and hemangioma in a patient without a history of trauma.

Case Presentation

An 85-year-old man with a medical history of hypertension, atrial fibrillation, early Alzheimer's disease, and osteoporosis presented to a primary care center with complaints of sudden-onset back pain, bilateral lower extremity numbness, and rapidly progressing weakness. He denied any trauma. To clarify the symptoms and rule out preliminary diagnoses, the patient was referred for brain CT, diffusion MRI, and spinal CT scans. On arrival, his vital signs were: blood pressure 130/80 mmHg, pulse 60 beats/min (atrial fibrillation), and oxygen saturation 92% on room air. Neurological examination revealed bilateral lower limb muscle strength of 1/5, positive Babinski reflexes, and marked tenderness over the thoracic spine. Abdominal examination showed right costovertebral angle tenderness. Laboratory results showed a white blood cell count of $10.94 \times 10^9/L$, hemoglobin 13.5 g/dL, plate-

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Figure 1. Sagittal contrast-enhanced thoracic computed tomography (CT) scan demonstrates diffuse hypodensity and collapse of the T3 vertebra associated with acute spinal cord compression. The arrow indicates the level of vertebral collapse.

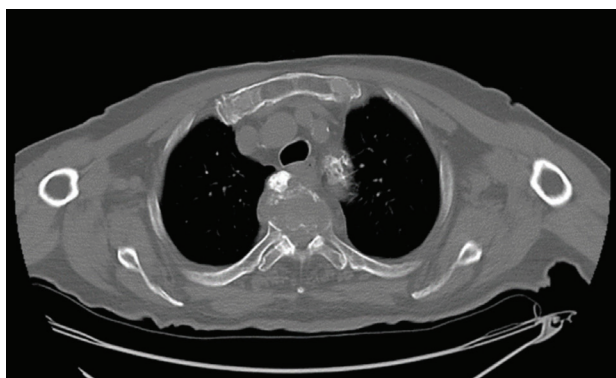


Figure 2. Axial contrast-enhanced thoracic CT image at the T3 level reveals significant spinal canal narrowing due to vertebral body collapse with associated hemangioma. The arrow indicates the direction of compression; the star indicates the vertebral hemangioma.

lets $229 \times 10^9/L$, with neutrophilia (86.4%) and relative lymphopenia (9.7%). Coagulation parameters were within near-normal limits (PT 15.8 s, INR 1.16, aPTT 23 s). Urinalysis showed specific gravity 1.009, mild proteinuria (1+), and microscopic hematuria (3+ erythrocytes per high power field). Initial differential diagnoses included Guillain-Barré syndrome, transverse myelitis, and non-traumatic spinal cord compression. Shortly after imaging, the patient developed acute confusion, severe bradycardia (30 beats/min), profound hypotension (50/20 mmHg), and respiratory failure, consistent with neurogenic shock. Immediate resuscitation was initiated with 100% oxygen (10 L/min), bag-valve-mask ventilation, intravenous atropine (1 mg), isotonic fluid resuscitation (1000 mL IV), and dopamine infusion (10 mcg/kg/min). Hemodynamic stability

was restored within minutes. Neuroimaging revealed no acute intracranial pathology. Thoracic CT demonstrated a hypodense appearance and collapse of the T3 vertebral body, with findings compatible with hemangioma and osteoporosis causing acute spinal cord compression (Figure 1 and 2). Following neurosurgical consultation, the patient received high-dose corticosteroid therapy with intravenous methylprednisolone (30 mg/kg bolus over 15 minutes, followed by 5.4 mg/kg/h for 23 hours) and was urgently taken for decompressive surgery. MRI could not be performed prior to surgery due to the patient's rapidly deteriorating neurological and hemodynamic status requiring emergency intervention. Following emergency decompressive surgery, the patient was admitted to the intensive care unit due to persistent hemodynamic instability and requirement for mechanical ventilatory support. Despite initial stabilization, the patient developed nosocomial pneumonia and sepsis during the intensive care follow-up. Unfortunately, the patient succumbed to multi-organ failure on postoperative day 34. No significant neurological improvement was observed prior to demise (motor strength remained 1/5 in lower extremities). Written informed consent was obtained from the patient's next of kin for publication of this case and accompanying images.

Discussion

Non-traumatic spinal shock is a rare condition with few cases documented in literature. Vertebral hemangiomas are benign vascular lesions often found incidentally, but in rare cases, they may become aggressive and lead to pathological fracture, epidural extension, or acute cord compression. In this patient, the coexistence of hemangioma and osteoporosis likely triggered sudden vertebral collapse and acute canal narrowing at T3 (2). Neurogenic shock, which often accompanies high spinal cord injury, results from disruption of sympathetic outflow from the T1–L2 spinal segments. This loss of sympathetic tone leads to vasodilation, hypotension, and bradycardia. Spinal shock, on the other hand, represents a complete loss of sensory, motor, and autonomic function below the injury level. Differentiating between spinal and neurogenic shock is critical, as both can coexist and require specific management (3). In the elderly, non-traumatic spinal shock may mimic cerebrovascular events or demyelinating diseases, leading to delayed diagnosis. Early CT/MRI imaging is crucial for identifying compressive lesions (4). Literature emphasizes that prompt administration of corticosteroids, aggressive hemodynamic support, and timely neurosurgical decompression can prevent irreversible neurological damage and improve outcomes (5). Although high-dose methylprednisolone (30 mg/kg bolus followed by 5.4 mg/kg/h for 23 hours) is primarily recommended

for traumatic spinal cord injury based on the National Acute Spinal Cord Injury Study (NASCIS) protocols, its use in non-traumatic acute spinal cord compression remains debated. In the present case, high-dose methylprednisolone was administered due to acute neurological deterioration and suspected spinal cord compression in the emergency setting, aiming to reduce vasogenic edema and inflammatory cascade prior to definitive surgical decompression. Similar approaches have been reported in selected non-traumatic compression cases where urgent anti-edema and neuroprotective therapy was considered beneficial as a bridge to emergency surgery (1,2).

Reported cases of non-traumatic spinal shock secondary to vertebral hemangioma are exceedingly rare (6). Shankar et al. described a similar presentation in a patient without trauma, where sudden collapse of the vertebral body caused acute cord compression and neurogenic shock. In our case, the combination of osteoporosis and hemangioma likely precipitated this catastrophic event. This highlights the need to consider non-traumatic etiologies when elderly patients present with unexplained paraparesis and shock.

Limitations

This is a single-patient report; broader studies and pooled analyses are needed to define the epidemiology, diagnostic approach, and optimal treatment protocols for non-traumatic spinal shock in elderly populations. Additionally, the absence of preoperative MRI due to the emergency nature of the case represents a limitation in fully characterizing the extent of spinal cord compression.

Conclusion

Non-traumatic spinal shock should be considered in elderly patients presenting with acute paraparesis, bradycardia, and hypotension, even in the absence of trauma or malignancy. Rapid diagnosis, early hemodynamic

stabilization, and urgent surgical consultation are vital to improving survival and neurological recovery. Delayed diagnosis may result in irreversible neurological damage and increased mortality. This underscores the importance of early recognition in emergency settings.

Ethical Declarations

Informed Consent: Written informed consent was obtained from the patient's next of kin for publication of this case and accompanying images.

Conflict of Interest: The authors declare no conflicts of interest.

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Author Contributions: Concept, data collection, analysis, writing, and approval of the final manuscript: Dr. Çağdaş Derdiyok.

Supervision and manuscript revision: Dr. Eren Duyar.

References

1. Tator CH. Spine trauma: basic science and clinical management. *J Neurosurg Spine*. 1996;85(5):684–690.
2. Fox MW, Onofrio BM. The natural history and management of symptomatic vertebral hemangiomas. *J Neurosurg*. 1993;78(1):36–45.
3. Furlan JC, Fehlings MG. Cardiovascular complications after spinal cord injury. *Spine*. 2008;33(6):636–646.
4. Rodallec MH, Feydy A, Larousserie F, et al. Spinal canal lesions: differential diagnosis. *Radiographics*. 2008;28(3):983–1006.
5. Harris M. Quality of life in patients with malignant spinal cord compression: A review of evidence-based literature. *Int J Palliat Nurs*. 2016;22(1):37–43.
6. Shankar JJ, Smith K, Das M. Non-traumatic spinal shock: a case report. *J Emerg Med*. 2012;43(2):e123–e126. doi:10.1016/j.jemermed.2010.05.078

Methodological Concerns Regarding the Use of Standard Pulmonary Embolism Scores for Predicting Thrombolysis

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Dear Editor,

The article by Ebor et al. titled “The Role of Standard Scoring Systems in Predicting Early Thrombolysis in Patients with Acute Pulmonary Embolism Presenting to the Emergency Department” addresses an important clinical question regarding early identification of pulmonary embolism (PE) patients who may require thrombolytic therapy [1]. However, several methodological concerns limit the interpretability of the conclusions.

The primary concern relates to the conceptual framework of the study. The Wells Score and Revised Geneva Score were originally developed as diagnostic probability tools, whereas the simplified Pulmonary Embolism Severity Index (sPESI) was designed for prognostic risk stratification, particularly mortality prediction, rather than treatment selection [2–4]. Evaluating these instruments as predictors of thrombolysis introduces a mismatch between the intended purpose of the scores and the investigated outcome. Hence, the observed lack of predictive accuracy may reflect inappropriate extrapolation beyond the validated clinical roles of these tools rather than poor score performance per se.

Another important limitation concerns the definition of the primary outcome. The manuscript repeatedly refers to “predicting the need for thrombolysis”; however, the actual measured endpoint appears to be whether thrombolysis was administered. These are not equivalent outcomes. Thrombolytic treatment decisions are influenced by multiple clinician-dependent and institutional

factors, including contraindications, imaging availability, local practice patterns, and physician preference. Current guideline-based reperfusion decisions rely mainly on hemodynamic instability, right ventricular dysfunction, myocardial injury, clinical deterioration, and bleeding risk rather than diagnostic probability scores alone [5].

Selection bias also substantially affects interpretation of the diagnostic scoring systems. The study excluded patients with negative CTPA findings and analyzed only confirmed PE cases [1]. Under such conditions, statements regarding misclassification of “low-risk” patients become problematic because the cohort no longer reflects the intended diagnostic population in which Wells or Geneva scores are normally applied [2,3]. Diagnostic probability tools should ideally be evaluated in an undifferentiated suspected PE population, not exclusively among confirmed cases.

In addition, the statistical approach appears limited for the stated objective. Only 16 patients underwent thrombolysis, restricting statistical power and preventing multivariable modeling [1]. Although the authors appropriately acknowledged the inability to perform logistic regression, the manuscript nevertheless discusses several variables as predictors of thrombolysis. Given the small event number, these associations should be interpreted cautiously.

Finally, variables identified as associated with thrombolysis, including hypotension, right ventricular strain, inotropic requirement, and central PE burden, are already established components of contemporary clinical deci-

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sion-making for reperfusion therapy [5,6]. Therefore, the observed associations may partially reflect circular reasoning rather than independent predictive utility.

Despite these concerns, the study raises a clinically relevant question and may help stimulate future prospective investigations focused on integrated bedside risk models for acute PE management.

References

1. Ebor J, Rangnani A, Rani JN, Ganesan P. The role of standard scoring systems in predicting early thrombolysis in patients with acute pulmonary embolism presenting to the emergency department: A retrospective cohort study. *Eurasian Journal of Critical Care*. 2026;8(1):1-7.
2. Wells PS, Anderson DR, Rodger M, et al. Derivation of a simple clinical model to categorize patients probability of pulmonary embolism: increasing the model's utility with the SimpliRED D-dimer. *Thromb Haemost*. 2000;83(3):416-420.
3. Le Gal G, Righini M, Roy PM, et al. Prediction of pulmonary embolism in the emergency department: the revised Geneva score. *Ann Intern Med*. 2006;144(3):165-171.
4. Jiménez D, Aujesky D, Moores L, et al. Simplification of the pulmonary embolism severity index for prognostication in patients with acute symptomatic pulmonary embolism. *Arch Intern Med*. 2010;170(15):1383-1389.
5. Konstantinides SV, Meyer G, Becattini C, et al. 2019 ESC Guidelines for the diagnosis and management of acute pulmonary embolism. *Eur Heart J*. 2020;41(4):543-603.
6. Rivera-Lebron B, McDaniel M, Ahrar K, et al.; PERT Consortium. Diagnosis, treatment and follow up of acute pulmonary embolism: consensus practice from the PERT Consortium. *Clin Appl Thromb Hemost*. 2019;25:1076029619853037.

Enhancing Basic Life Support Competency in Urology Departments: Implications of Hospital-Wide Knowledge Gaps

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To the Editor,

Differences in Basic Life Support (BLS) knowledge and preparedness among healthcare personnel represent a critical challenge for patient safety in hospital settings. In surgical specialties such as urology, where perioperative emergencies may occur unexpectedly, timely initiation of BLS is essential to ensure survival and favorable neurological outcomes. Urology departments are inherently multidisciplinary, involving surgeons, anesthesiologists, nurses, technicians, and administrative staff, all of whom may be present during an emergency situation. This letter is intended as a narrative commentary based on current literature and practical considerations regarding multidisciplinary BLS preparedness in urology departments.

During perioperative cardiac arrest or sudden clinical deterioration, even brief delays in initiating BLS can have fatal consequences, particularly in patients who are anesthetized, sedated, or hemodynamically unstable. Insufficient preparedness among non-clinical staff may compromise the effectiveness of emergency response, even when experienced clinical personnel are present. This highlights the necessity of a hospital-wide, inclusive approach to BLS education that encompasses all occupational groups rather than focusing solely on direct care providers.

Another important consideration is adherence to updated BLS guidelines, including appropriate use of automated external defibrillators (AEDs) and infection control measures. In urological operating rooms, where aerosol-generating procedures and electrocautery are

frequently employed, proper use of personal protective equipment during resuscitation is essential to protect healthcare workers while maintaining effective patient care. The COVID-19 pandemic has further emphasized the need to integrate infection control principles into BLS training, underscoring the importance of regularly updated and comprehensive educational programs (1).

From a scientific and practical perspective, structured and simulation-based BLS training offers a valuable strategy for improving both technical and non-technical skills. In urology departments, simulation scenarios reflecting perioperative emergencies—such as anesthetic-related cardiac arrest, massive intraoperative hemorrhage, or complex trauma—may enhance team coordination, role clarity, and confidence among both clinical and non-clinical staff. Tailoring training programs to address the specific needs of different occupational groups may further optimize learning outcomes and preparedness (2–4).

Furthermore, interdisciplinary training initiatives provide a foundation for future research exploring the long-term impact of repeated education, refresher courses, and simulation-based interventions on real-world clinical performance during in-hospital cardiac arrest events. Given the complexity of urological procedures and the high prevalence of comorbid conditions among this patient population, maintaining BLS competency across all staff groups is both a scientific responsibility and an ethical imperative.

In conclusion, strengthening BLS education through inclusive, multidisciplinary, and regularly updated train-

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ing programs is essential for improving emergency response and patient outcomes in hospital settings. Urology departments, in particular, may benefit from tailored simulation-based training, interdisciplinary collaboration, and structured competency assessments to ensure that all personnel—regardless of their direct patient care role—are prepared to respond promptly and effectively to life-threatening situations. Implementation of mandatory annual simulation-based BLS refresher programs involving both clinical and non-clinical personnel may represent a practical strategy to improve emergency preparedness in urology departments.

References

1. Al-Shiakh S, Tran QK, Caggiula A, et al. Attitudes among healthcare professionals towards cardiopulmonary resuscitation during COVID-19. *Am J Emerg Med.* 2022;52:34–42.
2. Griffin C, Aydın A, Brunckhorst O, et al. Non-technical skills: a review of training and evaluation in urology. *World J Urol.* 2020;38:1653–1661.
3. Pai DR, Kumar VH, Sobana R. Perioperative crisis resource management simulation training in anaesthesia. *Indian J Anaesth.* 2024;68:36–44.
4. Kazior MR, Ianchulev S, Nguyen J, et al. Creation of simulation-based curriculum of perioperative emergencies for residents in anesthesiology. *Cureus.* 2021;13:e15509.

Beyond the AUROC: Data Leakage, Random Splitting, and Neglected Calibration in Critical Care Machine Learning

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Dear Editor,

Machine learning (ML) is increasingly proposed for clinical risk prediction in emergency and critical care, including the triage of undifferentiated patients,¹ yet reported performance may be inflated by avoidable methodological weaknesses. A systematic review found that studies of supervised ML models were frequently poorly reported, methodologically weak, and at high risk of bias.² Overfitting, in which a model captures sample-specific noise rather than reproducible signal, is a recurrent cause of this over-optimism.^{3,4} Of 606 COVID-19 prognostic models in a living systematic review, 545 were at high risk of bias, inadequate sample size being the commonest cause (n=408, 67%),⁵ a concern reiterated in recent guidance on sample size for artificial intelligence-based models.⁶ High reported discrimination should therefore be read with caution.

A frequent, under-recognised source of bias is data leakage. When class-imbalance correction, feature selection, or normalisation is applied to the whole dataset before cross-validation rather than within each fold, the held-out observations contaminate model development. In radiomics, oversampling before cross-validation produced a positive bias of up to 0.34 in the area under the receiver operating characteristic curve (AUROC), attributable purely to this leakage.⁷ All preprocessing, feature selection, resampling, and hyperparameter tuning should therefore be confined to the training data and repeated within each resampling iteration, as the signalling questions of PROBAST+AI now make explicit.^{3,4,8} If a hold-out set is nonetheless used, partitioning should be at the

patient level, so that all records from one individual, such as repeated images or admissions, stay within a single partition; otherwise information leaks across sets and performance is again overestimated⁷.

Randomly splitting a single dataset into training and test subsets does not constitute external validation, because both subsets share one data source, and it is statistically inefficient, particularly in small or moderate-sized datasets.^{3,9} Splitting removes data from development, increases overfitting, and leaves a test set too small for reliable estimation; it can also be repeated until favourable results emerge, an approach analogous to p-hacking.³ These problems are magnified in small samples, where predictions become unstable and the estimated risk for one individual may span almost the entire probability scale.⁶ Where feasible, bootstrapping, with every modelling step repeated in each bootstrap sample, or properly nested repeated cross-validation uses the available data more efficiently.^{3,4}

Evaluation based solely on AUROC or accuracy is inadequate. A model may discriminate well yet be badly miscalibrated, systematically overestimating or underestimating risk and, in critical care, prompting inappropriate escalation or withholding of care; calibration is nevertheless assessed far less often than discrimination.¹⁰ The Hosmer–Lemeshow test is sensitive to arbitrary grouping and sample size and does not describe the extent or direction of miscalibration; calibration curves are therefore preferable.^{10,11} Authors should instead report a flexible calibration curve, calibration-in-the-large, and the calibration slope.^{10,11} The Brier score may be added as a mea-

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sure of overall prediction error, but because it captures discrimination and calibration jointly, it should not be interpreted as a pure measure of calibration.^{4,12}

Accuracy is particularly misleading under class imbalance, which is common for outcomes such as in-hospital cardiac arrest. Although imbalance corrections are routinely imported into ML pipelines, evidence from standard and ridge logistic regression shows that random undersampling, random oversampling, and SMOTE can substantially worsen calibration without improving discrimination, thereby reducing clinical utility.¹² Clinical usefulness should additionally be assessed through decision curve analysis.^{4,10}

Model complexity should be justified rather than assumed. A systematic review of direct comparisons found no consistent evidence that ML outperforms logistic regression for clinical prediction,¹³ while flexible algorithms have greater sample-size requirements to achieve comparable stability and calibration.⁶ Where strategies perform similarly, the simpler model is preferable at the bedside.⁴ Comparisons must also be fair: setting a new model's internally validated performance against an established score's externally validated performance is inappropriate, and head-to-head comparison should be performed in a dataset independent of both development cohorts.⁹

We therefore urge editors and reviewers to promote consistent use of two complementary resources: TRIPOD+AI for transparent reporting,¹⁴ and PROBAST+AI for assessing methodological quality, risk of bias, and applicability.⁸ Claims of clinical readiness should be constrained until a model has been externally validated, ideally by independent investigators, and, where feasible, prospectively evaluated for clinical impact.^{3,9} External validation has historically been uncommon: in a PubMed search covering 1961 to 2019, only 5% of prediction model studies mentioned it in the title or abstract.⁹ One performed within the development programme should not preclude subsequent independent assessment.^{3,9} Applying these standards would help ensure that reported performance reflects genuine clinical value for critically ill patients rather than an artefact of study design.

References

1. Miles J, Turner J, Jacques R, Williams J, Mason S. Using machine-learning risk prediction models to triage the acuity

- of undifferentiated patients entering the emergency care system: a systematic review. *Diagn Progn Res.* 2020;4:16.
2. Andaur Navarro CL, Damen JAA, Takada T, Nijman SWJ, Dhiman P, Ma J, et al. Risk of bias in studies on prediction models developed using supervised machine learning techniques: systematic review. *BMJ.* 2021;375:n2281.
3. Collins GS, Dhiman P, Ma J, Schluskel MM, Archer L, Van Calster B, et al. Evaluation of clinical prediction models (part 1): from development to external validation. *BMJ.* 2024;384:e074819.
4. Efthimiou O, Seo M, Chalkou K, Debray T, Egger M, Salanti G. Developing clinical prediction models: a step-by-step guide. *BMJ.* 2024;386:e078276.
5. Wynants L, Van Calster B, Collins GS, Riley RD, Heinze G, Schuit E, et al. Prediction models for diagnosis and prognosis of covid-19: systematic review and critical appraisal. *BMJ.* 2020;369:m1328.
6. Riley RD, Ensor J, Snell KIE, Archer L, Whittle R, Dhiman P, et al. Importance of sample size on the quality and utility of AI-based prediction models for healthcare. *Lancet Digit Health.* 2025;7(6):100857.
7. Demircioğlu A. Applying oversampling before cross-validation will lead to high bias in radiomics. *Sci Rep.* 2024;14(1):11563.
8. Moons KGM, Damen JAA, Kaul T, Hooft L, Andaur Navarro C, Dhiman P, et al. PROBAST+AI: an updated quality, risk of bias, and applicability assessment tool for prediction models using regression or artificial intelligence methods. *BMJ.* 2025;388:e082505.
9. Ramspek CL, Jager KJ, Dekker FW, Zoccali C, van Diepen M. External validation of prognostic models: what, why, how, when and where? *Clin Kidney J.* 2021;14(1):49-58.
10. Van Calster B, McLernon DJ, van Smeden M, Wynants L, Steyerberg EW. Calibration: the Achilles heel of predictive analytics. *BMC Med.* 2019;17(1):230.
11. Riley RD, Archer L, Snell KIE, Ensor J, Dhiman P, Martin GP, et al. Evaluation of clinical prediction models (part 2): how to undertake an external validation study. *BMJ.* 2024;384:e074820.
12. van den Goorbergh R, van Smeden M, Timmerman D, Van Calster B. The harm of class imbalance corrections for risk prediction models: illustration and simulation using logistic regression. *J Am Med Inform Assoc.* 2022;29(9):1525-1534.
13. Christodoulou E, Ma J, Collins GS, Steyerberg EW, Verbaekel JY, Van Calster B. A systematic review shows no performance benefit of machine learning over logistic regression for clinical prediction models. *J Clin Epidemiol.* 2019;110:12-22.
14. Collins GS, Moons KGM, Dhiman P, Riley RD, Beam AL, Van Calster B, et al. TRIPOD+AI statement: updated guidance for reporting clinical prediction models that use regression or machine learning methods. *BMJ.* 2024;385:e078378.