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ABOUT JOURNAL

Aim and scope

Annales Medicinae Urgentis (AMU) is a open-access peer reviewed medical journal published by the Croatian Society for Emergency Medicine that aims to improve the care of patients with emergency and critical illness by acquiring, discussing, distributing, and promoting evidence-based information relevant to emergency physicians and intensivists.

It publishes original original articles, reviews, case reports, meta-analysis, comments, methodologies, perspectives/ viewpoints, editorials, images, news, communications, letters to the editor, etc with no restrictions on the maximum length of manuscripts, provided that the text is concise and comprehensive. The AMU uses the Diamond Open Access model. This means that there are NO author processing fees and no fees to access the published papers.

HLZ - HRVATSKO DRUŠTVO ZA HITNU MEDICINU
CMA - CROATIAN SOCIETY OF EMERGENCY MEDICINE

CONTENT

ANNALES MEDICINAE URGENTIS: *MESSAGE FROM THE EDITORS*

Prof. Višnja Nesek Adam, MD, PhD

Prof. Ivan Gornik, MD,PhD

Dear Colleagues,

With great pleasure and pride, we are delighted to present the fourth issue of Annales Medicinae Urgentis, the official open-access, peer-reviewed journal of the Croatian Medical Association – Croatian Society of Emergency Medicine (CMA–CSEM). Each new issue represents a significant milestone in the growth of our journal and reflects our ongoing dedication to advancing the field of emergency and critical care medicine.

With every issue, we continue progressing toward meeting the standards for inclusion in international bibliographic and citation databases. This advancement reflects not only the growing quality and relevance of our published research but also the continuous improvement of our editorial processes and academic standards.

A notable enhancement in this issue is the further optimization of our automated manuscript submission and tracking system, designed to ensure transparency, streamline communication, and improve efficiency throughout the editorial workflow. In addition, Annales Medicinae Urgentis continues to operate under a double-blind peer-review system, ensuring objective evaluation and strengthening the scientific integrity of the journal. These measures mark a significant step forward, elevating the journal to an even higher professional and academic standard.

This issue features a wide range of contributions, including original research articles, systematic reviews, case reports, and other scholarly works relevant to emergency and intensive care medicine. Collectively, these articles demonstrate the increasing scientific engagement of our community and reaffirm the journal's role as a platform for knowledge exchange, evidence-based discussion, and professional development.

We sincerely thank our authors for their trust, our reviewers for their meticulous and constructive evaluations, and our editorial team for their dedication and hard work. Your contributions are essential to shaping Annales Medicinae Urgentis into a credible, visible, and internationally recognized journal.

We warmly encourage all members of the emergency and critical care community to actively engage with the journal: submit your research, share clinical insights through reviews or case reports, participate in peer review, or engage in scholarly discussions and knowledge dissemination. Every contribution, no matter its size, strengthens the journal, enriches our community, and ultimately enhances patient care.

Looking forward, we remain confident that through sustained commitment to quality, ethical rigor, and collaborative effort, Annales Medicinae Urgentis will continue to grow in impact and recognition. Each issue brings us closer to our shared goal of international indexing and visibility, fostering a more connected, evidence-driven, and thriving professional community.

Thank you for being an active part of this journey.

Warm regards,

Prof. Višnja Nesek Adam, MD, PhD

and Prof. Ivan Gornik, MD,PhD

Editors-in-Chief, Annales Medicinae Urgentis

ORIGINAL ARTICLE / IZVORNI ZNANSTVENI ČLANAK

LUNG ULTRASOUND ENABLES FASTER DIAGNOSIS AND BETTER OUTCOME IN PATIENTS WITH DYSPNEA IN THE EMERGENCY DEPARTMENT

ULTRAZVUK PLUĆA OMOGUĆAVA BRŽU DIJAGNOZU I BOLJE ISHODE U BOLESNIKA S DISPNEJOM U HITNOM BOLNIČKOM PRIJAMU

***Adis Keranović[1], Ivan Gornik[1,2]**

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Abstract

Background: Acute dyspnea is a common and urgent presentation in the emergency department, with acute heart failure (AHF) as one of its leading causes. Rapid differentiation between AHF and other etiologies is essential.

Materials and methods: This study aimed to evaluate the diagnostic accuracy of lung ultrasound (LUS) and compare it to chest X-ray (CXR) in patients with acute dyspnea, to show how much LUS is faster compared to CXR. This study included 242 adult patients presenting with acute dyspnea of ≤3 days' duration. All patients underwent CXR and LUS according to a standardized protocol in emergency department. The final diagnosis was established by experienced clinicians using all available clinical, and imaging data, blinded to the LUS results. Diagnostic performance measures examination times of LUS and CXR and they were compared.

Results: LUS results were available significantly faster (median 10.0 min) than CXR (median 62.5 min).

Conclusions: LUS demonstrated significantly shorter time to results. These findings support its use as a rapid, non-invasive, first-line tool for excluding AHF in acute dyspnea patients.

Key words: acute dypnea; emergency department; lung ultrasound

Sažetak

Uvod: Akutna dispneja čest je i hitan razlog dolaska bolesnika u hitnu medicinsku službu, a akutno zatajenje srca (AZS) jedan je od najčešćih uzroka. Brza diferencijacija AZS-a od drugih uzroka od ključne je važnosti.

Metode: Cilj ovog istraživanja bio je procijeniti dijagnostičku točnost ultrazvuka pluća (engl. *lung ultrasound*, LUS) i usporediti ga s rendgenskim snimkama (RTG) pluća u bolesnika s akutnom dispnejom, te pokazati koliko je LUS brži u odnosu na RTG-e pluća. U studiju je uključeno 242 odraslih bolesnika s akutnom dispnejom u trajanju ≤3 dana. Svi su bolesnici podvrgnuti RTG-u pluća i LUS-u prema standardiziranom protokolu u hitnoj medicinskoj službi. Konačnu dijagnozu postavili su iskusni kliničari koristeći sve dostupne kliničke i slikovne podatke, a bili su slijepi na rezultate LUS-a. Mjerena su dijagnostička svojstva i vrijeme izvođenja LUS-a i RTG-a te su međusobno uspoređivani.

Rezultati: Rezultati LUS-a bili su dostupni značajno brže (medijan 10,0 min) u odnosu na RTG-e (medijan 62,5 min).

Zaključak: LUS je pokazao značajno kraće vrijeme do dostupnosti rezultata. Ovi nalazi podržavaju uporabu LUS-a kao brze, neinvazivane diojagnostičke metode i kao prvi izbor u isključivanju akutnog zatajenja srca u bolesnika s akutnom dispnejom.

Ključne riječi: akutna dispneja; hitni prijam; ultrazvuk pluća

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Introduction

Acute dyspnea is one of the the most common and urgent reasons for emergency department (ED) visits and is frequently caused by acute heart failure (AHF). Other causes usually are pneumonia, pulmonary embolism, or chronic obstructive pulmonary disease (1). Rapid and accurate differentiation of these conditions is critical to initiating appropriate therapy and improving patient outcomes (2). Chest radiography (CXR) is mostly used tool in the evaluation of acute dyspnea. CXR, due to its broad availability, is typically the first imaging modality utilized. However, its sensitivity in early cardiogenic pulmonary edema is limited, and interpretation may be delayed, particularly in busy ED settings (3). Lung ultrasound (LUS) has emerged as a rapid, bedside, radiation-free, non-invasive technique that detects extravascular lung water through identification of B-lines (4,5). LUS is easily repeatable, requires minimal equipment, and can be performed in real time during initial patient assessment. Most diagnostic accuracy studies for AHF use a composite reference standard combining clinical, laboratory, and imaging data, often supplemented by echocardiography, to minimize bias and provide a robust benchmark (6).

Lung ultrasound enables rapid, non-invasive bedside diagnosis of acute heart failure, significantly faster than chest X-ray in acute dyspnea patients.

We hypothesised that lung ultrasound in patients with acute dyspnea has at least equal diagnostic value compared to CXR and that is significantly faster in the emergency setting.

Therefore, the aim of this study was to compare the diagnostic performance of lung ultrasound with that of chest X-ray in patients presenting with acute dyspnea in the emergency department. We evaluated the time required for each diagnostic method and to determine whether LUS can accelerate diagnostic decisionmaking while maintaining comparable accuracy. We we like to make LUS a valuable first-line tool in the emergency evaluation of acute dyspnea.

Methods

Participants

This study was conducted at the Emergency Department of the University Hospital Centre Zagreb and enrolled 242 adult patients (>18 years) presenting with acute dyspnea of ≤3 days' duration in which AHF was considered a differential diagnosis. Eligible patients were conscious, spontaneously breathing, and did not require mechanical ventilation. Written informed consent was obtained. Exclusion criteria included unconsciousness, need for invasive or non-invasive ventilation, hemodynamic instability requiring immediate intervention, current dialysis, chest trauma, or refusal to participate.

Data collection and clinical assessment

After confirming eligibility and consent, patients underwent a standardized diagnostic protocol including clinical examination, chest X-ray (CXR), and lung ultrasound (LUS). Final diagnosis was established by expert clinicians using all clinical data excluding knowledge of LUS results and served as the reference standard.

Chest X-ray

CXR was performed in posteroanterior and lateral views. Images were interpreted by board-certified radiologists who were blinded to the LUS results. Radiologic criteria for AHF included pulmonary venous redistribution, Kerley B lines, and interstitial or alveolar oedema. The presence of any of these signs classified the CXR as positive.

Lung ultrasound

Lung ultrasound was performed immediately after examination with patients in a supine or sitting position depending on clinical status. Two ultrasound machines were used: Esaote My Lab Six CrystaLine (1–8 MHz convex probe) and Philips Affiniti 70 (1–5 MHz convex probe). Scanning followed the international BLUE protocol, examining eight chest zones (bilateral anterior upper/lower and lateral upper/basal areas). A diagnosis of AHF by LUS required ≥2 positive regions bilaterally with ≥3 B-lines per region. Initial operator was the principal investigator, with a second blinded examiner rescanning in unclear cases.

Statistical analysis

Quantitative data (examination times) were expressed as medians and quartile ranges. Examination times were recorded and compared between LUS and CXR. Statistical significance was set at $p<0.05$. Sample size requirements were calculated using an online calculator provided by Akoglu (7).

Results

The median age was 79 years (range 30–100). Females were more frequently admitted (133 females, median age 80; 109 males, median age 76). Median ages were similar in patients with (80 years) and without AHF (77 years).

The time to ultrasound findings showed a relatively narrow distribution, ranging from 4.0 to 75.0 minutes, with a median of 10.0 minutes and a quartile range from 8.0 to 14.0 minutes. The median waiting time for chest X-ray results was 62.5 (28.25-106.5) minutes, with the longest waiting time recorded at 474.0 minutes. All LUS results preceded CXR reports (Table 1) (Figure 1).

Discussion

Key strength of LUS is its rapid availability. The main finding of our study is that LUS the time to results was significantly shorter than for CXR (median 10.0 vs. 62.5 minutes), supporting its role as a first-line test in acute dyspnea. The clinical importance of speed should not be underestimated.

Table 1. Time to diagnostic test lung ultrasound and chest radiography

	Desctiptive parameter (min)				
Diagnostic test	N	Arithmetic mean	Standard deviation	Minimum	Maximum
LUS	242	12,4	8,3	4,0	75,0
CXR	242	83,5	81,3	1,0	474,0

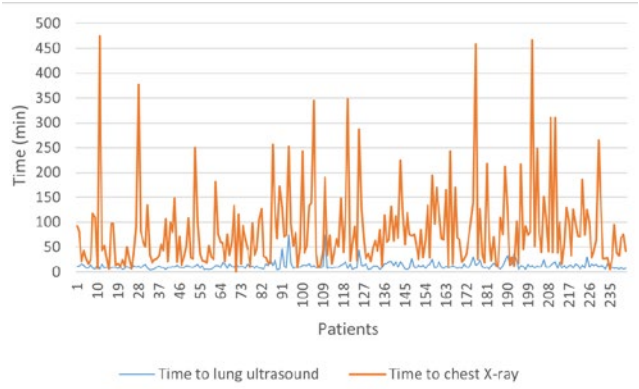

Figure 1. Time to lung ultrasound and chest radiography

Rapid diagnosis facilitates the initiation of earlier treatment, which may improve outcomes. For example, point-of-care LUS has been shown to alter diagnoses in a substantial proportion of patients, directly influencing management decisions (8). Moreover, studies report that LUS use improves patient flow and resource utilisation in emergency departments (9), reduces delays in critical care linked to higher mortality (10), and contributes to shorter length of stay and better survival outcomes (11). Together, these findings suggest that, beyond diagnostic accuracy, the timeliness of LUS may have significant downstream effects on both patient care and healthcare efficiency.

Faster lung ultrasound diagnosis supports early detection of acute heart failure and timely initiation of treatment in the emergency department.

Overall, while LUS cannot replace more specific modalities for confirming AHF, it offers an ideal balance of high sensitivity and rapid availability. In the emergency department, where rapid triage and exclusion of life-threatening conditions are paramount, LUS is best applied as a front-line rule-out tool integrated with confirmatory tests for comprehensive evaluation.

Conclusion

Lung ultrasound demonstrated significantly shorter time to results and faster diagnosis. These findings support its use as a rapid, non-invasive, first-line tool for excluding acute heart failure in acute dyspnoic patients.

Acknowledgement

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CASE REPORT / PRIKAZ SLUČAJA

COCAINE-ASSOCIATED SODIUM CHANNEL CARDIOTOXICITY PRESENTING WITH WIDE QRS TACHYARRHYTHMIA: A CASE REPORT

KOKAINOM INDUCIRANA KARDIOTOKSIČNOST ZBOG BLOKADE NATRIJSKIH KANALA SA ŠIROKOM QRS TAHIARITMIJOM: PRIKAZ SLUČAJA

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Abstract

Background: Cocaine toxicity is frequently mediated by sympathomimetic effects; however, direct inhibition of cardiac fast sodium channels (Nav1.5) may result in rate-dependent intraventricular conduction delay, QRS prolongation, and life-threatening ventricular arrhythmias.

Case presentation: A 25-year-old man with unknown medical history presented after confirmed cocaine use with altered mental status and seizures. During initial resuscitation, he developed progressive wide-complex tachycardia, resulting in cardiac arrest. Return of spontaneous circulation was achieved following advanced life support and administration of hypertonic sodium bicarbonate. The patient required intensive care but recovered with correction of metabolic derangements and supportive management.

Discussion: This case illustrates the electrophysiological consequences of cocaine-induced sodium channel blockade, typical electrocardiographic findings, and the role of sodium bicarbonate as targeted therapy.

Conclusion: Early recognition of sodium channel toxicity and prompt administration of sodium bicarbonate, alongside comprehensive supportive care, are critical to improving outcomes in severe cocaine-related cardiotoxicity.

Keywords: arrhythmia; cocaine; QRS widening; sodium bicarbonate; sodium channel

Sažetak

Uvod: Toksičnost kokaina često je posredovana simpatomimetičkim učincima; međutim, izravna inhibicija brzih natrijevih kanala u srcu (Nav1.5) može dovesti do o frekvenciji ovisnog intraventrikulskog poremećaja provođenja, produljenja QRS-a i po život opasnih ventrikulskih aritmija.

Prikaz slučaja: Muškarac od 25 godina s nepoznatom anamnezom zaprimljen je nakon potvrđenog korištenja kokaina s poremećenim mentalnim statusom i konvulzijama. Tijekom početne resuscitacije razvio je progresivnu tahikardiju sa širokim QRS kompleksom, što je rezultiralo srčanim zastojem. Povrat spontane cirkulacije postignut je nakon naprednih mjera održavanja života i primjene hipertoničnog natrijeva bikarbonata. Bolesnik je zahtijevao intenzivno liječenje, ali se oporavio uz korekciju metaboličkih poremećaja i potporne mjere.

Rasprava: Ovaj slučaj prikazuje elektrofiziološke posljedice blokade natrijevih kanala inducirane kokainom, tipične elektrokardiografske nalaze, te ulogu natrijeva bikarbonata kao ciljane terapije.

Zaključak: Rano prepoznavanje toksičnosti natrijevih kanala i pravodobna primjena natrijeva bikarbonata, uz sveobuhvatnu potpornu terapiju, ključni su za poboljšanje ishoda u teškoj kardiotoksičnosti povezanoj s kokainom.

Ključne riječi: aritmija; kokain; natrijev bikarbonat; natrijev kanal; proširenje QRS-a

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Introduction

Cocaine remains a major contributor to drug-related emergency department visits and is associated with substantial cardiovascular morbidity and mortality. Cardiac complications range from transient conduction abnormalities to myocardial ischemia, cardiomyopathy, malignant arrhythmias, and sudden cardiac death (2,3). While enhanced sympathetic activity and coronary vasoconstriction are well-recognised contributors, cocaine also exerts direct toxic effects on cardiac ion channels (1-3).

Cocaine cardiotoxicity is caused by use-dependent blockade of cardiac sodium channels (Nav1.5), leading to QRS widening, rate-dependent conduction slowing, and arrhythmias. Sodium bicarbonate can reverse this and is potentially lifesaving..

Experimental and clinical evidence shows that cocaine inhibits fast sodium channels (Nav1.5) and modulates calcium and potassium currents (1-3). Sodium channel inhibition reduces the slope of phase 0 depolarisation, resulting in slowed ventricular conduction and QRS prolongation. This interaction is state- and use-dependent, intensifying at higher heart rates and with repetitive depolarisation, thereby explaining the association between tachycardia and progressive QRS widening (1-3).

Recognition of toxic sodium channel blockade is clinically important because management differs from that for ischemic or structural causes of wide-complex arrhythmias. In this context, sodium bicarbonate represents a targeted and potentially lifesaving intervention (2,4).

Case presentation

A 25-year-old man with no known chronic illnesses and no regular medications was brought to the emergency department for an altered mental status. On arrival, he was febrile, tachycardic, tachypneic, hypotensive, and actively seizing with associated myoclonus. Urine toxicology screening was positive for cocaine and amphetamines.

During early resuscitation, the patient developed worsening tachycardia with progressive QRS widening, which rapidly degenerated into cardiac arrest. Advanced life support was initiated, including endotracheal intubation and mechanical ventilation. Benzodiazepines were administered for seizure control. A bolus of hypertonic sodium bicarbonate was given, after which narrowing of the QRS complex was observed, followed by return of spontaneous circulation after approximately eight minutes.

Laboratory evaluation revealed severe lactic acidosis, markedly elevated creatine kinase consistent with rhabdomyolysis, and transient renal and hepatic dysfunction. Computed tomography of the head showed no acute intracranial pathology. The patient was admitted to the intensive care unit, where metabolic abnormalities were corrected, and organ function improved. He was discharged from the ICU in stable condition after six days and referred for psychiatric follow-up.

Initial electrocardiograms showed markedly prolonged QRS complexes with lateral ST-segment depressions and ST elevation in lead aVR. Following sodium bicarbonate administration, serial ECGs showed progressive QRS narrowing and stabilisation of cardiac rhythm, consistent with reversal of sodium channel blockade.

Discussion

Cocaine produces conduction abnormalities through direct inhibition of Nav1.5 channels, binding preferentially to activated and inactivated channel states (1). This interaction reduces inward sodium current and delays ventricular depolarisation. Because binding is use-dependent, tachycardia exacerbates conduction slowing and promotes QRS prolongation (1-3).

In addition to sodium channel inhibition, cocaine disrupts repolarising potassium currents, alters intracellular calcium handling, induces mitochondrial dysfunction, and triggers catecholamine excess and myocardial ischemia (2,5,6). These overlapping mechanisms create a proarrhythmic substrate capable of producing ventricular tachycardia, ventricular fibrillation, and transient Brugada-like electrocardiographic patterns (2,5).

Cocaine's multi-channel cardiac toxicity and catecholamine surge predispose to malignant arrhythmias, highlighting the importance of early recognition and supportive interventions.

Clinical manifestations of cocaine-induced sodium channel toxicity range from asymptomatic conduction delay to unstable wide-complex arrhythmias and sudden cardiac arrest. Electrocardiographic findings suggestive of sodium channel blockade include QRS duration exceeding 100–120 ms, a prominent terminal R wave in lead aVR, and rightward terminal QRS axis deviation (2,4). Progressive QRS widening with increasing heart rate is particularly concerning and correlates with arrhythmic risk (2,4).

Metabolic acidosis, electrolyte abnormalities, co-ingestion of other cardiotoxic substances, and underlying structural heart disease or channelopathies may exacerbate toxicity (2,6).

Management priorities include airway protection, seizure control, and attenuation of sympathetic overactivity, most commonly with benzodiazepines (2,4). When sodium channel blockade is suspected, intravenous sodium bicarbonate is the treatment of choice (2,4,6).

The therapeutic benefit of sodium bicarbonate is attributed to serum alkalinization, which reduces drug–channel binding affinity, and increased extracellular sodium concentration, which competitively mitigates channel blockade (2,4). These effects frequently result in rapid QRS narrowing and hemodynamic improvement. Repeated boluses or infusion may be required, guided by ECG response and acid–base status.

Antiarrhythmic agents with sodium channel–blocking properties should be avoided, and β-blockers lacking α-adrenergic antagonism should be used cautiously due to the risk of unopposed vasoconstriction (7). In refractory cases, lipid emulsion therapy or extracorporeal life support may be considered (2,6).

Conclusion

Cocaine-related cardiotoxicity is multifactorial, with direct, use-dependent sodium channel inhibition representing a central and potentially reversible mechanism. In patients presenting with wide QRS tachyarrhythmias and suspected stimulant exposure, toxic sodium channel blockade should be promptly considered. Early ECG recognition and timely administration of sodium bicarbonate, in conjunction with comprehensive supportive care, can be lifesaving.

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CASE REPORT / PRIKAZ SLUČAJA

THE MYTH-BUSTER: APPROACH TO SMALL BOWEL OBSTRUCTION IN THE EMERGENCY DEPARTMENT – CASE REPORT AND UPDATED LITERATURE REVIEW

RAZBIJANJE MITOVA: PRISTUP OPSTRUKCIJI TANKOG CRIJEVA U HITNOM BOLNIČKOM PRIJAMU – PRIKAZ SLUČAJA I PREGLED LITERATURE

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Abstract

Small bowel obstruction (SBO) is a common disease that accounts for up to 4 % of emergency department (ED) visits. It occurs due to an interruption in the normal flow of intraluminal contents, either by intrinsic luminal obstruction or extrinsic compression. A characteristic clinical image consists of abrupt abdominal pain and distention, accompanied by nausea and vomiting. However, patients can present with symptoms which are far from typical. As obstruction progresses into ischaemia and bowel necrosis, delayed diagnosis and treatment can significantly increase patients' morbidity and mortality.

Through a case of a 59-year-old man presenting to our ED with atypical symptoms, as well as the review of current literature on the topic, we aim to present novel options and dispel old myths regarding the diagnosis and management of SBO in the ED. Atypical symptoms and findings? Efficacy of point-of-care ultrasound? Conservative vs operative treatment? Early markers for treatment prognosis? Usefulness of nasogastric probe and water-soluble contrast? We offer the reader an overview of which of these might and which might not have a place in the treatment of a patient with SBO in the ED.

Key words: acute abdomen; ileus; procalcitonin; small bowel obstruction; ultrasound

Sažetak

Opstrukcija tankog crijeva učestalo je hitno stanje te je ujedno i razlog i do 4 % posjeta hitnoj službi. Nastupa kada opstrukcija unutar lumena crijeva ili vanjska kompresija onemogući odgovarajuće pražnjenje crijevnog sadržaja. Karakterističan bolesnik predstavlja se s naglo nastalom boli u abdomenu praćenom distenzijom, mučninom i povraćanjem, no bolesnici s opstrukcijom tankog crijeva često se prezentiraju na sasvim neuobičajen način. Dugotrajna opstrukcija progredira u ishemiju i nekrozu crijeva, stoga svako zakašnjenje u postavljanju dijagnoze ili liječenju značajno povećava rizik od razvoja komplikacija i smrtnog ishoda.

Kroz slučaj 59-godišnjeg muškarca s opstrukcijom tankog crijeva te obradu trenutne literature na ovu temu, cilj nam je predstaviti novitete i suzbiti mitove u obradi i liječenju. Koji su atipični simptomi i nalazi na koje možemo naići? Koja je korist ultrazvuka u postavljanju dijagnoze? Kada se odlučiti za konzervativno, a kada operativno liječenje? Postoje li rani biljezi za prognozu liječenja? Koja je uloga nazogastrične sonde i vodotopljivog kontrasta u dijagnozi i liječenju? Istražite s nama što od navedenog ima, a što nema, svoje mjesto u pristupu pacijentu s opstrukcijom tankog crijeva u hitnoj službi.

Ključne riječi: akutni abdomen; ileus; opstrukcija tankog crijeva; prokalcitonin; ultrazvuk

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Introduction

Small bowel obstruction (SBO) is a common disease that warrants surgical evaluation (1-3). It accounts for up to 4 % of emergency department (ED) visits, approximately 15 % of hospital admissions, and 20 % of emergency surgeries for abdominal pain (4-5). Between 20 and 30 % of patients with SBO undergo surgery (6). Bowel obstruction occurs when the normal flow of intraluminal contents is interrupted, either by intrinsic luminal obstruction or extrinsic compression (7). The small bowel is involved in approximately 80 % of mechanical intestinal obstructions. Obstruction leads to progressive dilation of the bowel oral to the blockage, while the bowel located aborally to the blockage decompresses as luminal contents pass. As the process continues, bowel wall becomes oedematous, normal absorptive function is disturbed, and fluid is sequestered intraluminally (8). If left untreated, complete obstruction can progress to bowel ischaemia, significantly increasing morbidity and mortality rate.

SBO can be classified as acute or chronic, based on symptom recurrence and duration, and as partial or complete, depending on the severity of bowel obstruction (9-10). A distinctive form of complete SBO is a closed-loop obstruction, in which a bowel segment is obstructed at two locations, with no proximal or distal outlet. Such obstructions can rapidly lead to ischaemia and necrosis.

Patients classically present with an abrupt onset of colicky abdominal pain, nausea, vomiting, and abdominal distention. Pain is most often described as periumbilical and cramping with paroxysms occurring every few minutes (11). Complete obstruction leads to cessation of passage of stool or flatus. However, passage may continue for an additional 12 or even 24 hours following the onset of other symptoms due to the evacuation of contents from the distal bowel. Patients with chronic obstruction will have intermittent, often self-resolving symptoms by the time they reach the ED.

Small bowel obstruction is a common and potentially serious emergency, often difficult to diagnose and manage in the ED, requiring careful evaluation and up-to-date clinical strategies..

Approach to a patient with SBO in the ED can be far from simple, and recent studies have begun to question some of the previously established "rules" in its management, as well as explore new "tools" that could both simplify and improve treatment and the patient's prognosis. Through a case presentation of one such patient in our ED and a review of the current literature, we offer the reader a few tips & tricks when dealing with SBO.

Case presentation

A 59-year-old man was brought to the ED by ambulance due to suspected STEMI – ST elevations in leads I and aVL were initially described. Patient had no previous illnesses to report. He arrived from Switzerland on a plane earlier that day. He complained of a piercing pain that started in his epigastrium several hours earlier and spread to his left hemithorax and neck area. He also experienced severe nausea, without emesis, accompanied by episodes of profuse sweating. Pain was constant at first. By the time of his arrival at the ED, it became intermittent, occurring every 5 to 10 minutes. He had taken no analgesics to relieve the pain. Ambulance was called by his family members when he felt lightheaded and fell in the bathroom while trying to relieve himself. He didn't hit his head, but lost consciousness for a few seconds.

During transport, he was stable and had received 300 mg of aspirin. Upon arrival at the ED, his vital signs were taken: RR 140/90 mmHg, heart rate 90/min, SpO_2 96 %, respiratory rate 16/min, body temperature 36.6°C. ECG upon arrival showed no pathologic findings; ST elevations in leads I and aVL were insignificant. He was placed on a heart monitor, and symptomatic treatment was initiated: Nitroglycerin spray, Pantoprazole, Metoclopramide and Metamizole. Initial clinical exam revealed moist, pale skin, normal heart and lung auscultation, and a soft, non-tender abdomen with audible bowel sounds. Symptoms persisted despite administered symptomatic treatment, every few minutes, patient would start shivering and sweating profusely and would complain of an increase in nausea and pain in his chest and upper stomach.

Initial laboratory results came back unremarkable – an increase in total leucocyte count (13.6) on account of increase in neutrophils, CRP of 1.4 mmol/L, lactates of 1.2 mmol/L, with electrolytes (sodium (Na), potassium (K),and chloride (Cl), liver enzymes (aspartate aminotransferase (AST), alanine aminotransferase (ALT), gamma-glutamyl transferase (GGT), and alkaline phosphatase (ALP), lipase, urea, creatinine and high sensitivity troponin I within appropriate reference ranges. As the patient's symptoms persisted, acute aortic syndrome was taken into consideration as a potential differential diagnosis. The d-dimer level was obtained and came back positive, 1.92 mg/L. CT aortography revealed no signs of acute aortic syndrome, but instead signs of strangulated ileus of small bowel – a distended small bowel wall 2,8 cm in width with the visible inflammation of surrounding fatty tissue. A nasogastric tube (NGT) was immediately placed, and an abdominal surgeon was consulted, who indicated emergency surgery.

The procedure was initially attempted via a laparoscopic approach; however, due to inability to identify transition points, conversion to a midline laparotomy was required. Two transition points were identified intraoperatively: a proximal one located approximately 40 cm aboral to the ligament of Treitz and a distal one approximately 50 cm oral to the ileocecal valve. A clockwise rotation of the mesentery consistent with small bowel volvulus was visualised. Following detorsion, the affected bowel appeared viable, demonstrating normal

colouration, preserved peristalsis, and intact mesenteric arterial pulsations. There was no evidence of ischaemia or necrosis; therefore, resection was not indicated. Postoperative course was uneventful, and the patient was discharged on postoperative day five.

Management of small bowel obstruction – myths & novelties

1) Elevated troponin and ECG changes outside myocardial infarction

There are several reported cases in the literature of SBO presenting with symptoms mimicking myocardial infarction with or without findings of ischaemic ECG changes and troponin elevation (14-17). Most recognised STEMI patterns involve the inferior leads (II, III, and aVF). While the mechanism of ST-segment elevation in such cases is not yet fully understood, it is speculated to be related to the increased intra-abdominal pressure, which compresses the diaphragmatic surface of the heart, particularly the inferior wall (18-19). Suggested explanations also include elevated vagal tone due to pain causing coronary artery spasms, stress-related catecholamine-associated cardiomyopathy, and variant angina. Other rarely described ECG findings in SBO patients included unspecified tachyarrhythmias, T-wave inversions in the inferolateral and anterior leads, signs of right heart strain, and left bundle branch block (LBBB).

Small bowel obstruction can rarely present with symptoms and ECG changes mimicking acute myocardial infarction, including ST-segment elevation and tachyarrhythmias.

Elevated troponin levels in SBO patients are most likely the result of a physiologically stressful state leading to demand-supply mismatch of oxygen in the heart – the so-called "type 2" myocardial infarction (20). A few cases of stress-related cardiomyopathy, such as Takotsubo syndrome, have been reported in patients with SBO (21-22). A retrospective study by Kumar et al. described a significant increase in mortality of SBO patients with elevated troponin levels (67%) compared to the overall patient group (32 %), most likely due to delayed diagnosis and treatment (12).

2) Overlooked risk factors

The most common cause of mechanical SBO are intraperitoneal adhesions, accounting for approximately 55-80 % of all cases (23). Up to 80 % of these cases have a history of prior intraabdominal surgery; the rest had prior peritonitis or no discernible cause for adhesions (24). If a patient has never undergone intra-abdominal surgery, a hernia with small bowel incarceration is the most likely cause (25-29). Older patients with suspected SBO with no prior abdominal surgery and absence of a hernia on examination should be evaluated for malignancy (30).

Intraperitoneal adhesions are the most common cause of mechanical SBO, particularly in patients with prior abdominal surgery.

An often-overlooked risk factor for SBO in previously healthy patients is congenital bowel anomalies, particularly intestinal malrotation (31). Its incidence is 1 in 200-500 newborns (32). The prevalence of malrotation in adults is unknown. Most cases present during the first year of life; however, they can also remain undiagnosed until later age – cases have been reported even in octogenarians (33-34). Malrotation in adults can present with obscured clinical symptoms, such as recurrent abdominal pain and vomiting, often resulting in multiple hospital visits. It may also present acutely, due to midgut volvulus, and may result in bowel ischaemia and gangrene. A characteristic CT finding is a reversed relationship between the superior mesenteric artery and the superior mesenteric vein, which can also be visualised by ultrasound (US). All patients, regardless of age, should undergo surgery, as it is impossible to predict the development of complications (35).

Congenital bowel anomalies, such as intestinal malrotation, represent an often, overlooked risk factor in previously healthy adults and may lead to acute complications requiring surgery.

3) Role of Point-of-Care ultrasound in diagnosis and management

Following physical exam and laboratory evaluation, imaging of the abdomen should be obtained. Supine and upright plain radiographs are often the initial imaging tests due to their widespread availability, low cost, and ability to follow disease progression serially (36-37). The standard of care is Computed tomography (CT) of the abdomen with intravenous contrast, if not contraindicated (38). CT without contrast enhancement can be used instead if necessary (39).

US has been investigated as a diagnostic option for SBO. Its benefits include rapid diagnosis and serial assessments without radiation exposure; however, its efficiency is highly operator-dependent (40-44). Published studies, such as the 2018 meta-analysis by Gottlieb et al. and the 2021 meta-analysis by Lin et al., demonstrate US's high sensitivity (up to 92 %) and specificity (up to 96 %) in diagnosing SBO (45). However, this finding is limited by the fact that most studies were conducted in non-ED settings. In fact, Lin et al.

demonstrated significantly lower specificity when considering only US performed in the ED.

Ultrasound offers a rapid, radiation-free option for initial diagnosis and serial monitoring of SBO, but CT remains the gold standard for definitive evaluation.

Another downside to US is that the criteria for diagnosing SBO haven't been clearly defined. SBO is typically diagnosed when the lumen of fluid-filled small bowel loops is dilated, although the definition of dilation varies across studies. It is most often defined as bowel diameter ≥2.5 cm measured from outer wall to outer wall; however, some physicians consider a diameter ≥1.5 cm a positive sign of SBO (46). At an early stage of the disease, the bowel loop diameter might yet be within the normal range. Still, bowel loops are fluid-filled and hyperkinetic, with hyper-representation of Kerckring folds (47). Another finding to observe by US is a change in peristalsis. Peristalsis is demonstrated by whirling movements of the bowel contents (48). It can be reduced, ineffective, with a back-and-forth motion, or completely absent – while its alteration is an excellent criterion for diagnosis of SBO, its evaluation is completely subjective (49). Finally, visualisation of free fluid, alongside previous findings, suggests the development of bowel infarction/ischaemia. Initially, free fluid is located only between the recesses of the mesenteric fan, giving rise to the characteristic 'sign of the thong' (50). As obstruction progresses, the amount of free fluid increases, and it can be found in the abdominal cavity.

At this point, US cannot be considered a substitute for imaging such as CT; however, it may have a role in the management of SBO as an initial screening tool and for serial monitoring of disease progression.

4) Timing of operative vs conservative management

Not every SBO requires surgical treatment – in fact, current guidelines, such as the Bologna guidelines for diagnosis and management of adhesive small bowel obstruction and the Eastern Association for the Surgery of Trauma practice management guideline, favour non-operative management in all patients with adhesive small bowel obstruction, unless there are signs of peritonitis, strangulation, and/or bowel ischaemia. Simply put, the main goal is to avoid surgery when unnecessary and to avoid delaying it when it is necessary (13).

Non-operative management is safe and effective for most adhesive SBO cases, with surgery reserved for signs of peritonitis, strangulation, or bowel ischaemia.

Unequivocal duration of non-operative management remains undefined – most recommend a 48-h to 72 h period as safe and appropriate (51-54). Patients typically display improvement within 48 h. However, some studies associate conservative therapy with increased risk of recurrent obstruction, and the risk of recurrence also worsens with each episode of SBO, with SBO related to adhesive disease recurring in up to 50 % of cases (55-56). Early results from an ongoing randomised controlled trial on the topic have demonstrated that non-operative management within 48 hours prevented surgery in 80 % of patients with SBO, with an interim analysis finding no significant between-group differences in mortality, complication rates, or bowel resection rates (57).

5) Potential markers for treatment prognosis

Most SBOs can be treated conservatively, but there are no objective criteria for when treatment fails or surgery is needed.

Recently, procalcitonin (PCT) has been suggested as a marker for bowel strangulation and a predictor of operative treatment (58-59). Several previous studies indicated a correlation between PCT and bowel ischaemia and necrosis (60-62). In a retrospective study by Cosse et al., a PCT-based algorithm was compared to the previously suggested Gastrografin test (which used a water-soluble contrast to assess restoration of bowel peristalsis). While the need for operative treatment was similar between both groups, the time to surgery and length of hospital stay were significantly lower in the PCT group (48 h *vs* 72 h, and 4 *vs* 6 days, respectively). A clinical trial investigating the use of a PCT-based algorithm is currently in development by the same team - cutoffs of 0.2 μg/L (failure of conservative management) and 0.6 μg/L (need for surgery) have been set based on their previous results on the subject (which accurately identified more than 80% of patients) (63). If the initial PCT is between 0.2 and 0.6 μg/L, a second assay will be performed after 24 h. If conservative management is initiated 48 h after symptom onset or bowel function is absent, operative management will be performed. Based on the findings so far, the introduction of the PCT-based algorithm might improve the quality of SBO management.

6) Efficacy of nasogastric tube in conservative treatment

NGTs have been considered the backbone for management of non-operative SBO, dating back to the early 20th century (64). Their use is universally accepted, and decompression via NGT is included in the Bologna guidelines for the management of SBO. Use of NGT can assist with symptom management by relieving abdominal distention, pain, nausea, and vomiting by decompressing contents proximal to the obstruction. However, they are also associated with substantial discomfort and pain, which is why some physicians tend to avoid them. Additionally, to function properly, NGTs require management – if they become occluded, clamped, or are assembled improperly, they can stent open the oesophagus and increase the risk of aspiration.

Literature evaluating NGT use in SBO patients is scarce; only a few retrospective studies are available (65-67). They showed no differences in risk of bowel ischaemia, need for surgery or mortality rates between the two groups, but almost all of them noted prolonged hospital stay (up to 2-3 days, depending on the study) in the NGT group, as well as higher rates of complications such as pneumonia and respiratory failure. No major complications were observed during treatment of SBO without an NGT. One five-year retrospective study showed a significantly higher surgery rate in the NGT group (8 % *vs* 2 %) and a far longer time to surgery (58.8 h *vs* 19.4 h); however, these results may reflect a selection bias toward patients with greater disease severity.

Further research is needed to determine which patients would benefit from NGT decompression and in which patients it can be avoided, a prospective controlled trial currently in development will yield some answers (68).

7) Use of water-soluble contrast as a diagnostic and therapeutic tool

Water-soluble contrast (WSC), such as *Gastrografin*, was evaluated at the end of the 20th century to predict the need for surgical treatment. The rationale for this idea was that WSC transit would help differentiate complete from partial SBO and predict whether partial SBO might resolve without operative treatment. Some authors have reported that detection of *Gastrografin* in the right colon 4-6 h post-ingestion was a reliable indicator of the success of conservative treatment (69-71). The Bologna guidelines still recommend WSC as the sole imaging study for patients with a clear SBO diagnosis and no signs of immediate surgery. It is now considered that WSC appearing in the colon on X-ray within 24 h of administration predicts resolution without the need for operative intervention.

The role of nasogastric tubes and water-soluble contrast in SBO management is increasingly questioned, with ongoing trials expected to clarify their efficacy.

Aside from its diagnostic use, the potential therapeutic role of WSC was also investigated. It has been theorised that the hyperosmolar property of the WSC could reduce bowel wall oedema by drawing fluid into the lumen. *Gastrografin* has also been reported to enhance smooth muscle contractility, but supporting literature is currently lacking (72). A randomised controlled study by Assalia et al. in 1994 was among the first to demonstrate a correlation between WSC use and improved resolution of obstruction and a shorter hospital stay. There is currently no consensus in the available literature, as subsequent studies have yielded conflicting results (73-77). The latest meta-analysis found no significant reduction in the need for operative management, or in mortality rates (78). The only positive result was a 0.15 day (3.6 h) reduction in hospital stay, which is not clinically significant.

The benefit of WSC appears to be more pronounced in cases of partial rather than complete obstruction. The latest guidelines of Eastern Association for the Surgery of Trauma (EAST) for SBO treatment recommend considering it in the setting of partial SBO that has not resolved within 48 hours, as it is believed to improve bowel function (time to bowel movement) and decrease the length of stay (Level 2 recommendation).

Conclusion

Our review offers a brief overview of some of the contested and controversial topics in the management of SBO in the ED. Some of these principles, such as NGS and WSC, have been utilised and recommended for decades based on anecdotal experiences and are only now starting to be questioned. In contrast, others that are only now in development, such as PCT and point-of-care US, will, over time, show whether they deserve their place in the sun. It is important to keep in mind, however, that no medical condition can be completely reduced to a perfect, solve-it-all algorithm, and that, alongside knowledge, creativity and willingness to challenge old beliefs and test new approaches, are qualities that every physician should strive for.

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CASE REPORT / PRIKAZ SLUČAJA

WHEN OXYGEN LIES: A CASE OF HIDDEN METHEMOGLOBINEMIA

KADA KISIK ZAVARAVA: PRIKAZ SLUČAJA SKRIVENE METHEMOGLOBINEMIJE

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Abstract

Acquired methemoglobinemia is a potentially life-threatening condition in which haemoglobin is oxidised into a form incapable of transporting oxygen. Recreational use of alkyl nitrites ("*poppers*") represents an under-recognised cause, particularly among young individuals without underlying comorbidities. We report a 30-year-old male who ingested 3,4-methylenedioxymethamphetamine (MDMA) and inhaled poppers, subsequently developing mild cyanosis, headache, and persistently reduced oxygen saturation unresponsive to supplemental oxygen. Co-oximetry demonstrated a methemoglobin level of 17.4 %. The patient remained circulatory stable, with headache as the sole symptom. Supportive management consisting of oxygen at 2 L/min and intravenous crystalloids was initiated, methylene blue was withheld. Serial measurements showed spontaneous improvement to 9.0 % at two hours and complete normalisation (1.2 %) at six hours. This case underscores the importance of targeted exposure history and early co-oximetry in patients with unexplained cyanosis or an oxygen saturation gap. It demonstrates that supportive therapy may be adequate in moderate methemoglobinemia.

Key words: 3,4-methylenedioxymethamphetamine (MDMA); alkyl nitrites; cyanosis; emergency medicine; methemoglobinemia; methylene blue

Sažetak

Stečena methemoglobinemija potencijalno je životno ugrožavajuće stanje u kojem je željezo u hemoglobinu oksidirano u feri (Fe^{3+}) oblik, čime se narušava sposobnost vezanja kisika. Rekreativna uporaba alkil-nitrita ("*poppers*") predstavlja često zanemareni uzrok intoksikacije kod mladih i inače zdravih odraslih osoba. Prikazujemo slučaj 30-godišnjeg muškarca koji je nakon unosa 3,4-metilenedioksi-metamfetamina (MDMA-e) i inhalacije *poppers-a* razvio simptome blage cijanoze usana i nokatnih ploča i glavobolju te perzistentno nisku saturaciju unatoč oksigenoterapiji. Ko-oksimetrijom je utvrđena razina methemoglobina od 17.4 %. Bolesnik je bio hemodinamski stabilan, bez značajnih simptoma osim blage glavobolje. Primijenjena je isključivo potporna terapija, nadoknada kisika 2 L/min i intravenska infuzija kristaloida, a antidot (metilensko modrilo) nije bio primijenjen. Serijskim mjerenjem ko-oksimetrije zabilježeno je spontano smanjenje razine methemoglobina na 9,0 % unutar dva sata i normalizacija na 1,2 % nakon šest sati. Ovaj slučaj ističe važnost usmjerene anamneze izloženosti i ko-oksimetrije kod pacijenata s neobjašnjenom cijanozom, niskom saturacijom kisikom (SaO_2) te značajnim zjapom saturacije kisikom (engl. *oxygen saturation gap*), te pokazuje da potporna terapija može biti dovoljna u umjerenim oblicima methemoglobinemije.

Ključne riječi: 3,4-metilendioksimetamfetamin (MDMA); alkil-nitriti; cijanoza; hitna medicinska služba; methemoglobinemija; metilensko modrilo

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Introduction

Methemoglobinemia occurs when haemoglobin is oxidised from its reduced state to a form incapable of transporting oxygen efficiently. This process also increases haemoglobin's affinity for oxygen, limiting its release to peripheral tissues (1). Acquired methemoglobinemia is most commonly associated with exposure to oxidising substances, including nitrites, nitrates, certain local anaesthetics, and select antimicrobial agents (1–6).

Recreational alkyl nitrites are inhaled compounds that produce brief vasodilatory and psychoactive effects due to rapid pulmonary uptake. High nitrite concentrations may exceed endogenous reductive capacity, leading to methemoglobin accumulation (2). Clinical manifestations range from minimal symptoms and mucocutaneous discolouration to significant impairment of oxygen delivery Although 3,4-methylenedioxymethamphetamine (MDMA) has rarely been associated with methemoglobinemia, alkyl nitrites are the primary causative agent in most reported cases (7).

Standard pulse oximeters frequently yield artefactual low oxygen saturation readings because methemoglobin alters light absorption. Consequently, pulse oximetry alone cannot reliably identify the condition. Co-oximetry, which quantifies individual haemoglobin species, remains the diagnostic gold standard (8).

Standard pulse oximeters often show falsely low oxygen saturation in methemoglobinemia because methemoglobin changes light absorption, making pulse oximetry alone unreliable for diagnosis.

Current haematology and toxicology guidelines recommend early measurement of methemoglobin levels in patients presenting with unexplained cyanosis or a saturation gap. Supportive care is usually sufficient for mild to moderate elevations, while methylene blue is reserved for symptomatic patients or those with substantially higher levels (1). American Heart Association recommendations follow similar principles but emphasise caution in patients with glucose-6-phosphate dehydrogenase (G6PD) deficiency, in which methylene blue may induce haemolysis (3).

Case presentation

A 30-year-old man with no known medical history presented to the emergency department with head pressure and bluish discolouration of the lips and nail beds. He denied chest pain, dyspnea, dizziness, palpitations, or syncope. He reported ingesting two MDMA tablets approximately twelve hours before presentation and intermittently inhaling poppers throughout the evening, including immediately before symptom onset.

On room air, vital signs were as follows: blood pressure 125/78 mmHg, heart rate 88 beats/min, respiratory rate 16 breaths/min, temperature 36.8 °C, and oxygen saturation (SaO_2) 92 %. Physical examination revealed mild cyanosis without respiratory di stress. Cardiovascular, respiratory, and neurological examinations were unremarkable (Glasgow Coma Scale score of 15).

Arterial blood gas analysis with co-oximetry showed a PaO_2 of 95 mmHg and a methemoglobin level of 17.4 %. CT head showed no acute pathology; an incidental orbital mass adjacent to the medial rectus muscle was noted.

Given the moderate elevation in methemoglobin and the absence of significant symptoms, conservative management was pursued. At a methemoglobin level of 17.4 %, in the absence of cardiopulmonary or neurological compromise, current recommendations support observation and supportive care rather than methylene blue administration. The patient improved steadily with supportive care. After six hours, cyanosis had resolved, the headache had subsided, and room-air oxygen saturation had increased to 98 %. He was discharged with instructions for outpatient follow-up, including further evaluation of the orbital lesion and repeat laboratory testing.

Discussion

Small quantities of methemoglobin are continuously produced under physiological conditions but are normally reconverted to functional haemoglobin through efficient enzymatic pathways (1). When exposure to oxidising agents overwhelms these mechanisms, clinically significant methemoglobinemia develops. Numerous reports in emergency medicine underscore the importance of early identification to prevent progression to severe hypoxic injury (4,5).

Methemoglobin interferes with the light-absorption principles used by pulse oximeters, resulting in persistently low saturation readings despite adequate arterial oxygen tension. When cyanosis persists and no respiratory disease is evident, co-oximetry should be performed to quantify haemoglobin derivatives directly (7).

As methemoglobin levels increase, symptoms typically intensify. Minor elevations may be asymptomatic, whereas progressive increases can lead to cardiopulmonary strain, neurological impairment, or respiratory compromise. Markedly elevated levels may result in life-threatening hypoxic injury (7).

Methemoglobin interferes with the light-absorption principles used by pulse oximeters, resulting in persistently low saturation readings despite adequate arterial oxygen tension.

Methemoglobin interferes with the light-absorption principles used by pulse oximeters, resulting in persistently low saturation readings despite adequate arterial oxygen tension.

Methylene blue accelerates the NADPH-dependent reduction of methemoglobin to functional haemoglobin and is indicated in patients with significant symptoms or high methemoglobin concentrations. In individuals with G6PD deficiency, methylene blue may precipitate haemolysis, necessitating alternative therapies such as high-dose ascorbic acid or exchange transfusion (1,2).

Supportive care alone is often sufficient in clinically stable patients with moderate methemoglobinemia, as demonstrated in this case. Once the offending agent is eliminated, methemoglobin levels generally decline predictably. When appropriate, clinicians should also provide brief harm-reduction counselling to reduce the risk of recurrent exposure (5,6).

Conclusion

Although medications such as dapsone and local anaesthetics are well-recognised causes of methemoglobinemia, recreational substances including MDMA and alkyl nitrites represent an increasingly relevant but frequently overlooked aetiology. MDMA metabolism may generate oxidative intermediates, while alkyl nitrites exert a direct oxidising effect on haemoglobin iron. Combined use may increase the likelihood of clinically significant methemoglobinemia in individuals without underlying comorbidities (9–11).

This case underscores the importance of a thorough exposure history, awareness of pulse oximetry limitations, and early use of co-oximetry in evaluating unexplained cyanosis. In clinically stable patients with modest elevations, supportive therapy alone may be sufficient to achieve full recovery. Continued recreational use of these substances underscores the need for ongoing clinician awareness.

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CASE REPORT / PRIKAZ SLUČAJA

THE ROLE OF POINT-OF-CARE ULTRASOUND IN THE EARLY DETECTION OF THE SOURCE OF INFECTION IN EMERGENCY MEDICINE – PRESENTATION OF TWO CASES

ULOGA ULTRAZVUKA UZ KREVET BOLESNIKA U RANOM OTKRIVANJU IZVORA INFEKCIJE U HITNOJ MEDICINSKOJ SLUŽBI – PRIKAZ DVA SLUČAJA

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Abstract

Background: Severe infections in emergency medicine are associated with high mortality and the development of organ dysfunction, especially when the source of infection is not recognized promptly. Point-of-care ultrasound (POCUS) allows rapid and targeted assessment of ultrasound findings that may indicate a possible source of infection early in patient care.

Case report: Two patients with elevated inflammatory parameters and an unclear clinical presentation are described. In the first case, POCUS enabled an early diagnosis of acute gangrenous cholecystitis as the source of infection, with the development of sepsis according to the Sepsis-3 criteria, which resulted in urgent surgical intervention. In the second case, POCUS ruled out deep vein thrombosis and confirmed soft tissue cellulitis, and enabled rapid initiation of antibiotic therapy and avoidance of unnecessary additional diagnostics.

Conclusion: POCUS represents a valuable diagnostic tool in the early treatment of patients with elevated inflammatory parameters and an unclear clinical presentation. It enables the assessment of findings that point to the source of infection and rational clinical decision-making in emergency medicine.

Key words: early diagnosis; emergency medicine; point-of-care ultrasound; sepsis; source of infection

Sažetak

Uvod: Teške infekcije u hitnoj medicini povezane su s visokom smrtnošću i razvojem organske disfunkcije, osobito kada izvor infekcije nije pravodobno prepoznat. Prikrevetni ultrazvuk (engl. *Point-of-care ultrasound*, POCUS) omogućuje brzu, ciljano usmjerenu procjenu ultrazvučnih nalaza koji mogu upućivati na mogući izvor infekcije u ranoj fazi zbrinjavanja bolesnika te može pridonijeti usmjeravanju daljnje dijagnostičke i terapijske obrade.

Prikaz slučaja: Prikazana su dva bolesnika s povišenim upalnim pokazateljima i nejasnom kliničkom slikom. U prvom slučaju, POCUS je omogućio ranu dijagnozu akutnog gangrenoznog kolecistitisa kao izvora infekcije, s razvojem sepse prema kriterijima Sepsis-3, što je rezultiralo hitnom kirurškom intervencijom. U drugom slučaju, POCUS je isključio duboku vensku trombozu i potvrdio celulitis mekog tkiva te omogućio brzo započinjanje antibiotske terapije i izbjegavanje nepotrebne dodatne dijagnostike.

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Zaključak: POCUS predstavlja vrijedan dijagnostički alat u ranom liječenju bolesnika s povišenim upalnim pokazateljima i nejasnom kliničkom slikom. Omogućuje procjenu nalaza koji upućuju na izvor infekcije i racionalno kliničko donošenje odluka u hitnoj medicini.

Ključne riječi: hitna medicina; izvor infekcije; point-of-care ultrazvuk; rana dijagnoza; sepsa

Introduction

Despite significant advances in diagnosis and treatment, severe infections still represent a major challenge in clinical practice. They are associated with high mortality and the development of organ dysfunction, especially when the source of the infection is not recognized (1). Sepsis is one of the possible consequences of late detectionand treatment of infectious process (2). Recognition and localization of the source of infection are keys to early clinical decision-making in the emergency department. The sources of infection in patients with an unclear clinical presentation are numerous, and most often include the respiratory and urinary systems, intra-abdominal infections, and skin and soft tissue infections (2). Intra-abdominal infections are associated with high morbidity and mortality, especially in the case of delayed control of the source of infection (3). Point-of-care ultrasound (POCUS) has become an indispensable diagnostic tool in modern emergency medicine (4).

> Previous research suggests that point-of-care ultrasound can improve the identification of the source of infection compared with initial clinical assessment, with a reported diagnostic accuracy of approximately 80–90 %."

It is a targeted ultrasound examination performed by a non-radiologist at the patient's bedside, with the aim of rapid diagnostic orientation, and clinical decision-making (5). Previous research suggests that point-of-care ultrasound can improve the identification of the source of infection compared with initial clinical assessment, with a reported diagnostic accuracy of approximately 80–90 % (3,6). The aim of our paper is to demonstrate the role of early point-of-care ultrasound in identifying the source of infection in patients with unclear clinical presentation in the emergency department, through the presentation of two clinical cases.

Methods

The paper was a retrospective review of two case reports of patients treated at the Emergency Medicine Center of the University Hospital, in whom POCUS was applied in the early phase of initial workup due to suspected infection of unknown origin. POCUS was performed within the first hour of arrival at the emergency department, before performing advanced imaging tests. The examination was goal-directed and problem-oriented, integrated into the clinical examination. POCUS findings were used for immediate clinical decision-making and preceded the decision on further imaging diagnostics or therapeutic procedures. The ultrasound examination was adapted to the clinical presentation: in the first case, a focused examination of the hepatobiliary system was performed, and in the second, a focused examination of the deep venous system and soft tissues of the lower extremities. The examinations were performed by an emergency medicine specialist with formal education in clinical ultrasound according to the World Interactive Network Focused On Critical UltraSound (WINFOCUS) program.

Case reports

Case report 1

A 75-year-old patient presented to the emergency department due to poor general condition for three days, with fever up to 38.8 °C, chills, and shivering. He had a history of transient epigastric pain with a belt-like spread, but on admission denied abdominal pain. He had no nausea, vomiting, dyspnea, or cough. On admission was conscious, oriented, hemodynamically stable (blood pressure 160/76 mmHg, pulse 75/min, respiratory rate 22/min, oxygen saturation 96%, body temperature 38.5 °C). The abdomen was soft, with audible peristalsis and mild localized tenderness in the right hemiabdomen. Personal history includes aortic valve surgery due to severe aortic stenosis, recovered ischemic cerebrovascular insult, arterial hypertension, and type 2 diabetes. Laboratory findings showed leukocytosis (12.1 $\times$ 10^9/L), elevated C-reactive protein (CRP) (193.9 mg/L), thrombocytopenia (133 $\times$ 10^9/L), slightly elevated creatinine (114 µmol/L), and elevated total bilirubin. (31.3 µmol/L) and direct bilirubin (11.8 µmol/L). Within 20 minutes of arrival, a POCUS of the abdomen was performed, which showed an enlarged gallbladder (>10 cm) with a thickened and irregular wall (>5 mm), a concretion in the neck of the gallbladder with positive sonographic Murphy's sign (Figure 1).

Abdominal multislice computed tomography (MSCT) subsequently confirmed acute gangrenous cholecystitis (Figure 2) and was used for preoperative assessment and surgical planning.

The patient underwent emergency surgery, and the pathohistological findings confirmed the diagnosis of gangrenous cholecystitis with hydrops of the gallbladder. Empiric antibiotic therapy (meropenem) for 7 days was given.

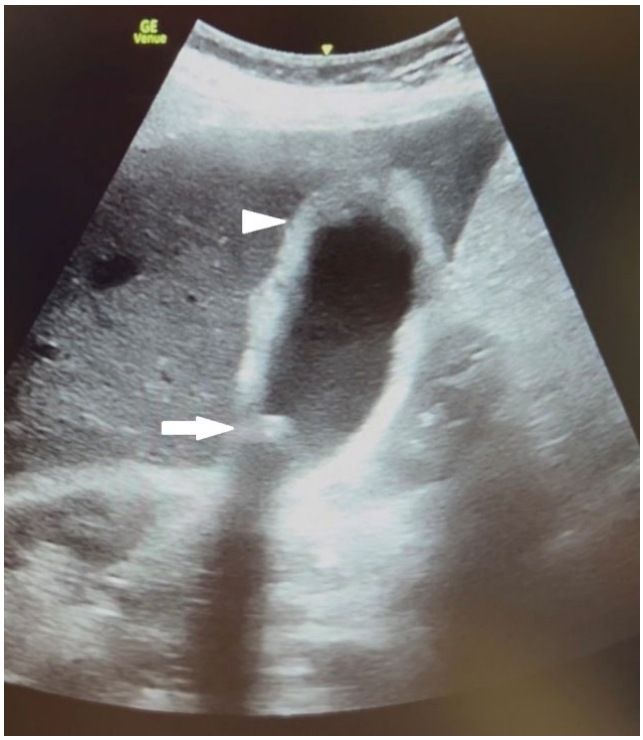

Figure 1. Pocus of the gallbladder showed an enlarged gallbladder (>10 cm) with a thickened and irregular wall (>5 mm) (white arrowhead) with a concretion in the neck of the gallbladder (white arrow)

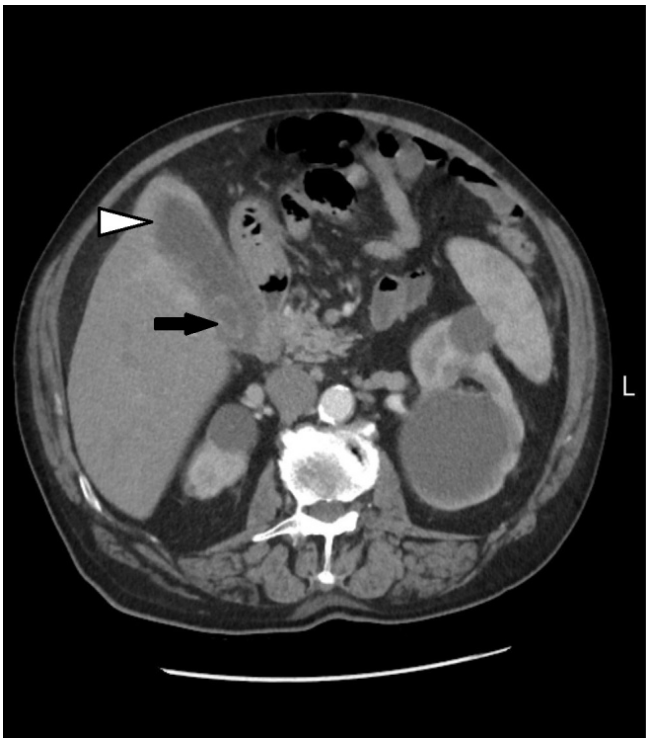

Figure 2. MSCT of the abdomen showed an enlarged gallbladder, thickened gallbladder wall (white arrowhead), and a calculus (black arrow)

The early application of POCUS enabled rapid identification of the intra-abdominal source of infection, and shortened the time to surgical control of the source of infection despite the atypical clinical presentation.

Case report 2

An 80-year-old patient presented to the emergency department with sudden onset of pain and swelling in his left leg that had occurred the day before. Ten days earlier, osteosynthesis of the pertrochanteric femoral fracture had been performed. The postoperative period was uneventful. He now denies trauma. He was afebrile and hemodynamically stable on admission. Clinical examination revealed swelling and tenderness of the left upper leg with warm, taut skin of normal color. Laboratory findings showed leukocytosis (12.7×10^9/L), elevated CRP (124.7 mg/L), and elevated D-dimer (2.63 mg/L). Other findings were within reference values. Deep vein thrombosis was excluded by POCUS examination of the venous system of the lower limb, where the examined veins were properly compressible, without intraluminal echogenic masses. POCUS of the soft tissues of the left upper leg shows thickened and heterogeneous subcutaneous fat tissue with pronounced interstitial edema, a characteristic "cobblestone" appearance, without clearly delimited fluid collections and signs of abscess (Figure 3).

Color Doppler showed increased vascularization of the subcutaneous tissue, which supports an inflammatory etiology. (Figure 4). The finding was consistent with cellulitis. After the orthopedist's examination, the patient was admitted to the orthopedics department, where treatment with intravenous antibiotics (ceftriaxone), blood products, and continuation of already prescribed thromboprophylaxis started. During hospitalization, the patient improved with regression of local swelling and a decrease in inflammatory parameters. The use of POCUS enabled the early differentiation of infectious etiology from vascular complications. It also prevented unnecessary additional imaging tests. After 6 days of hospitalization, the patient is discharged home.

Discussion

The presented cases highlight the challenges of early diagnostic work-up of patients with unclear clinical presentation in the emergency department, in whom the initial clinical examination often does not allow reliable localization of the source of infection. In such circumstances, laboratory indicators may indicate the presence of an inflammatory process, but without a clear diagnostic direction. Elevated values of CRP, as a nonspecific marker of inflammation, are often used in this context as a stimulus for further diagnostic work-up (7). In situations requiring rapid clinical decision-making, an accessible diagnostic tool is needed to guide further treatment. POCUS represents an important extension of the clinical examination in the emergency department. It allowed an orientation assessment of possible sources of infection

Figure 3. POCUS of the soft tissues of the left thigh showed thickened and heterogeneous subcutaneous fat with marked interstitial edema (asterix), a characteristic "cobblestone" appearance (white arrowhead), without clearly demarcated fluid collections and signs of abscess

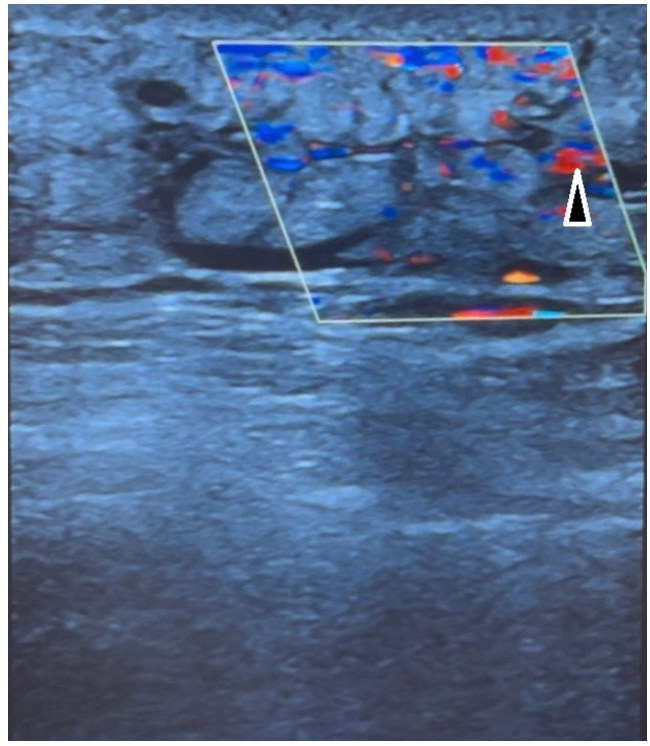

Figure 4. Color Doppler showed increased vascularization of the subcutaneous tissue, which further supports the inflammatory etiology

and the integration of findings into immediate therapeutic decision-making. The difference in Sequential Organ Failure Assessment (SOFA) score between the two patients reflects the different degrees of systemic response to infection at the time of admission. In both cases, POCUS enabled the adaptation of the diagnostic and therapeutic approach to the patient's clinical presentation, which was in line with the recommendations of the Surviving Sepsis Campaign, which emphasize the importance of timely identification and control of the source of infection (8).

POCUS enabled early differentiation of infectious from vascular etiology and directed further treatment, demonstrating its practical value in patients with unclear clinical presentation in the emergency department.

In the first case presented, POCUS enabled the identification of an intra-abdominal source of infection led to sepsis and prompt surgical control of the infection source. Acute calculous cholecystitis is increasing in incidence in the elderly population, with biliary tract infections, including cholecystitis and cholangitis, being the second most common cause of sepsis and associated with increased morbidity and mortality rates (9). Studies have shown that acute cholecystitis in the geriatric population may present asymptomatically, with patients older than 65 years of age having an increased frequency of atypical clinical presentations (10). In such clinical circumstances, POCUS is a valuable tool because it allows rapid orientation assessment and early suspicion of an intra-abdominal source of infection. According to available data, the sensitivity of POCUS performed by emergency physicians for the diagnosis of acute cholecystitis is 71 % (95 % CI 62–78 %), with a high specificity of 94 % (95 % CI 88–98 %), confirming its reliability as a method for confirmation of the diagnosis (11). MSCT findings in the presented case were consistent with typical radiological features of gangrenous cholecystitis, including gallbladder distension, wall thickening and irregularity, and pericholecystic inflammation (12). In this case, the main contribution of POCUS was not to replace CT, but to reveal the biliary source of infection in a patient with sepsis-like presentation and no dominant abdominal symptoms. By identifying acute cholecystitis early in the emergency department, POCUS redirected further diagnostic and therapeutic management, while MSCT served a complementary role in preoperative assessment and surgical planning.

In the second presented case, POCUS played major role in the differential diagnosis of patients with elevated inflammatory parameters and localized symptoms on the lower extremity. The clinical presentation with sudden swelling and pain in the

leg, with elevated D-dimer values, justified the suspicion of deep vein thrombosis. However, point-of-care ultrasound ruled out thrombosis already in the early stages of treatmentwhile ultrasound examination of soft tissues showed diffuse edema with pronounced hypervascularization of the subcutaneous tissue, in accordance with the diagnosis of cellulitis. The use of POCUS enabled early differentiation of infectious from vascular etiology and directed further treatment. In the differential diagnosis of soft tissue infections, POCUS shows a high sensitivity of 95 % (95% CI 89–97 %) and specificity of 85 % (95% CI 79–90 %) for the detection of abscesses versus cellulitis, enabling quick and safe clinical decision-making without the need for additional tests (13).Serum lactate was not measured in any case because the patients had no clinical or hemodynamic signs of septic shock, and the diagnosis of sepsis in the first case was based on proven infection and present organ dysfunction assessed by the SOFA score, in accordance with the recommendations of the Surviving Sepsis Campaign guidelines (8).The presented cases confirm the practical value of problem-oriented POCUS applicationin the treatment of patients with an unclear clinical presentation in the emergency department. In both cases, the ultrasound findings were integrated into the overall clinical assessment and played a role in guiding further diagnostic and therapeutic treatment, emphasizing its function as a tool for clinical decision-making, and not as a substitute for standard imaging methods.

Conclusion

Point-of-care ultrasound is a valuable addition to the clinical examination in the management of patients with unclear clinical presentations in emergency medicine. In the presented cases, the problem-oriented application of POCUS enabled the identification of the source of infection, guided further diagnostic and therapeutic management in patients at different stages of the infectious process. These examples, from everyday clinical practice, indicate the importance of targeted and systematic educationemergency physicians withPOCUS usein the clinical decision-making process. Despite the limitations associated with the retrospective design and small number of studies, this study indicates the need for future prospective studies to assess the impact of POCUS on decision-making and time to control the source of infection.

Ethics statement

This case report was carried out in full compliance with ethical research guidelines. Informed consent to publish was obtained priorto publication, and measures were taken to safeguard the privacy and maintain confidentiality of the data presented.

Disclosure

The authors declare that no funds, grants, or other support were received during the preparation of this manuscript. The authors declare they have no financial interests.

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ORIGINAL ARTICLE / IZVORNI ZNANSTVENI ČLANAK

HELICOPTER EMERGENCY MEDICAL SERVICE PROVIDES FASTER AND MORE EFFICIENT PATIENT CARE

HELIKOPTERSKA HITNA MEDICINSKA SLUŽBA OMOGUĆUJE BRŽU I UČINKOVITIJU SKRB ZA BOLESNIKE

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Abstract

Background: Helicopter emergency medical service (HEMS) represents an integral part of the patient care process in modern and advanced healthcare systems. The activation of the helicopter emergency medical team can be primary, meaning the helicopter emergency medical team is dispatched to the scene of an incident immediately after a report, and secondary, when the HEMS team is dispatched to an agreed meeting point with the ground emergency medical service team.

Materials and methods: The retrospective analysis includes patients for whose care the Zagreb base helicopter emergency medical team was primarily activated during 2025. All patients were treated at clinical centers in Zagreb. The time to scene and transport time of the ground emergency medical service (GEMS) team was estimated using Google maps with corrections, while the time of the helicopter emergency medical team was estimated using available data from medical and aviation records.

Results: Out of 398 interventions, 111 were primary interventions, of which 75 patients were treated at the corresponding clinical centers. The patients were mostly male, with a median age of 59 years. The most common indication for helicopter emergency medical team activation was injuries, followed by internal medicine and neurological emergencies. In 43 interventions, the helicopter emergency medical team had a shorter time to reach the patient. In 41 interventions, the ground emergency medical service team was equally fast or up to 5 minutes slower than the helicopter emergency medical team. Transport time to an appropriate facility was shorter with the helicopter emergency medical team in all 75 interventions.

Conclusion: The advantage of the helicopter emergency medical team in time to scene is conditioned by the geographical characteristics of the area and the distribution of the ground emergency medical service team, therefore helicopter emergency medical team may not always be faster in reaching the scene. However, the patient's transport to an appropriate facility is consistently shorter by helicopter.

Key words: ground emergency medical service; helicopter emergency medical service; primary intervention

Sažetak

Uvod: Helikopterska hitna medicinska služba (HHMS) predstavlja sastavni dio procesa skrbi za bolesnike u modernim i razvijenim zdravstvenim sustavima. Aktivacija helikopterskog hitnog medicinskog tima može biti primarna, što znači da se tim šalje neposredno na mjesto događaja odmah nakon dojave, ili sekundarna, kada se HHMS tim upućuje na dogovoreno mjesto susreta s timom zemaljske hitne medicinske službe.

Materijali i metode: Retrospektivna analiza obuhvatila je bolesnike za čiju je skrb helikopterski hitni medicinski tim iz zagrebačke baze primarno aktiviran tijekom 2025. godine. Svi bolesnici su zbrinuti u kliničkim centrima u Zagrebu. Vrijeme dolaska do mjesta

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događaja i vrijeme transporta zemaljske hitne medicinske službe (ZHMS) procijenjeno je pomoću Google Maps uz korekcije, dok je vrijeme helikopterskog tima procijenjeno na temelju dostupnih podataka iz medicinskih i zrakoplovnih evidencija.

Rezultati: Od ukupno 398 intervencija, 111 su bile primarne, od kojih je 75 bolesnika zbrinuto u odgovarajućim kliničkim centrima. Većina bolesnika bili su muškarci, s medijanom dobi od 59 godina. Najčešći razlog aktivacije helikopterskog tima bili su ozljede, a zatim hitna stanja iz interne medicine i neurologije. U 43 intervencije helikopterski tim stigao je brže do bolesnika. U 41 intervenciji zemaljski tim bio je podjednako brz ili do 5 minuta sporiji od helikopterskog tima. Vrijeme transporta do odgovarajuće ustanove bilo je kraće helikopterom u svih 75 intervencija.

Zaključak: Prednost helikopterskog tima u vremenu dolaska do mjesta događaja ovisi o geografskim karakteristikama područja i raspodjeli zemaljskih timova hitne službe, stoga helikopterski tim ne mora uvijek biti brži u dolasku na mjesto intervencije. Međutim, transport bolesnika do odgovarajuće ustanove je dosljedno kraći kada se koristi helikopter.

Ključne riječi: helikopterska hitna medicinska služba; primarna intervencija; zemaljska hitna medicinska služba

Introduction

The chain of care for emergency patients in Croatia consists of ground emergency medical service (GEMS) teams, unified emergency admissions, and recently, helicopter emergency medical service (HEMS) teams. HEMS in Croatia was established in April 2024 and operates in four bases: the Rijeka and Split bases are operational 24 hours a day and the Osijek and Zagreb bases are operational during daylight hours. Interventions to which the HEMS team is assigned can be primary, secondary or interhospital transports. The HEMS team can be dispatched directly to the scene of the intervention immediately after receiving the call and such interventions are called primary. In secondary interventions, the helicopter service team is dispatched to the agreed meeting point with the GEMS team (1).

The Zagreb base covers the area of nine surrounding counties, which is home to almost half of the population of Croatia (2). The hospital system in Croatia is organized at the regional and national levels. Regional hospitals provide secondary-level healthcare and, by their very organizational structure, do not have all medical and diagnostic services, and are therefore not able to provide definitive care for certain categories of patients, such as polytraumatized patients, patients with cerebrovascular incident or myocardial infarction. National hospitals have such an opportunity.

The Croatian network of primary percutaneous coronary intervention is organized according to regional centers covering certain areas, meaning that the patients who require such intervention are not always transported to the nearest hospital. The treatment of cerebrovascular incidents depends on local protocols, which mostly include initial treatment and thrombolysis in the nearest facility that can provide it. However, the latest guidelines for stroke treatment recommend direct transport to a facility capable of performing endovascular thrombectomy, especially if there is no possibility of rapid subsequent interhospital transport (less than 45 minutes) (3).

In many countries, the guidelines for injured patient care increasingly emphasize rapid transport to an appropriate facility that can provide definitive care for the patient's life-threatening injuries. This is precisely why it is important to develop thrombectomy centers and thus ensure patient care (4,5,6).

Numerous studies have been conducted on the effectiveness and cost-effectiveness of helicopter emergency services, and most note that it is difficult to draw definitive conclusions due to data heterogeneity.

Evidence on the effectiveness and cost-effectiveness of helicopter emergency services remains inconclusive due to variability in study data.

The key conclusion is that early arrival at an appropriate facility improves better outcomes and quality of life. However, HEMS is not necessarily always faster. Studies by individual countries on the cost-effectiveness of emergency helicopter service depending on the distance from the appropriate facility have shown that HEMS has an advantage over GEMS if the distance is greater than 50 km (7,8). The aim of this study was to compare time to scene/patient and transport time between HEMS and GEMS in primary activations of the Zagreb HEMS base during 2025.

Methods

This retrospective study includes all patients for whose care the emergency helicopter service of the Zagreb base was primarily activated between January 1, 2025 and December 21, 2025. General patient data, medical intervention criteria, and flight data were obtained from medical and flight records from the "e-hitna" program. The HEMS team time to scene includes activation time and flight time to the intervention site. The activation time must not exceed 5 minutes, but can sometimes be longer due to specific circumstances. Ideal approach for GEMS would be to determine EMS team response times using official EMS operational data but we were not able to use it.

Therefore, times related to the GEMS team were estimated using Google Maps in an ideal time period without traffic congestion. It is assumed that the team to arrive at the intervention site is the one whose base is closest, regardless of whether it is a team with a doctor or with two nurses.

All patients, except children, were transported by helicopter service to the same clinical hospital. It was assumed that GEMS teams would transport these patients to tertiary centers in Zagreb according to existing protocols if the definitive care for their condition was not available in the corresponding institution. Statistical analysis was performed using Microsoft Excel. Quantitative data were expressed as medians.

Results

During 2025, the Zagreb HEMS base was activated a total of 398 times, of which 111 were primary interventions, meaning that the helicopter team was activated and sent to the scene of the incident immediately after the intervention was reported.

A total of 75 patients were treated at tertiary centers. The remaining patients, out of a total of 111, were not treated in a tertiary center for several reasons. Most commonly, this was because the intervention was discontinued, patient died, or the patient was managed at another healthcare facility and did not require treatment in a tertiary center. The median age was 59, with the exception of two patients for whom data was not available (Figure 1). The majority were men, 54 of them (Figure 2).

The helicopter team was most often dispatched to traffic accidents and other injuries, as many as 48 times. It was activated 16 times due to suspected neurological events, and 9 times due to internal medicine emergencies, most often due to suspected acute coronary syndrome. The team was dispatched twice to treat a patient with choking due to a foreign body airway obstruction.

The HEMS team had a shorter time to the scene of the intervention in 43 cases, the GEMS team in 31 cases, and arrival times were equal in one case. The median difference in time to scene between helicopter and ground teams was 3 minutes in favor of the helicopter team.

In the analyzed interventions, the median time to transport patients to an appropriate facility that can provide definitive care was 48 minutes for GEMS and 13 minutes for HEMS teams. The patient transport time was shorter with the helicopter team, with a median of 34 minutes for all interventions (Figure 3).

The median duration of the entire intervention was 30 minutes for HEMS versus 70 minutes for GEMS. The median difference in total intervention duration between the HEMS and GEMS teams was 34 minutes (Figure 4).

Based on this, we conclude that the patient care and outcomes of our patients are better due to faster transport and more timely management in an appropriate healthcare facility.

Discussion

Helicopter emergency medical service represents an upgrade to the existing network of ground emergency medical service teams. In most analysed interventions, the time to scene was faster with the helicopter service, but the difference is not statistically significant and depends on geographical specificities of the location, GEMS network distribution, road connectivity and traffic conditions. Statistically significant differences in time to scene of the GEMS and HEMS teams occur in the case of interventions in rural and difficult-to-reach areas.

However, the transport time to an appropriate facility was faster by helicopter in all analyzed interventions, which is expected given the often long distances transport to tertiary centers in Zagreb.

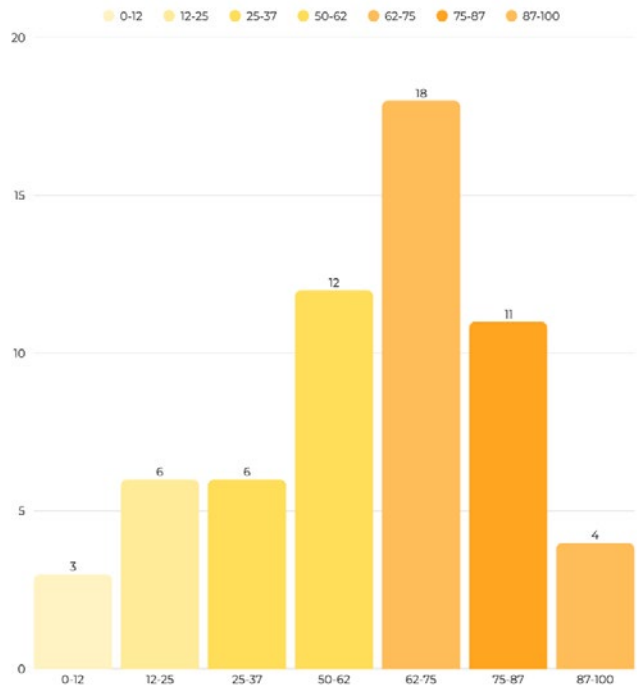

Figure 1. Patients' age distribution

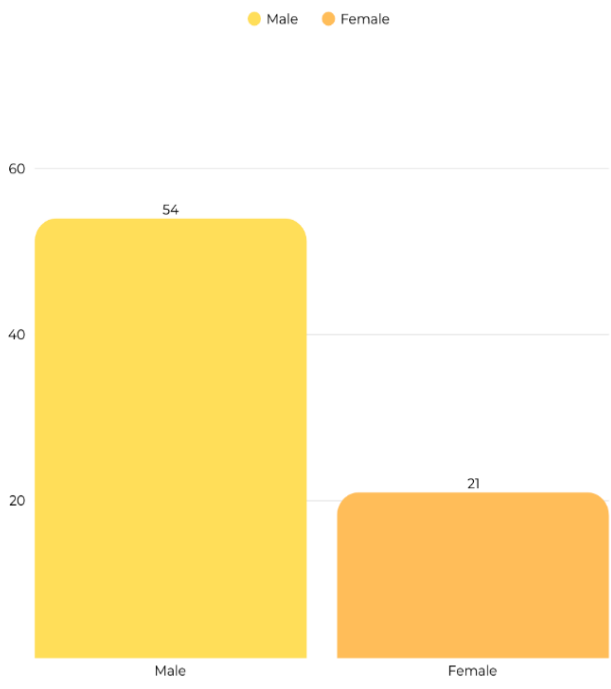

Figure 2. Patients' sex distribution

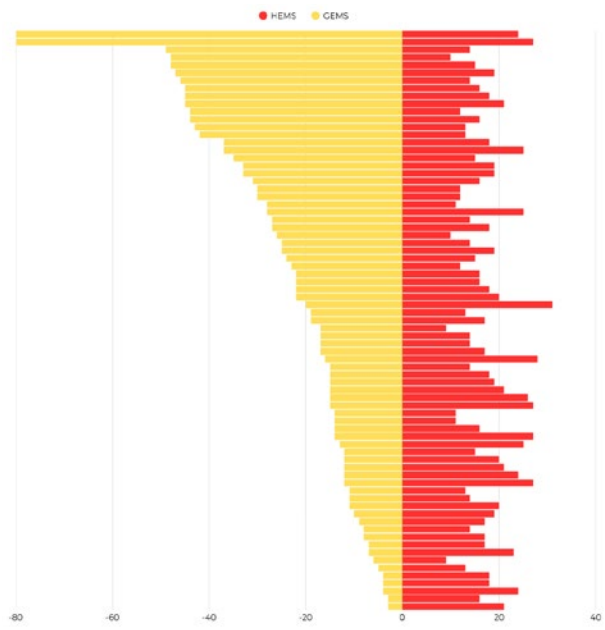

Figure 3: Arrival times for GEMS and HEMS

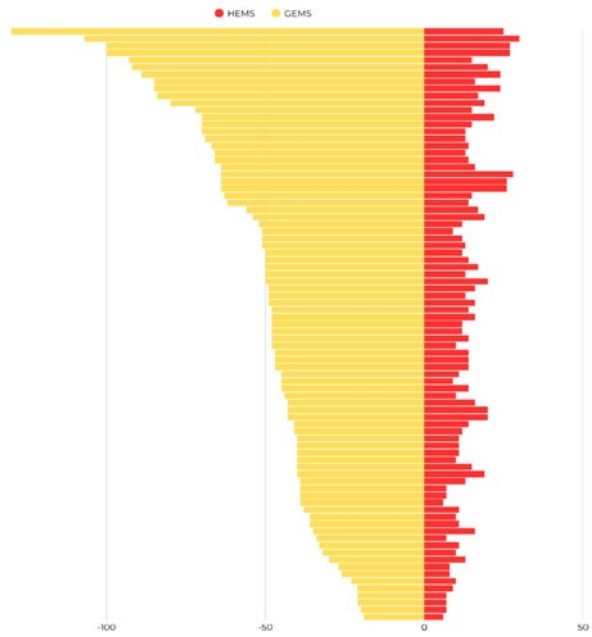

Figure 4: Transport times for ground emergency medical service (GEMS) and helicopter emergency medical service (HEMS)

HEMS improves transport times to appropriate facilities, particularly in rural areas, potentially enhancing patient survival despite variable time-to-scene advantages over GEMS.

We do not have data for 30 days mortality for our patients but reviewing the literature, we found evidence that response and transport times and earlier arrival to an appropriate healthcare facility significantly affect patient survival. This finding indicates that patient care for our patients is therefore improved.

The efficiency of the overall treatment of life-threatening patients is additionally conditioned by the organization of the hospital network at the national level. Due to their organizational structure, regional hospitals are not equipped to provide definitive treatment for certain patient conditions, which is why transport to a higher level of care is necessary.

HEMS provides a critical advantage for life-threatening cases in hard-to-reach areas, reducing transport time to specialized care.

Conclusion

The establishment of specialized centers and categorizations, such as trauma centers, cerebrovascular stroke centers, percutaneous coronary intervention centers and burn centers, represents a key step in improving emergency patient care. It is in this context that HEMS fulfills its full clinical and organizational value. The possibility of rapid and direct transport of the patient to a specialized center shortens the total duration of the intervention and reduces the time until the provision of definitive patient care, potentially improving clinical outcomes.

Acknowledgement

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REVIEW ARTICLE / PREGLEDNI ČLANAK

DRINK SPIKING AND RELATED EMERGENCY DEPARTMENT VISITS: A NARRATIVE REVIEW

PODMETANJE TVARI U PIĆE I POVEZANI DOLASCI U HITNI BOLNIČKI PRIJAM: PREGLEDNI RAD

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Abstract

Background: Drink spiking the covert administration of psychoactive agents into an unsuspecting person's drink or food, remains a persistent public health and forensic challenge. Victims frequently present to emergency departments (EDs) with sudden central nervous system depression, anterograde amnesia, and physiologic abnormalities that complicate timely recognition.

Objective: To synthesise current evidence relevant to frontline emergency clinicians on the pharmacology, clinical recognition, toxicology, specimen handling, and acute management of drinkspiking presentations, and to propose ED-focused system measures to improve detection, patient care, and forensic preservation.

Methods: This narrative review integrates peer-reviewed literature, poison centre registry reports, forensic guidance, and recent reviews addressing commonly implicated agents. Emphasis was placed on pharmacokinetic, toxicodynamic features that determine detection windows, bedside recognition clues, prioritised ED investigations, specimenhandling imperatives, and agent-specific management strategies.

Conclusions: Drink spiking presents a complex intersection of acute medical risk, forensic urgency, and psychosocial trauma. Emergency clinicians should prioritise early recognition of agent-specific toxidromes, timely collection and preservation of specimens, trauma-informed care, and coordination with forensic and toxicology services. Strengthening ED workflows and regional analytic capacity will enhance detection, patient outcomes, and legal processes.

Key words: benzodiazepines; drink spiking; emergency department; forensic toxicology; gammahydroxybutyric acid; ketamine; poisoning.

Sažetak

Uvod: Dodavanje psihoaktivnih tvari u piće ili hranu bez pristanka druge osobe (engl. *drink spiking*) predstavlja rastući javnozdravstveni i forenzički problem. Žrtve se često javljaju u objedinjeni hitni bolnički prijam (OHBP) s iznenadnom depresijom središnjeg živčanog sustava, anterogradnom amnezijom i nespecifičnim fiziološkim poremećajima, što otežava pravodobno prepoznavanje i liječenje.

Cilj: Sinteza dostupnih dokaza važnih za liječnike hitne medicine o farmakologiji, kliničkom prepoznavanju, toksikologiji, rukovanju uzorcima i akutnom liječenju slučajeva „*drink spikinga*" te prijedlozi sustavnih mjera za poboljšanje otkrivanje, skrbi i forenzičke zaštite.

Metode: Narativni pregled literature obuhvatio je recenzirane radove, podatke iz registara centara za kontrolu trovanja, forenzičke smjernice i nedavne radove koji se odnose na najčešće agense. Poseban naglasak stavljen je na farmakokinetičke i toksikodinamičke značajke koje određuju prozore detekcije, kliničke znakove, pretrage u OHBPu, postupke očuvanja uzoraka i specifične mjere liječenja.

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Zaključak: „*Drink spiking*“ predstavlja složen izazov za hitnu medicinu. Liječnici u OHBPu trebaju prepoznavati toksidrome specifične za agense, pravodobno prikupljati i čuvati uzorke, primjenjivati traumainformirani pristup te koordinirati rad s forenzičkim i toksikološkim službama. Jačanje procedura u OHBPu i regionalnih analitičkih kapaciteta poboljšat će detekciju, ishode pacijenata i pravne procese.

Ključne riječi: benzodiazepini; *drink spiking*; forenzička toksikologija; gamahidroksibutirat; hitni bolnički prijam; ketamin; trovanje

Introduction

Drink spiking, defined as the non-consensual administration of psychoactive agents into an individual's drink or food, has become an increasingly recognised cause of emergency department (ED) presentations (1). Although public awareness has grown, the true incidence remains difficult to quantify because of underreporting, inconsistent coding, and the short detection windows of many implicated agents (2). Victims often present with rapidonset central nervous system depression, anterograde amnesia, and physiologic abnormalities that are disproportionate to reported alcohol intake. These features complicate clinical assessment and delay recognition (2).

Drink spiking frequently presents to emergency departments with sudden central nervous system depression, anterograde amnesia, and clinical severity disproportionate to reported substance use.

Emergency physicians must rapidly differentiate voluntary intoxication from covert drug administration, initiate appropriate stabilisation, and preserve forensic evidence under trauma-informed protocols (3). This narrative review synthesises current knowledge on drink spiking with a focus on ED recognition, toxicological considerations, and acute management.

Methods

This narrative review was conducted by synthesising peer-reviewed articles, poison centre registry reports, forensic guidance documents, and recent reviews addressing drug-facilitated incapacitation. Sources were selected to emphasise the relevance of the emergency department, including pharmacokinetic and toxicodynamic data that inform detection windows, bedside recognition clues, recommended specimen types and preservation methods, and agent-specific management strategies. The review focuses on commonly implicated agents (gammahydroxybutyrate/gammabutyrolactone, GHB/GBL, benzodiazepines and designer analogues, ketamine, sedating antihistamines, alcohol, volatile inhalants, nitrites, and novel psychoactive substances) and on operational measures that EDs can implement to improve detection and forensic preservation. The references cited reflect the literature base informing the narrative synthesis.

Discussion

Drink spiking denotes the non-consensual introduction of psychoactive agents—commonly sedatives, dissociatives, hypnotics, or volatile compounds—into an individual's consumable item. Typical clinical hallmarks include rapid sedation, anterograde amnesia, and impaired psychomotor function in a person who does not recall ingesting a sedative. Agents most frequently implicated include gammahydroxybutyrate and its precursor gammabutyrolactone, benzodiazepines (including flunitrazepam and other prescription agents), ketamine, synthetic sedatives and designer benzodiazepines, sedating antihistamines (e.g., diphenhydramine), and alcohol, often used concurrently to potentiate effects. Less commonly, volatile inhalants and alkyl nitrites have been reported. Perpetrators favour agents that are colourless and odourless, act rapidly to incapacitate, produce amnesia, and in many cases have short detection windows that complicate forensic confirmation (48).

Gammahydroxybutyrate (GHB) and gamma-butyrolactone (GBL)

GHB and GBL are among the most frequently implicated agents in drug-facilitated incapacitation. Acting primarily as GABA-A receptor agonists, they produce profound sedation and anterograde amnesia within 10–20 minutes of ingestion, with peak effects at 30–60 minutes and a short elimination half-life of approximately 30–60 minutes (4-6). Clinically, GHB intoxication is characterised by a rapid *"switchoff"* loss of consciousness, shallow respiration, bradycardia, hypotension, and a striking inability to form new memories during the period of intoxication (5). Because of their short systemic persistence, analytical confirmation requires early specimen collection: obtain blood as soon as possible (preferably within the first few hours) and collect urine early; refrigerate urine and, when recommended, acidify it to minimise analyte loss (4,5,7). Emergency management is supportive: airway protection and ventilatory support are paramount in severe cases, aspiration precautions are essential, and ICU admission should be considered for prolonged depressed consciousness or respiratory compromise (5,8). There is no specific antidote for GHB (58).

Benzodiazepines and designer benzodiazepines

Benzodiazepines act as positive allosteric modulators at GAB-A receptors, producing sedation, anxiolysis, muscle relaxation, and anterograde amnesia. Classic agents such as flunitrazepam and lorazepam have variable onsets (15–60 minutes) and half-lives that permit detection in blood and urine for more extended periods than GHB; however, many designer benzodiazepines (novel analogues) are not detected by routine immunoassays and require targeted liquid chromatography–tandem mass spectrometry (LC–MS/MS) for confirmation. (9). Clinically, benzodiazepine intoxication presents with sedation, slurred speech, ataxia, and, in severe cases or with co-ingestion (e.g. alcohol, opioids), respiratory depression. Flumazenil can reverse benzodiazepine effects but may trigger seizures in mixed overdoses or in benzodiazepinedependent patients; reserve its use for carefully selected cases after toxicology advice (10). ED priorities include airway and respiratory support, monitoring for delayed respiratory depression when co-ingestants are suspected, and early specimen collection for chromatographic testing when clinical suspicion persists despite negative routine screen results (9).

Ketamine

Ketamine is an NMDA receptor antagonist that produces dissociation, analgesia, and amnesia. After oral or intranasal exposure, effects typically begin within 5–15 minutes and may include perceptual disturbances, derealisation, and horizontal nystagmus—features that help distinguish ketamine from pure sedatives. Cardiovascular stimulation (tachycardia, hypertension) is common (11). Ketamine typically produces dissociative effects and horizontal nystagmus; its metabolite, norketamine, prolongs the time during which chromatographic methods can detect exposure (11,12). ED management focuses on airway monitoring, benzodiazepines for severe agitation, and cardiovascular monitoring and treatment as indicated. Specimen collection for targeted chromatographic assays should be arranged early when ketamine exposure is suspected (11,12).

Volatile inhalants and solvents

Volatile solvents and aerosol propellants are less commonly used for drink spiking (they are more often inhaled), but they have been reported in some cases. These agents are highly lipophilic, produce rapid central nervous system depression, and can sensitise the myocardium to catecholamines, thereby increasing the risk of ventricular arrhythmias (13). Clinical clues include chemical odour on breath or clothing, conjunctival injection, dermatitis, and sudden CNS depression inconsistent with oral ingestion patterns. Management includes decontamination (removal of contaminated clothing and thorough skin washing), highflow oxygen, cardiac monitoring, and avoidance of catecholamine surges; specialised testing is rarely available in the ED, and detection windows are very short (13).

Sedating antihistamines (e.g., diphenhydramine)

Over-the-counter sedating antihistamines can be used opportunistically for spiking. They produce sedation and anticholinergic effects—dry mucous membranes, mydriasis, tachycardia, urinary retention, and, in severe cases, delirium. Onset is typically within 15–60 minutes, with duration of several hours. Routine toxicology screening may detect common antihistamines, but severe central anticholinergic toxicity may require physostigmine under toxicology guidance (13). ED care is supportive, with attention to airway protection, active cooling if hyperthermic, and cardiac monitoring.

Alcohol (co-ingestion)

Alcohol is frequently co-administered to potentiate the sedative effects of other agents, slow gastric emptying, and prolong unconsciousness. Ethanol is rapidly absorbed, with peak blood concentrations occurring within 30–90 minutes and exhibits zero-order elimination kinetics (14). Clinically, alcohol potentiates respiratory depression and sedation from other agents and complicates attribution of symptoms. ED clinicians should measure serum ethanol level, anticipate potentiation of respiratory compromise, and consider a more extended observation period or lower admission thresholds when alcohol co-ingestion is suspected (14).

Alkyl nitrites *("poppers")*

Alkyl nitrites are inhaled agents that produce vasodilation, transient hypotension, and, in some cases, methemoglobinemia. Clinical presentation includes flushing, headache, dizziness, syncope, and cyanosis with low pulse oximetry readings that do not correct with supplemental oxygen. Methemoglobinemia should be suspected when pulse oximetry readings are low despite a normal PaO_2. Measurement of methemoglobin level and treatment with intravenous methylene blue are indicated for symptomatic patients or for significant elevations (15). Alkyl nitrite exposure may lead to methemoglobinemia; symptomatic or clinically substantial cases should be treated with intravenous methylene blue using standard weight-based dosing per local protocol (15).

Novel psychoactive substances and designer sedatives

Novel psychoactive substances encompass a heterogeneous group of synthetic sedatives, cathinones, and other compounds that vary widely in potency and in the toxidrome they produce. Many NPS evade routine immunoassays and require LC-MS/MS or high-resolution mass spectrometry for detection (16-18). Clinical presentations range from profound sedation and amnesia to agitation, psychosis, and cardiovascular instability. When routine screening tests are negative but clinical features suggest exogenous intoxication, clinicians should preserve specimens and engage regional toxicology laboratories early (16-18).

Early recognition in the ED relies on integrating toxidromic patterns with contextual clues such as shared drinks, abrupt behavioural changes, or witness reports.

Clinical presentation and ED recognition clues

Patients present with a spectrum of findings. Neurological features commonly include sudden somnolence, slurred speech, ataxia, and anterograde amnesia; behavioural changes, such as delirium or dissociation, may be prominent with ketamine or specific NPS (4,7,11). Cardiovascular signs range from hypotension and bradycardia (notably with GHB) to tachycardia and hypertension (with ketamine or anticholinergic agents) (19,20). Respiratory depression and aspiration risk are central concerns in severe intoxication. Forensic clues—chemical odour on breath or clothing, reports of unusual taste, communal drink sharing, or witness accounts of abrupt behavioural change, should heighten clinical suspicion. Recognising suspected spiking depends on combining observed toxidromes with contextual information such as shared drinks or eyewitness accounts (4). Specific bedside signs can help differentiate agents: horizontal nystagmus and dissociation suggest ketamine; anticholinergic features point to antihistamines; diaphoresis and rapid recovery with amnesia are characteristic of GHB; low pulse oximetry readings with normal PaO_2 may indicate methemoglobinemia from nitrites (4,11,15).

Diagnostic methodologies and forensic specimen handling

Routine ED immunoassays often fail to detect GHB, designer benzodiazepines, and many NPS; definitive identification typically requires gas chromatography–mass spectrometry (GC-MS) or liquid chromatography–tandem mass spectrometry (16,18,21,22). Clinicians should collect forensic specimens early: obtain blood as soon as possible (preferably within the first few hours) and urine; refrigerate urine and, when recommended, acidify it to minimise analyte loss (4,7,23). Routine immunoassays do not detect many designer sedatives and novel compounds; definitive identification generally requires chromatographic-mass spectrometry techniques (16-18,22). Proper specimen handling—refrigerating samples, dual labelling, acidifying urine when indicated, and strict chainofcustody documentation—is essential to maintain evidentiary value (4,23). Early liaison with regional toxicology and forensic laboratories expedites appropriate testing and specimen transport (21,22).

Emergency department management: stabilisation and agent-specific care

Initial ED management follows ABC priorities: secure the airway, support breathing, and stabilise circulation. Continuous cardiac monitoring and pulse oximetry are mandatory in moderate-to-severe presentations. GHB and GBL have no specific antidote; care is supportive and focuses on airway protection and ventilatory support, with rapid respiratory depression or bradycardia sometimes requiring ICU admission for monitoring (2,8). For benzodiazepine exposures—including designer analogues—management is likewise supportive; flumazenil can reverse benzodiazepine effects but may precipitate seizures in mixed overdoses or in benzodiazepinedependent patients, so its use should be limited to carefully selected cases after toxicology consultation (10). Ketaminerelated presentations are managed by treating agitation with benzodiazepines when necessary, monitoring cardiovascular status and treating severe hypertension according to standard protocols, and observing patients for resolution of dissociative symptoms with psychiatric follow-up as indicated (11). Sedating antihistamine toxicity is treated supportively for anticholinergic effects, with physostigmine considered only in severe cases under toxicology guidance (13). For volatile inhalant exposures, remove contaminated clothing and decontaminate skin to prevent ongoing or secondary exposure, anticipate arrhythmias, and avoid interventions that provoke catecholamine surges (13). Alkyl nitrite inhalation can produce methemoglobinemia; clinicians should measure methemoglobin levels and treat symptomatic or clinically significant cases with intravenous methylene blue using standard weight-based dosing per local protocol while monitoring the response (15). Seizures are initially managed with benzodiazepines, and refractory seizures may require escalation to barbiturates or propofol in an intensive care setting. In all cases, clinicians should consider co-ingestions (notably alcohol and opioids), which increase the risk of respiratory depression and complicate antidote use. ED teams must also address sexual assault care needs, sexually transmitted infections (STI) prophylaxis, emergency contraception, HIV post-exposure prophylaxis and coordinate with forensic exam teams and victim advocates (19,21).

Forensic imperatives, documentation, and trauma-informed care

Forensic integrity depends on meticulous documentation and the preservation of evidence. Clinicians should record verbatim patient statements when possible, timestamp all findings and interventions, photograph injuries with consent, and preserve clothing and suspected containers in sealed evidence bags, following chain-of-custody protocols (19). Timely sampling, appropriate preservation measures (e.g., acidifying urine when indicated), and strict chain-of-custody documentation are critical for forensic validity (4,23). Trauma-informed communication explaining procedures, obtaining consent, minimising repeated recounting, and involving victim advocates and mental health professionals, improves patient cooperation and reduces re-traumatisation (20). Use trauma-informed approaches: explain interventions, seek consent, limit repeated retelling, and involve victim support and mental health services to improve cooperation and reduce retrauma (20).

Trauma-informed communication, coordinated forensic evidence handling, and clear documentation are essential components of ED care for suspected drug-facilitated incapacitation.

Disposition, follow-up, and psychosocial support

Admission is indicated for persistent respiratory depression, haemodynamic instability, significant arrhythmias, refractory seizures, or inability to protect the airway. Patients who return to baseline mental status within an observation period (commonly 6–8 hours), have typical vital signs, and have social supports may be discharged with clear instructions, referrals to sexual assault services, and follow-up for toxicology results and mentalhealth care. ED teams should offer STI prophylaxis, emergency contraception, and HIV post-exposure prophylaxis according to local protocols and ensure documented safety planning (21).

Surveillance, prevention, and system-level recommendations for EDs

EDs should implement practical tools to improve recognition and response: standardised order sets that bundle initial labs and specimen kits; EHR prompts that flag combinations of memory loss, communal drinking, and disproportionate sedation; specimentimelines; and simulation training that integrates medical stabilisation with forensic evidence preservation. Implementing system measures standardised ED order sets, specimentimeline checklists, EHR alerts, and ready access to regional toxicology—enhances detection and preserves evidentiary value (11,22). Regional access to advanced toxicology (GCMS, LCMS/MS) and 24/7 poison centre consultation enhances diagnostic yield and patient care (11,22). Embedding standardised registry codes for suspected non-consensual drug administration will enable surveillance and targeted prevention efforts (21, 24).

Standardised ED workflows including specimen timing checklists, order sets, and rapid access to toxicology consultation significantly improve diagnostic accuracy and forensic outcomes.

Prevention, harm reduction, and legal considerations

Prevention requires a multifaceted approach: public awareness campaigns, venue staff training, tamper-evident products, mobile safety applications, and policy incentives for venues that adopt best practices. Legal frameworks vary; explicit statutes criminalising non-consensual drug administration can streamline prosecutions and reduce evidentiary burdens, while confidential reporting pathways balance victim autonomy with public safety (25, 27).

Research gaps and future directions

Key research priorities include prospective ED-based cohort studies with standardised coding to establish incidence; validation of point-of-care assays for GHB and other agents; pharmacokinetic modelling of emerging sedatives to refine detection windows; evaluation of wearable biosensors and digital epidemiology tools for real-time cluster detection; and longitudinal studies of neurocognitive and psychosocial outcomes after drug-facilitated assault (28,33). Cost-effectiveness analyses of prevention programmes and trials of ED protocols will inform resource allocation and policy.

Conclusion

Drink spiking remains a clinically and forensically challenging presentation in emergency medicine. Early recognition of agent-specific toxidromes, prompt specimen collection with appropriate preservation, trauma-informed care, and coordination with forensic and toxicology services are essential to optimise patient outcomes and preserve legal evidence. Implementing ED protocols, improving access to advanced toxicology, and strengthening surveillance and prevention strategies will be critical to reducing the burden of drug-facilitated assaults.

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REVIEW ARTICLE / PREGLEDNI ČLANAK

CHEMSEX-RELATED VISITS TO EMERGENCY DEPARTMENTS: A NARRATIVE REVIEW

POSJETI BOLNIČKOM PRIJAMU VEZANI UZ *"CHEMSEX"*: PREGLEDNI RAD

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Abstract

Chemsex refers to the deliberate use of psychoactive substances to shape sexual experience by intensifying arousal, extending endurance, reducing inhibition, and facilitating interpersonal connection. In recent years, this practice has emerged as a significant contributor to acute intoxication presentations in emergency departments (EDs), particularly within large European urban centres. These presentations are characterised by intentional polydrug exposure, narrow safety margins, and overlapping toxidromes that challenge conventional single-substance ED protocols. This narrative review synthesises current evidence on epidemiology, substance-specific motivations, and ED-relevant clinical manifestations, with a focus on synthetic cathinones, methamphetamine, gamma-hydroxybutyrate/gamma-butyrolactone (GHB/GBL), ketamine, 3,4 methylenedioxymethamphetamine (MDMA), cocaine, alkyl nitrites, phosphodiesterase type 5 inhibitors, cannabis, and novel psychoactive substances. By mapping desired psychosexual effects to pharmacological mechanisms and acute risks, we outline practical ED management priorities, opportunities for harm-reduction integration, and implementation pathways. The aim is to translate lived chemsex practices into actionable emergency care strategies that reduce morbidity and strengthen linkage to ongoing support services. Chemsex-related presentations require recognition of characteristic polydrug toxidromes and coordinated emergency care that integrates acute management with harm-reduction and referral pathways.

Key words: acute intoxication; chemsex; emergency department; harm reduction; polydrug use; synthetic cathinones.

Sažetak

„*Chemsex*" označava namjernu uporabu psihoaktivnih tvari radi oblikovanja seksualnog iskustva, pojačavanja uzbuđenja, produljenja izdržljivosti, smanjenja inhibicija i olakšavanja seksualne povezanosti. U posljednjih nekoliko godina ta je praksa postala značajan uzrok akutnih intoksikacija koje dovode bolesnike u hitne bolničke prijeme, osobito u velikim europskim gradovima. Prezentacije povezane s *chemsexom* često uključuju istodobnu uporabu više supstanci, imaju uske sigurnosne margine i stvaraju preklapajuće toksidrome, što predstavlja izazov za standardne protokole Objedinjenog hitnog bolničkog prijama (OHBP) usmjerene na pojedinačne droge.

Ovaj pregledni rad sažima dostupne dokaze o epidemiologiji, motivacijama za uporabu pojedinih supstanci i kliničkim manifestacijama relevantnima za hitnu medicinu. Posebna pozornost posvećena je sintetskim katinonima, metamfetaminu, GHB/GBLu, ketaminu, MDMAi, kokainu, alkilnitritima, inhibitorima fosfodiesteraze tipa 5, kanabisu i novim psihoaktivnim tvarima. Povezujući željene psihoseksualne učinke s farmakološkim mehanizmima i akutnim rizicima, iznosimo praktične prioritete za zbrinjavanje u OHBPu, mogućnosti integracije mjera smanjenja štete te smjernice za njihovu provedbu.

Cilj rada je kliničke slučajeve „*chemsexa*" prevesti u primjenjive strategije hitne medicinske skrbi koje smanjuju morbiditet i poboljšavaju povezivanje pacijenata s dugoročnim oblicima

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podrške. Kliničke prezentacije povezane sa *Chemsex*-om zahtijevaju prepoznavanje karakterističnih toksidroma povezanih sa unosom više vrsta droga te koordinirano hitno zbrinjavanje koje integrira akutno liječenje s mjerama smanjenja štete i odgovarajućim upućivanjem na daljnju skrb.

Ključne riječi: akutna intoksikacija, *chemsex;* hitni bolnički prijam; smanjenje štete; uporaba više droga; sintetski katinoni.

Introduction

Chemsex encompasses a heterogeneous but increasingly prevalent set of sexualised drug-use practices in which individuals intentionally combine stimulants, empathogens, dissociatives, depressants, and adjunctive agents to modulate desire, stamina, intimacy, and performance during prolonged sexual encounters. Across European emergency departments, clinicians report a growing share of acute intoxication presentations linked to these practices, with substantial regional variation driven by local drug markets, social networks, and access to sexual health and addiction services. In high-prevalence settings such as Barcelona, chemsex-related intoxications have come to represent a majority of adult toxicology presentations over a short period, underscoring the pace of change in ED burden (1).

> Chemsex-related intoxications represent a growing burden for emergency departments in European urban centres.

Patients presenting with *chemsex*-related toxicity are most commonly young to middle-aged men, with men who have sex with men (MSM) representing the majority of reported cases. Compared with other intoxication populations, these individuals frequently exhibit higher rates of human immunodeficiency virus (HIV) infection and co-occurring psychiatric conditions, including anxiety, depression, and bipolar disorder (2-4).

These intersecting vulnerabilities are associated with greater clinical acuity, recurrent ED utilisation, and more complex disposition planning. A defining challenge for emergency care is the intentional use of multiple substances to achieve specific experiential trajectories. While this approach allows users to fine-tune arousal, emotional connection, and endurance, it simultaneously compresses therapeutic windows. It produces mixed toxidromes that are difficult to manage using traditional single-substance frameworks (3-6).

Methods

This manuscript adopts a narrative review approach to integrate published evidence on emergency department presentations associated with chemsex. Emphasis is placed on substance-specific motivations, acute clinical manifestations, ED management priorities, and harm-reduction and implementation strategies relevant to emergency care. The objective is interpretive synthesis rather than quantitative pooling, reflecting the heterogeneity of study designs, populations, and outcome measures in the available literature.

Relevant studies were identified through structured searches of PubMed, Embase, Scopus, and Web of Science for publications between 2010 and 2025. Search strategies combined terms related to chemsex or sexualised drug use with emergency care, acute toxicity, and specific substances (e.g., mephedrone, methamphetamine, GHB/GBL, ketamine, MDMA, cocaine, alkyl nitrites, sildenafil/tadalafil, cannabis). Reference lists of key reviews and observational studies were manually screened to identify additional sources. They included observational cohorts, cross-sectional surveys, ED case series, reviews, and implementation studies reporting ED-relevant outcomes. Given variability in definitions, self-reporting, and toxicological confirmation, findings are synthesised thematically rather than statistically.

Epidemiology and clinical context

Urban EDs across Europe report increasing numbers of chemsex-related intoxication presentations, with local trajectories shaped by substance availability, community norms, and access to preventive and treatment services. In Barcelona, chemsex-related visits increased from 13.1% of adult toxicology presentations in 2018 to 59.1 % in 2020, illustrating the scale of change that can occur in concentrated urban settings (1). Most cohorts are predominantly men who have sex with men (MSM) and show higher HIV seropositivity and psychiatric comorbidity than other intoxication populations, factors associated with agitation, psychosis, prolonged observation, and repeat ED attendance (2,6,7).

Although oral and intranasal routes predominate, intravenous drug administration ("*slamming*") carries disproportionate clinical risk. Presentations involving injection are more frequently complicated by bloodstream infections, vascular injury, and transmission of blood-borne viruses, necessitating targeted harm-reduction counselling and follow-up (8).

SUBSTANCE-SPECIFIC MOTIVATIONS AND ED PRESENTATIONS

Synthetic cathinones

Synthetic cathinones such as mephedrone and methylone are commonly selected for their ability to induce intense stimulation rapidly, heightened tactile sensitivity, sociability,

and increased sexual drive. These effects are mediated through potent monoaminergic activity involving dopamine, norepinephrine, and serotonin pathways. In the ED, presentations are dominated by features of sympathetic overactivation, including agitation, tachycardia, hypertension, hyperthermia, and diaphoresis. Additional risks include seizures, hyponatremia related to polydipsia or altered antidiuretic hormone regulation, and serotonin toxicity when combined with other serotonergic agents. Management focuses on benzodiazepine sedation, active cooling, intravenous fluids, and close monitoring for evolving neuropsychiatric and cardiovascular instability (3,4).

Methamphetamine

Methamphetamine plays a central role in many chemsex settings due to its long duration of action and capacity to sustain wakefulness, sexual focus, and physical endurance over extended periods. ED presentations frequently involve severe agitation, paranoid psychosis, hypertensive crises, tachyarrhythmias, hyperthermia, and rhabdomyolysis, often exacerbated by sleep deprivation and polydrug use. Acute management prioritises aggressive benzodiazepine sedation to reduce sympathetic drive, continuous cardiac monitoring, evaluation for ischemia when indicated, active cooling, and renal protection with intravenous fluids (3,6).

Gamma-hydroxybutyrate /gamma-butyrolactone

GHB/GBL is frequently used to counterbalance stimulant effects by promoting relaxation, emotional openness, and social disinhibition. Because the margin between desired and toxic doses is narrow, minor dosing errors or co-ingestion with alcohol or benzodiazepines can rapidly result in profound central nervous system depression. ED priorities include airway protection, supportive care, and vigilant monitoring, recognising the fluctuating course associated with redistribution and rapid awakening. Observation is typically required until consciousness and protective reflexes are reliably restored (5,9)

Ketamine

Ketamine is incorporated into some chemsex settings for its dissociative and analgesic properties, which can alter body perception, reduce performance-related anxiety, and intensify tactile experiences. ED presentations may include confusion, agitation, dissociation, perceptual disturbances, hypertension, tachycardia, and nystagmus. Although respiratory depression is uncommon at recreational doses, the risk increases with co-ingestion of other sedatives. Management emphasises supportive care, reduction of environmental stimuli, and benzodiazepines for distressing emergence reactions, with observation until mental status normalises (3).

3,4-Methylenedioxymethamphetamine

MDMA is commonly used for its empathogenic effects, which participants describe as enhancing emotional warmth, bonding, and tactile pleasure. Acute toxicity in the ED most often reflects dysregulated thermoregulation, excessive physical exertion, and disturbances of fluid balance, leading to hyperthermia, hyponatremia, and, in severe cases, rhabdomyolysis or hepatic injury. Management includes rapid external cooling, sedation to reduce muscle activity, cautious correction of electrolyte abnormalities, and monitoring for serotonin toxicity, particularly in the presence of other serotonergic substances (5).

Cocaine

Cocaine is used for its rapid-onset stimulant effects, including increased confidence and perceived sexual performance enhancement. ED presentations commonly involve anxiety, chest pain, tachyarrhythmias, and hypertensive urgency. When combined with phosphodiesterase type 5 (PDE5) inhibitors to counter stimulant-associated erectile dysfunction, cardiovascular complexity increases. ED care centres on benzodiazepine sedation, cardiac monitoring, evaluation for myocardial ischemia when indicated, and cautious blood pressure management (4).

Alkyl nitrites

Alkyl nitrites (“*poppers*”) are inhaled for their brief vasodilatory effects, facilitating receptive anal intercourse by reducing smooth muscle tone. Adverse effects prompting ED evaluation include dizziness, headache, hypotension, and syncope. Rarely, significant methemoglobinemia may occur, presenting with cyanosis and hypoxia unresponsive to oxygen therapy. Management consists of supportive care and intravenous methylene blue in symptomatic cases (5).

Phosphodiesterase type 5 inhibitors

PDE5 inhibitors such as sildenafil and tadalafil are used to maintain erectile function during prolonged sessions or in the context of stimulant use. ED-relevant adverse effects include hypotension, headache, flushing, visual disturbances, and, rarely, priapism. Concomitant use with nitrates for chest pain can result in severe hypotension, making careful medication history essential. Management in the emergency department is primarily supportive and includes haemodynamic monitoring, intravenous fluids for symptomatic hypotension, and avoidance of nitrate administration. Priapism requires urgent urological evaluation and treatment according to established emergency protocols (4).

Cannabis

Cannabis is often used adjunctively to modulate anxiety, promote relaxation, or smooth transitions between stimulant and depressant phases. ED presentations are usually mild but may include panic attacks, severe anxiety, nausea, or transient psychosis, particularly with high-potency products or polydrug use. Management is typically supportive, with reassurance and benzodiazepines for severe anxiety (6).

Novel psychoactive substances

An expanding range of novel psychoactive substances—including designer benzodiazepines, synthetic opioids, and

hallucinogenic compounds—has been increasingly identified in chemsex contexts. Their unpredictable potency and limited detection on routine toxicology screens complicate ED assessment. Presentations may involve prolonged sedation, respiratory depression, agitation, or hallucinations. Management relies on toxidrome-based supportive care, targeted antidotes when appropriate (e.g., naloxone), and early toxicology consultation (10,11).

Polydrug patterns and mixed toxidromes

Chemsex commonly involves sequencing multiple substances to achieve a desired experiential arc, such as stimulants for arousal and endurance, MDMA for intimacy, GHB/GBL for disinhibition, ketamine for dissociation, and adjunctive agents for performance support or anxiety modulation. The cumulative effects of serotonergic agents, stimulant–vasoactive combinations, and central nervous system depressants produce overlapping and sometimes contradictory clinical features. These interactions increase the risk of hyperthermia, arrhythmia, serotonin toxicity, and respiratory compromise, particularly in the setting of prolonged sessions and sleep deprivation (1,2,11).

Presentations commonly involve intentional polydrug use and complex mixed toxidromes.

Emergency department recognition and acute management

Initial ED assessment should include a brief, nonjudgmental inquiry to establish chemsex context, including substances used, dosing intervals, routes of administration, session duration, and co-ingestion of alcohol or prescribed medications. Airway and breathing require particular attention in presentations involving depressants such as GHB/GBL or designer benzodiazepines. Circulatory monitoring is essential for stimulant-related toxicity, with benzodiazepines forming the cornerstone of treatment to reduce sympathetic overactivity.

Emergency management prioritises supportive care, benzodiazepine sedation, and early recognition of complications.

Hyperthermia and electrolyte disturbances require prompt recognition and intervention, including active cooling, sedation, and cautious correction of hyponatremia. Antidotes such as naloxone or methylene blue should be used when indicated, while flumazenil is generally avoided due to seizure risk in polydrug exposures. Given limitations of routine toxicology, clinical pattern recognition remains central to management (5, 10).

Harm reduction and implementation in emergency departments

ED encounters represent a critical point of contact during which individuals may be receptive to risk-reduction messaging and linkage to ongoing care. Brief interventions, rapid HIV and STI testing, post-exposure prophylaxis initiation, and referral to PrEP, addiction, and mental health services have shown feasibility and early effectiveness in reducing short-term harm and improving engagement (2, 9,11-13). Standardised screening tools, embedded order sets, and partnerships with community-based services facilitate consistent, stigma-free care and continuity of care beyond discharge (8).

Emergency departments provide an opportunity for harm-reduction interventions and linkage to sexual health and addiction services.

Limitations and research priorities

The available evidence is constrained by reliance on self-reported substance use, geographic concentration in Western Europe, inconsistent definitions of chemsex, and limited laboratory confirmation of emerging substances. Future priorities include standardised ED case definitions, prospective multicentre cohorts, expanded rapid toxicology for novel agents, and intervention trials evaluating ED-based harm-reduction bundles with outcomes such as repeat ED utilisation, linkage to care, and incident HIV/STI diagnoses (14).

Conclusion

Chemsex-related emergency department presentations arise from deliberate, highly structured patterns of multi-substance use designed to shape sexual experience, endurance, and interpersonal connection. Understanding how these motivations intersect with pharmacological risk enables clinicians to anticipate complex toxidromes, prioritise supportive care, and avoid pitfalls associated with single-substance assumptions. By integrating structured screening, disciplined acute management, and clear pathways to sexual health, addiction, and mental health services, emergency departments can reduce morbidity while delivering patient-centred, stigma-free care in an evolving clinical landscape.

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REVIEW ARTICLE / PREGLEDNI ČLANAK

THE PHYSIOLOGICALLY DIFFICULT AIRWAY: RECOGNITION AND OPTIMIZATION BEFORE ENDOTRACHEAL INTUBATION IN CRITICALLY ILL PATIENTS

FIZIOLOŠKI OTEŽAN DIŠNI PUT: PREPOZNAVANJE I OPTIMIZACIJA PRIJE ENDOTRAHEALNE INTUBACIJE U KRITIČNIH BOLESNIKA

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Abstract

Airway management in critically ill patients remains one of the highest-risk procedures in acute care medicine. Traditionally, airway difficulty has been defined primarily by anatomical factors that complicate visualization of the glottis or placement of an endotracheal tube. However, increasing evidence indicates that physiological instability plays a critical role in adverse events during tracheal intubation. The physiologically difficult airway refers to situations in which underlying respiratory, hemodynamic, or metabolic disturbances predispose patients to rapid clinical deterioration during induction of anesthesia and initiation of mechanical ventilation. Common scenarios include severe hypoxemia associated with acute respiratory distress syndrome or pneumonia, circulatory instability such as septic or cardiogenic shock, metabolic derangements including diabetic ketoacidosis, and right ventricular dysfunction related to pulmonary embolism or pulmonary hypertension. Recognition of these high-risk physiological states, together with appropriate optimization prior to intubation, is essential for reducing peri-intubation complications and improving outcomes. This article reviews current understanding of the physiologically difficult airway, highlights key high-risk conditions, and discusses evidence-based strategies aimed at optimizing oxygenation, maintaining hemodynamic stability, improving procedural success, and ensuring safe post-intubation management.

Key words: airway management; critical care; emergency medicine; physiologically difficult airway

Sažetak

Zbrinjavanje dišnog puta kritičnih bolesnika je jedan od najrizičnijih zahvata u akutnoj medicine. Tradicionalno se otežan dišni put primarno definirao kroz anatomske čimbenike koji kompliciraju vizualizaciju glasnica ili plasiranje endotrahealnog tubusa. Ipak, sve je više dokaza koji ukazuju da fiziološka nestabilnost igra kritičnu ulogu u pojavi neželjenih događanja tijekom trahealne intubacije. Fiziološki otežan dišni put označava situacije u kojima postojeći respiratorni, hemodinamski ili metabolički poremećaji dovode bolesnike u rizik od naglo nastalog kliničkog pogoršanja tijekom uvoda u anesteziju i započinjanja mehaničke ventilacije. Uobičajene situacije uključuju hipoksemiju teškog stupnja povezanu s akutnim sindromom respiratornog distresa ili upalom pluća, cirkulacijsku nestabilnost poput septičkog ili kardiogenog šoka, metaboličke poremećaje poput dijabetičke ketoacidoze i poremećaja funkcije desne klijetke vezanog uz plućnu emboliju ili plućnu hipertenziju. Prepoznavanje ovih visokorizičnih fizioloških

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stanja, zajedno s prikladnom optimizacijom prethodno intubaciji, je nužno za smanjenje peri-intubacijskih komplikacija i poboljšanje ishoda. Ovaj članak nudi pregled trenutnog razumijevanja fiziološki otežanog dišnog puta, naglašava ključna visokorizična stanja i navodi strategije temeljene na dokazima koje za cilj imaju optimizaciju oksigenacije, održavanje hemodinamske stabilnosti, povećavanje uspješnosti saog zahvata i osiguravanje sigurnog poslijeintubacijskog zbrinjavanja.

Ključne riječi: fiziološki otežan dišni put; hitna medicina; intenzivna medicina; zbrinjavanje dišnog puta

Introduction

Airway management is a fundamental intervention in critically ill patients. Endotracheal intubation provides definitive airway protection and enables controlled oxygenation and ventilation, making it a cornerstone of anesthesiology, emergency medicine, and intensive care practice. Traditionally, difficult airway assessment has focused on anatomical factors such as limited mouth opening, restricted cervical spine mobility, and upper airway abnormalities that complicate glottic visualization and tube placement. Over the past decades, structured guidelines, particularly from the American Society of Anesthesiologists, have improved safety and standardized approaches for both anticipated and unanticipated difficult airways (1,2).

Despite these advances, tracheal intubation in critically ill patient´s remains associated with high morbidity and mortality. Many adverse events occur in patients with anatomically uncomplicated airways, often due to severe physiological disturbances present before intubation (3). Induction of anesthesia, transient apnea, and initiation of positive-pressure ventilation may exacerbate pre-existing respiratory, cardiovascular, or metabolic instability, potentially leading to profound hypoxemia, hypotension, or cardiac arrest.

Critically ill patients face a high risk of complications during intubation, even when their airway appears easy, due to their unstable physiological condition

Airway management in the intensive care unit (ICU) or emergency department differs substantially from controlled operating room environments. These patients frequently present with severe hypoxemia, circulatory compromise, or metabolic disturbances, reducing physiological reserve and increasing vulnerability to peri-intubation complications. Procedures are often performed under time constraints, with incomplete physiological stabilization, further heightening risk. Mosier introduced the concept of the physiologically difficult airway in 2015 to describe situations in which airway access may be technically straightforward, but the patient's underlying physiological state places them at high risk for adverse outcomes during induction and initiation of mechanical ventilation (4). Recognition of this concept has expanded airway assessment beyond anatomy, emphasizing the importance of physiological optimization before, during, and after intubation.

Tracheal Intubation in Critically Ill Patients

Intubation outside the operating room carries substantially higher risk than elective procedures. Complications arise from both underlying disease and physiological effects of induction, apnea, and positive-pressure ventilation. The INTUBE study, a multicenter prospective cohort enrolling 2,964 critically ill adults from 197 sites across 29 countries, reported major adverse events in approximately 45% of patients within 30 minutes of intubation (5). Cardiovascular instability occurred in 42.6%, severe hypoxemia in 9.3%, and cardiac arrest in 3.1% (5). These findings highlight the importance of comprehensive physiological assessment and optimization prior to intubation.

Physiologically Difficult Airway in Critically Ill Patients

Critically ill patients have limited physiological reserve, reducing their ability to tolerate the stress associated with airway management. Induction of anesthesia results in suppression of sympathetic tone and spontaneous ventilation, while positive-pressure ventilation alters intrathoracic pressure and decreases venous return. In healthy individuals, these changes may be well tolerated, but in critically ill patients, they can rapidly precipitate hypoxemia, hypotension, or cardiovascular collapse (6). The physiologically difficult airway emphasizes that the main risks during tracheal intubation in this population are often due to underlying physiological instability rather than anatomical challenges alone.

Four primary physiological derangements are associated with increased peri-intubation risk: severe hypoxemia, hypotension or circulatory shock, severe metabolic acidosis, and right ventricular failure. Other conditions, such as elevated intracranial pressure, obesity, or pregnancy, may further increase risk and should be considered during airway planning (6).

Severe hypoxemic respiratory failure dramatically shortens the safe apnea period. Patients with acute respiratory distress syndrome (ARDS), severe pneumonia, or pulmonary edema typically have reduced functional residual capacity and increased intrapulmonary shunting, which accelerate oxygen desaturation during apnea (7). Critically ill patients often have increased oxygen consumption and impaired gas exchange due to ventilation–perfusion mismatch. Even brief

interruptions in ventilation during laryngoscopy may lead to critical hypoxemia. Preoxygenation strategies that go beyond standard oxygen delivery such as high-flow nasal oxygen (HFNO), non - invasive positive-pressure ventilation (NIV), or apnoeic oxygenation can improve oxygen stores, prolong safe apnoea time, and reduce peri-intubation hypoxemia (7).

Hemodynamic instability is another core factor. These patients frequently have compromised cardiovascular function due to sepsis, hemorrhage, or cardiogenic shock. Induction agents may decrease vascular tone and myocardial contractility, while positive-pressure ventilation further reduces venous return and cardiac output (7). This effect may be exacerbated by concurrent sedatives, vasodilators, or other medications. Optimization of hemodynamics before intubation, including fluid resuscitation when appropriate and early use of vasopressors such as norepinephrine, is essential. Selection of induction agents also impacts risk; ketamine and etomidate are often preferred over propofol due to their lesser cardiovascular depressive effects (8).

Severe metabolic acidosis presents unique challenges. Patients with diabetic ketoacidosis or lactic acidosis rely on high minute ventilation to maintain acid–base balance. Loss of spontaneous ventilation after induction can rapidly worsen acidosis, leading to hemodynamic instability, arrhythmias, or cardiac arrest. Minimizing apnea duration and promptly establishing adequate mechanical ventilation are critical in these patients.

Right ventricular failure further increases vulnerability. Positive-pressure ventilation raises pulmonary vascular resistance and reduces venous return, which can strain a right ventricle already functioning near maximal capacity, as in acute pulmonary embolism or chronic pulmonary hypertension. Even small increases in pulmonary pressures or reductions in preload may precipitate sudden hemodynamic collapse. Management may require tailored ventilatory strategies, careful fluid management, and inotropic support to preserve right ventricular function (8,9).

The main physiological risks during intubation in critically ill patients are severe hypoxemia, hypotension, metabolic acidosis, and right ventricular failure. Optimizing oxygenation, hemodynamics, and ventilation before intubation is essential to reduce complications.

Collectively, these physiological derangements underscore the complexity of airway management in critically ill patients. The main derangements and recommended pre-intubation optimization strategies are summarized in Table 1.

Management of the physiologically difficult airway

Successful management of the physiologically difficult airway requires a structured, physiologyfocused approach that anticipates and mitigates risks related to hypoxemia, hemodynamic instability, acid–base derangements, and right ventricular dysfunction. This strategy goes beyond securing anatomical access, emphasizing physiological optimization before, during, and after intubation, which improves outcomes and reduces periintubation complications (10,11).

Patient Assessment

Preparation begins with a comprehensive assessment of the patient's physiological status and identification of highrisk features. Standardized airway management bundles that integrate patient assessment, oxygenation and hemodynamic optimization, airway equipment preparation, and planned postintubation monitoring have been associated with reduced rates of hypoxemia and other adverse events (11,12).

Oxygenation Strategies

Oxygenation optimization is a cornerstone of safe airway management. Preoxygenation aims to increase oxygen reserves

Table 1. Key Physiological Derangements and Pre-Intubation Optimization

Physiological Derangement	Mechanism of Risk	Pre-Intubation Optimization
Severe hypoxemia	Rapid oxygen desaturation due to reduced functional residual capacity, V/Q mismatch	High-flow nasal oxygen, noninvasive ventilation, apneic oxygenation
Hypotension / circulatory shock	Decreased cardiac output and perfusion, exacerbated by induction and positive-pressure ventilation	Careful fluid management, early vasopressor support (e.g., norepinephrine), selection of induction agents with minimal cardiovascular depression
Severe metabolic acidosis	Dependence on high minute ventilation to maintain acid-base balance; apnea worsens acidosis	Minimize apnea duration, promptly initiate effective mechanical ventilation
Right ventricular failure	Increased pulmonary vascular resistance, decreased venous return; risk of acute hemodynamic collapse	Tailored ventilatory strategies (limit plateau pressures), preload optimization, inotropic support if indicated

and prolong the duration of safe apnea. Traditional facemask oxygen delivery is often inadequate in critically ill patients due to poor alveolar recruitment and shunt physiology. Strategies such as noninvasive ventilation (NIV) or highflow nasal oxygen (HFNO) have been shown to improve oxygenation and reduce periintubation hypoxemia. For example, the PREOXI randomized trial found that preoxygenation with NIV significantly reduced the incidence of severe hypoxemia (SpO_2 <85%) compared with facemask oxygen (9.1% vs. 18.5%) among critically ill adults undergoing tracheal intubation (11). A recent systematic review and network metaanalysis supports the efficacy of NIV and HFNC over conventional oxygen therapy for reducing intubationassociated hypoxemia (13). These methods improve alveolar recruitment, increase functional residual capacity, and may allow continuous apneic oxygenation during laryngoscopy (8,13).

Safe airway management in critically ill patients requires anticipating and optimizing physiological risks, hypoxemia, hemodynamic instability, metabolic acidosis, and right ventricular dysfunction—beyond simply securing anatomical access.

Hemodynamic management

Hemodynamic support is critical. Periintubation hypotension and cardiovascular collapse are frequent and associated with poor outcomes. Proactive strategies include careful fluid management when appropriate and early preparation of vasopressor support. While evidence is not yet definitive on routine fluid boluses preventing hypotension, early initiation of vasopressors such as norepinephrine or phenylephrine remains common practice in unstable patients (13). Maintaining metabolic stability is essential, especially in patients with severe acidosis who depend on high minute ventilation to maintain acid–base balance. Minimizing apnea duration and rapidly achieving effective mechanical ventilation after intubation help prevent worsening acidosis and arrhythmias. Patients with right ventricular dysfunction require ventilatory strategies that avoid excessive increases in pulmonary vascular resistance. Tailored ventilator settings that limit plateau pressures and preserve venous return, along with preload optimization and inotropic support when indicated, can mitigate the risk of acute hemodynamic collapse (12).

First-pass intubation strategy

Procedural strategies that maximize firstpass intubation success reduce exposure to hypoxemia and hemodynamic instability. Evidence suggests that video laryngoscopy and adjuncts such as bougies increase firstpass success rates compared with direct laryngoscopy, particularly in highrisk settings, and should be considered when available (8,12,14). Multiple intubation attempts are associated with increased risk of desaturation, aspiration, and cardiovascular deterioration.

Structured strategies, including pre-intubation optimization, first-pass intubation techniques, and vigilant post-intubation monitoring, are essential to reduce peri-intubation complications and improve outcomes

Postintubation care is equally important. Continuous monitoring of oxygenation, ventilation, and hemodynamics allows early identification of deterioration. Implementation of lungprotective ventilation strategies, appropriate vasopressor titration, and correction of metabolic abnormalities reduce secondary complications. Structured airway bundles that include postintubation elements further enhance patient safety.

Conclusion

Airway management in critically ill patients is complicated not only by anatomical challenges but also by profound physiological instability. Severe hypoxemia, hemodynamic compromise, metabolic acidosis, and right ventricular failure substantially increase the risk of peri-intubation complications. Recognition of these high-risk physiological states, targeted pre-intubation optimization, structured procedural strategies, and vigilant post-intubation monitoring are essential for safe airway management. Integrating physiological considerations into airway planning enables clinicians to anticipate complications and tailor interventions, ultimately improving outcomes in critically ill patients.

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CASE REPORT / PRIKAZ SLUČAJA

ZBRINJAVANJE PENETRANTNIH RANA PRSNOG KOŠA U IZVANBOLNIČKOJ HITNOJ MEDICINSKOJ SLUŽBI

MANAGEMENT OF PENETRATING CHEST INJURIES IN THE PREHOSPITAL EMERGENCY MEDICAL SERVICE

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Sažetak

Penetrantne ozljede prsnog koša ubrajamo u životno ugrožavajuća stanja koja zahtijevaju žurnu skrb. Karakterizirane su prodorom kože i ulaskom stranog tijela u prsnu šupljinu, a učestalost u značajno ovisi o promatranom geografskom području i aktivnim ratnim sukobima. Nemoguće je, samo na temelju vanjskog izgleda rane, pretpostaviti veličinu unutrašnje ozljede. Stabilni bolesnik s naizgled malom ranom možegu brzo postati hemodinamski nestabilan zbog čega sve penetrantne ozljede prsnog koša ubrajamo u najveći stupanj hitnosti. Kod bolesnika čije ozljede nisu tako velike da uzrokuju smrt, najčešći uzrok smrti su opstrukcija dišnog puta, tenzijski pneumotoraks, hematotoraks ili srčana tamponada. S obzirom da je kod većine ovakvih bolesnika moguće smanjiti posljedice ranjavanja i spriječiti smrtni ishod, bitno je odmah po dolasku na mjesto intervencije i tijekom transporta stabilizirati bolesnika u okviru mogućnosti te je od velike važnosti navedene bolesnike čim ranije odvesti u odgovarajuću zdravstvenu ustanovu koja ima odgovarajuće mogućnosti zbrinjavanja navedenih bolesnika.

Ključne riječi: hematotoraks; izvanbolnička hitna medicinska služba; penetrantna ozljeda prsnog koša; pneumotoraks,

Abstract

Penetrating injuries of the thoracic cavity are life-threatening conditions that require urgent care. They are characterized by penetration of the skin and the entry of the foreign object into the chest cavity. The incidence mostly depends on geographic region and the presence of active armed conflicts. It is impossible to determine the extent of internal injury only based on the external look of the wound. Hemodynamically stable patients with small wounds can become unstable very fast, therefore, all penetrating chest injuries must be classified as the highest level of emergency. In patients whose injuries are not devastating enough to cause death immediately, the most common causes of death include airway obstruction, tension pneumothorax, hemothorax and cardiac tamponade. In the majority of these patients it is possible to minimize the consequences of the injury and prevent fatal outcome. Therefore, it is crucial to begin with the stabilization of the patients immediately upon arrival at the injury site and during emergency transport within the limits of available knowledge and resources with transport to the adequate trauma center.

Key words: hemothorax; penetrating chest injury; pneumothorax; prehospital emergency medical service

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Uvod

Penetrantne ozljede prsnog koša karakterizirane su prodorom kože i ulaskom stranog tijela u prsni koš, a najčešće je riječ o ubodnim i prostrijelnim ranama. Unatoč što većina trauma prsišta nastaje kao posljedica tupe ozljede u sklopu politraume poput pada s visine ili prometnih nesreća, penetrantne ozljede prsnog koša češće zahtijevaju kirurško liječenje i daleko su smrtonosnije (1). Učestalost penetrantnih ozljeda značajno ovisi o promatranom geografskom području i aktivnim ratnim sukobima. U Europi 3 % traumatskih smrti otpada na penetrantne ozljede prsnog koša, a najviše im podliježu mlađi muškarci s prosječnom dobi od 30 godina (2,3).

Bolesnici sa smrtnim ishodom neposredno nakon traume umiru zbog teških ozljeda srca i velikih krvnih žila. Sljedeći vrhunac smrtnosti nastupa unutar nekoliko sati nakon ozljede, najčešće zbog stanja poput opstrukcije dišnog puta, tenzijskog pneumotoraksa ili masivnog krvarenja. Stoga je od ključne važnosti da pravilno zbrinjavanje započne već u prvom susretu s bolesnikom na terenu, a nastavi se u odgovarajućoj bolničkoj ustanovi (4). Ukoliko bolesnik preživi dolazak u bolnicu, smrtnost se smanjuje na samo 6 % (3).

Vanjski izgled penetrantne ozljede prsnog koša nije pouzdan pokazatelj težine intratorakalnih ozljeda; stoga svaka takva ozljeda zahtijeva neposrednu procjenu i hitno zbrinjavanje kako bi se spriječile smrtonosne komplikacije.

Gotovo je nemoguće samo na temelju izgleda ulazne rane i kliničkog pregleda odrediti razinu oštećenja intratorakalnih organa. Oštra sredstva poput noža obično se kreću po pravilnoj putanji dok rane od metka često mogu skretati uz manje predvidiv smjer kretanja i prenošenje energije na okolna tkiva prilikom čega uzrokuju sekundarna oštećenja okolnih struktura (4). Često postoji značajno nepoklapanje između vanjskog izgleda ubodne rane i ozljede podležećih organa. Nikada se ne smije pretpostaviti da ne postoji značajno oštećenje unutarnjih organa samo na temelju vanjskog izgleda rane. Čak i bolesnici koji su naizgled hemodinamski stabilni mogu se pogoršati u vrlo kratkom vremenu. Navedeno je razlog zašto se svakoj penetrantnoj ozljedi prsnog koša u izvanbolničkoj hitnoj službi (IHMS) mora pristupiti s najvećim stupnjem hitnosti uzimajući u obzir sve potencijalne životno ugrožavajuće ozljede.

Prikaz slučaja

Tim 1 IHMS upućen je od Medicinsko prijavno-dojavne jedinice (MPDJ) na crveni kriterij. Zaprimljen je poziv o ubodnoj rani prsnog koša u dječaka starog 17 godina. Po dolasku na mjesto intervencije zatiče se bolesnik kojem je prva pomoć pružena od prolaznika, pri čemu je stavljena sterilna gaza na ubodnu ranu, a noge stavljene u autotransfuzijski položaj. Lokalnim pregledom prsnog koša utvrđena je otvorena rana duljine 2 cm u sredini desnog prsišta bez aktivnog vanjskog krvarenja no s vidljivim plućnim tkivom. Sredstvo ozljeđivanja je prije dolaska tima IHMS-a bilo izvađeno.

Odmah nakon uvida u ranu, unutar minute od dolaska na intervenciju, kontaktiran je MPDJ radi indiciranog transporta helikopterskom hitnom medicinskom službom do odgovarajuće zdravstvene ustanove. Rana je inicijalno zbrinjavana pritiskom rukavice preko sterilnog zavoja. Pregledom bolesnika utvrđuje se:

AVPU skala: A- bolesnik je urednog verbalnog kontakta, no prostriran i narušenog općeg stanja

c: nedostatak većih vanjskih krvarenja koje zahtijevaju zbrinjavanje

A: dišni put otvoren

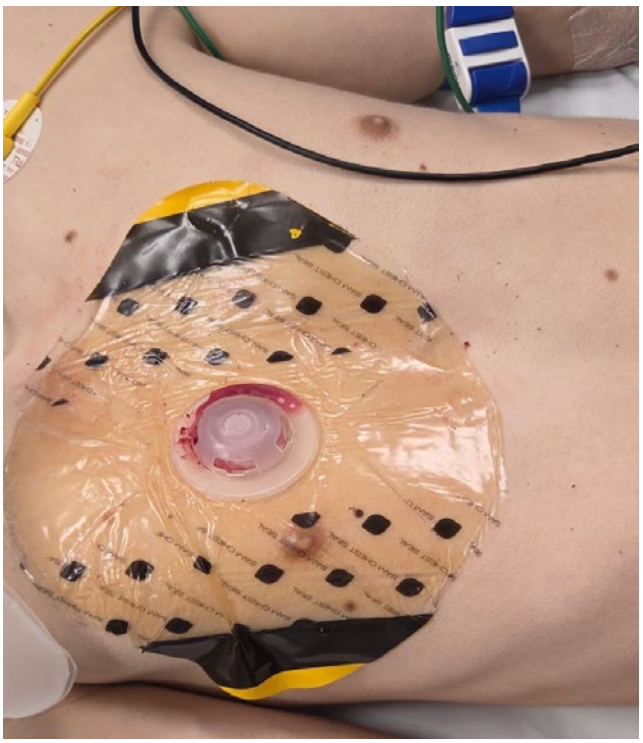
B: početna saturacija kisikom mjerena pulsnim oksimetrom 77 %

- na strani uboda potpuno oslabljen šum disanja, dok je sa suprotne strane šum disanja bio uredan, traheja medioponirana, a jugularne vene bez distenzije

C: početni krvni tlak 80/40

- izuzetno slabo pipljiv periferni puls
- kapilarna reperfuzija manja od 2 sekunde
- srčana akcija ritmična, tonovi jasni, nečujni patološki šumovi

Postavljena je sumnja na pneumotoraks. Odmah se primijenio kisik u protoku od 15 L/min na masku sa spremnikom po čemu dolazi do normalizacije periferne saturacije. Na ranu je postavljen okluzivni zavoj s ventilom pri čemu su se ispod ventila primijetili mjehurići zraka i nešto primjesa krvi (slika 1).



Slika 1. Okluzivni pokrov s ventilom

Započeta je nadoknada tekućine 0,9% NaCl-a do povratka perifernog pulsa. Primijenjeno je 500 ml tekućine jednim venskim putem. Kontrolni tlak je iznosio 90-100/60. S obzirom na mehanizam ozljede postavljena je sumnja na hematotoraks pa je pomoću drugog venskog puta ordiniran 1 gram traneksamične kiseline.

Uz navedeno, budući da se bolesnik nije žalio na značajnu bolnost, od analgezije je ordiniran gram paracetamola. Postavljen je monitor čime su se kontinuirano pratile srčana akcija i vitalne funkcije. Na temelju mehanizma ozljede definitivno se mogla isključiti ozljeda kralježnice pa je s poda podignut rasklopnim nosilima i prebačen na nosila te predan helikopterskom timu hemodinamski stabiliziran i pri svijesti, bez znakova razvoja tenzijskog pneumotoraksa. Helikopterski tim je sletio na mjesto intervencije 10 minuta nakon dolaska zemaljskog tima, dok je bolesnik unutar 40 minuta od prvog doticaja sa hitnom službom zbrinut u odgovarajućem trauma centru čime je ispoštovano pravilo zlatnog sata.

Po dolasku u bolničku ustanovu bolesnik je bio hipotezivan i tahikardan, no održane saturacije na oksigenoterapiju. U početnom zbrinjavanju ultrazvučno je verificran hematotoraks radi čega je odmah postavljen torakalni dren na koji se dobilo gotovo 2000 mL čiste krvi. Odmah potom bolesnik je zbrinut u operacijskoj sali po principu „damage control surgery" gdje je uz operacijsko liječenje primio koncentrate eritrocita, fibrinogen, dodatan gram traneksamične kiseline, kalcijev glukonat, odgovarajuću analgeziju uz ostalu suportivnu terapiju po protokolu za zbrinjavanje traume. Eksplorativnom torakotomijom utvrđena je još litra krvi u prsnom košu uz transekciju arterije mamarije s aktivnim krvarenjem i laceracija desne pretklijetke koje su sanirane. Nakon 48 sati od ozlijeđivanja, bolesnik je prebačen s odjela intenzivne medicine na odjel dječje kirurgije urednih vitalnih pokazatelja i dobrog općeg stanja, a nakon određenog vremena otpušten je na kućno liječenje

Rasprava

Klinička slika

Pneumotoraks je najčešća dijagnoza u bolesnika sa zadobivenim penetrantnim ozljedama prsnog koša (5). Naime, ozljeda pleure dovodi do ulaska zraka između parijetalne i visceralne pleure, izjednačavanja atmosferskog i intratorakalnog tlaka (koji je inače niži), što onemogućuje širenje plućnog parenhima prilikom udaha te posljedično dovodi do kolapsa plućnog krila. Mali pneumotoraks može biti klinički neprepoznatljiv, dok se simptomatski očituje s hipoksijom, tahipnejom, tahikardijom, bolovima u prsima i smanjenim disajnim šumom na zahvaćenoj strani. Ukoliko se na mjestu ozljede razvije ventilni mehanizam koji omogućava daljnji ulazak zraka u pleuralni prostor, ali ne i njegov izlazak, nastaje tenzijski pneumotoraks koji uzrokuje pomicanje medijastinalnih struktura na suprotnu stranu uz pritisak na gornju i donju šuplju venu, smanjenje venskog povrata i kardiopulmonalno zatajenje te teški akutni respiracijski distres. Vanjski znakovi traume s teškom dispnejom, asimetričnim disajnim šumom i hipotenzijom ukazuju na tenzijski pneumotoraks, dok su prepunjene vratne vene i devijacija traheje rijetko prisutni te se vide tek u krajnjem stadiju bolesti (6). Zrak iz pleuralnog prostora može ući u prileđeća meka tkiva radi čega se može javiti potkožni emfizem koji se očituje oteklinom zahvaćenog mjesta i krepitacijama pri palpaciji.

Rano prepoznavanje pneumotoraksa, hematotoraksa i srčane ozljede ključno je za sprječavanje brzog pogoršanja i smanjenje smrtnosti.

Ukoliko dođe do ozljede neke od krvnih žila nastaje hematotoraks koji označava nakupljanje krvi u pleuralnom prostoru. Bolesnik može iskrvariti bez vidljivog vanjskog krvarenja jer se u pleuralni prostor jednog plućnog krila može skupiti čak do 3 litre krvi što je više od polovice cirkulirajućeg volumena (4). Šok koji se razvija u penetrantnim ranama prsnog koša najčešće je hemoragični, no u manjem broju može biti opstruktivni radi tenzijskog pneumotoraksa ili srčane tamponade (5).

U literaturi opisuje se anatomska regija poznata kao „*cardiac box*", definirana proksimalno ključnom kosti, distalno donjim rebrima, a lateralno medioklavikularnim linijama. Ova regija označava područje prsnog koša u kojem je povećan rizik od ozljeda srca i velikih intratorakalnih krvnih žila. Istraživanja su pokazala kako su ubodne rane ove regije visoko povezane sa srčanom ozljedom, dok se kod prostrijelnih rana isto nije pokazalo. No, srčana ozljeda se ne može isključiti čak i ukoliko ulazna rana nije u navedenom prostoru (7). Otprilike 3% bolesnika s penetrantnom ranom prsnog koša ima srčanu ozljedu, a karakterizira ju visoki mortalitet. Najčešće je ozlijeđena desna klijetka radi svog anteriornog položaja, a potom lijeva klijetka, dok su ozljede atrija rijetke i manje opasne (8). Radi male popustljivosti perikardijalne šupljine akumulacija čak i male količine krvi do 50 ml radi oštećenja srčanog mišića ili koronarnih krvni žila može uzrokovati srčanu tamponadu. Klinički ju karakterizira Beckova trijada (hipotenzija, distendirane vratne vene i prigušeni srčani tonovi) koja u većini pacijenata nije prisutna uz znakove šoka i paradoksalni puls (pad sistoličkog tlaka za veći od 10 mmHg prilikom udisaja) (5). Jugularna venska distenzija može biti prisutna ukoliko bolesnik leži i bez izljeva, a isto tako može biti odsutna u bolesnika s perikardijalnim izljevom u hipovolemiji (5).

Teške ozljede velikih intratorakalnih krvnih žila poput aorte, trunkusa brahiocefalikusa, lijeve potključne arterije i lijeve zajedničke karotidne zajedno s prileđećim venama često uzrokuju smrt na mjestu događaja ili dovode do razvoja teškog hemoraškog šoka do dolaska u bolnicu (9).

Izolirane ozljede traheobronhalnog stabla i jednjaka su rijetke, a ozljede abdominalnih organa treba imati na umu

s obzirom na to da se ošit prilikom inspirija može uzdići čak do 4. interkostalnog prostora isto kao što ozljede donjeg dijela prsnog koša mogu uzrokovati oštećenje abdominalnih organa.

Liječenje

Zlatno pravilo IHMS-a je ne odgađati transport radi radnji koje nisu izravno povezane sa spašavanjem života. Prilikom pregleda bolesnika potrebno je slijediti uvriježeni cABC (engl. c-catastrophic hemorrhage, A-airway, B-breathing, C-circulation) pristup. Velika vanjska krvarenja u izoliranim penetrantnim ranama prsnog koša su rijetkost, dok su puno češća unutarnja krvarenja pa adekvatnu hemostazu u uvjetima IHMS najčešće nije moguće postići. Ako je po dolasku do bolesnika strano tijelo i dalje ubodeno, ono se ne smije uklanjati, već se mora stabilizirati i fiksirati. Međutim, ako je pogođena velika pulsirajuća krvna žila, potrebno je omogućiti pulsiranje oko stranog tijela kako bi se spriječilo potpunu opstrukciju protoka krvi. U bolesnika bez svijesti s prisutnim centralnim pulsom i spontanim respiracijama potrebno je zaštiti dišni put nekim od pomagala (orofaringealni ili nazofaringealni tubus), a ako je frekvencija disanja manja od 10 ili veća od 30 udaha u minuti potrebno je ventilirati bolesnika sa samoširećim balonom. Zlatni standard zbrinjavanja dišnog puta kod ovih bolesnika je endotrahealna intubacija. Povećani otpor pri ventilaciji samoširećim balonom može upućivati na razvoj tenzijskog pneumotoraksa, pri čemu je primjena ventilacije pod pozitivnim tlakom apsolutno kontraindicirana. Neovisno o prisutnosti respiratornog distresa i vrijednosti periferne saturacije, svim bolesnicima potrebno je primijeniti kisik visokim protokom, uz mogućnost titracije prema kliničkom stanju bolesnika. U bolesnika sa znakovima šoka idealno je postaviti dva venska puta. Kod primjene tekućine treba biti oprezan i ne dopustiti volumno opterećenje bolesnika uz posljedičnu koagulopatiju koja pogoršava krvarenje. Kod hipotenzivnih bolesnika bez traume glave s odsutnim perifernim pulsevima potrebno je primijeniti nadoknadu tekućine sve do povrata perifernog pulsa, odnosno postizanja sistoličkog tlaka od 90 mmHg koji je dovoljan za održavanje tkivne perfuzije. Ukoliko je prisutna i trauma glave preporuča se ograničena nadoknada volumena do ciljnog sistoličkog tlaka od 110 mmHg radi omogućavanja adekvatnog perfuzijskog tlaka i oksigenacije središnjeg živčanog sustava (10). Nužno je slijediti algoritam zbrinjavanja krvarenja i koagulopatije u politraumi te primijeniti traneksamičnu kiselinu ukoliko postoji sumnja na obilno krvarenje jer se pokazalo kako rana primjena traneksamične kiseline unutar tri sata od ozljede značajno smanjuje smrtnost (10).

Na mjestu nesreće ključna je brza stabilizacija i sprječavanje životno ugrožavajućih komplikacija, pri čemu transport ne smije biti odgađan radi sporednih postupaka.

Osnovni cilj zbrinjavanja penetrantne rane je spriječiti ulazak zraka između dva lista pleure. Nažalost, neminovno je da će do dolaska tima nešto zraka ući, a nastavit će ulaziti ukoliko postoji i pridružena ozljeda plućnog parenhima, pa je primarni cilj zbrinjavanja spriječiti nastanak tenzijskog pneumotoraksa. Obavezno se mora provjeriti i postojanje izlazne rane. Početno po dolasku na mjesto nesreće potrebno je zabrtviti ranu rukom u rukavici. U nedostatku boljeg, može se postaviti okluzija od sterilnog zavoja po čemu je potrebno staviti nepropusni plastični materijal te pričvrstiti isti sa sve četiri strane. Prethodne preporuke o lijepljenju tri od četiri strane radi mogućeg izlaska zraka iz prsne šupljine su napuštene prema najnovijim smjernicama (4). Danas su dostupne brojne tvornički pripremljene brtve s ili bez izlaznog ventila koje jednako učinkovito sprečavaju ulazak zraka kroz ranu i pomažu u početnoj stabilizaciji. No, zlatni standard su obloge s izlaznim ventilom koje sprječavaju ulazak novom zraku dok omogućavaju izlazak već skupljenog zraka i sprječavaju nastanak tenzijskog pneumotoraksa (11). Dostupne su brojne verzije istih od kojih je najpoznatija Ashermanova valvula.

Dekompresija pneumotoraksa u IHMS je prihvatljiva isključivo u slučaju visoke kliničke sumnje na tenzijski pneumotoraks i barem jednim znakom od slijedećih:

- respiracijski distres uz nisku perifernu saturaciju unatoč primijenjenim maksimalnim protocima kisika uz perifernu cijanozu
- hemodinamska nestabilnost unatoč svim poduzetim suportivnim mjerama
- poremećaj svijesti
- dugo vrijeme transporta do bolničke ustanove
- srčani arest (5)

Ukoliko je bolesnik hemodinamski stabilan ili se dostupnim neinvazivnim mjerama može postići stabilnost, ista se u IHMS ne preporuča radi visokog rizika nastanka jatrogenog pneumotoraksa. Postoji nekoliko načina dekompresije poput torakostomije prstom ili iglom i postavljanje torakalnog drena. Ukoliko je indicirano, u IHMS-u se preporuča koristiti dekompresiju iglom pri čemu se koristi igla promjera 14G ili šira i duljine 6-9 cm. Razlikujemo dva pristupa. U prednjem pristupu cilja se gornji rub donjeg rebra drugog međurebrenog prostora u medioklavikularnoj liniji. U bolesnika koji leže na leđima zrak se više nakuplja sprijeda radi čega je ovaj pristup pogodniji. Također, manja je mogućnost da tijekom transporta dođe do slučajnog pomaka igle. No, s obzirom na to da je sjenka prsnog koša na ovom mjestu nešto deblja (pretili ili bolesniki s razvijenim prsnim mišićima) igla može biti prekratka, a veća je i vjerojatnost ozljede vitalnih struktura poput srca i velikih krvnih žila (12). U lateralnom pristupu cilja se gornji rub donjeg rebra u 4. ili 5. interkostalnom prostoru u prednjoj aksilarnoj liniji. To je područje "sigurnog trokuta" odnosno površine tijela gdje je najmanja vjerojatnost doticaja s vitalnim strukturama, a omeđuje ga s prednje strane lateralni rub m. pectoralis major, sa stražnje strane prednji rub m. latissimus

dorsi, s donje strane linija u ravnini 5. interkostalnog prostora, a s gornje strane aksile. Ovdje je stijenka prsnog koša tanja, no veća je mogućnost slučajnog pomicanja katetera tijekom transporta. Nakon uspješno plasirane igle čuje se šuštanje zraka, a preko se mora staviti okluzivni pokrov, najbolje s ventilom (12). Istraživanja su pokazala kako dekompresija iglom na mjestu nesreće smanjuje smrtnost unutar 24 sata u usporedbi s torakalnom drenažom unutar 15 min od dolaska u bolnicu (13). No isto tako, druga istraživanja su pokazala kako je često procjena postojanja tenzijskog pneumotoraksa na terenu pogrešna, pa je i dekompresija iglom neuspješna uz veći rizik od komplikacija i lošijeg ishoda za bolesnike (14). Kod dekompresije prstom također se koristi prednji ili lateralni pristup kad se na gore opisanim anatomskim lokacijama zareže koža te se podležeće tkivo disecira dostupnim tupim sterilnim intrumentom nakon čega se umetne prst do kad se ne osjeti rahlo tkivo pluća. Naknadno se može uvoditi i torakalni dren, a mjesto se mora zbrinuti okluzivnim pokrovom (12).

Primjena okluzivnih obloga s ventilom i pravovremena dekompresija pneumotoraksa značajno smanjuju rizik od tenzijskog pneumotoraksa te smrtnosti.

Treba imati na umu i imobilizaciju bolesnika sa zadobivenim ubodnim ranama. Imobilizacija kralježnice neće biti potrebna ukoliko je bolesnik pri svijesti i bez neurološkog ispada, a ozljeda je izolirana i nije nanijeta visokom energijom uz odbacivanje bolesnika.

Naposljetku, bitno je istaknuti kako će dolaskom u zdravstvenu ustanovu kod većine bolesnika s izoliranim penetrantnim ranama prsnog koša biti nastavljeno konzervativno liječenje započeto na terenu, dok će većini onih koji trebaju pristupiti kirurškom zbrinjavanju biti dovoljna torakalna drenaža, a tek će manji postotak morati pristupiti torakotomiji (15).

Zaključak

Razvojem izvanbolničke hitne medicinske službe i pravilnom edukacijom, ona više ne služi isključivo transportu bolesnika, već pridonosi i početnoj stabilizaciji te povećanom preživljavanju životno ugroženih bolesnika. Bitno je poznavati granice zbrinjavanja bolesnika na terenu i ne odgađati transport vitalno ugroženih pacijenata, ali tijekom samog transporta osigurati pravilno zbrinjavanje. Komunikacija između zemaljskog tima koji prvi pristupa bolesniku, aktivacija helikopterske hitne službe prema indikaciji te upućivanje bolesnika u odgovarajuću bolničku ustanovu s mogućnostima zbrinjavanja specifičnih stanja ključni su za optimalan ishod.

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REVIEW ARTICLE / PREGLEDNI ČLANAK

PATIENT SAFETY IN THE EMERGENCY DEPARTMENT

SIGURNOST BOLESNIKA U HITNOM BOLNIČKOM PRIJAMU

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Abstract

Patient safety in the emergency department (ED) is a major concern because this high-pressure setting combines crowded conditions, rapid decision making, and frequent handovers, all of which increase the risk of error. Common threats include diagnostic delays, communication failures, and especially medication errors, which affect over one third of ED patients in some studies. Crowding, multitasking, and interruptions further raise the likelihood of patient misidentification and wrong patient orders. Medication safety is a central focus of ED safety strategies.

Systematic reviews show many errors occur during prescribing and administration, with dosing mistakes and wrong application frequency particularly numerous. Involving clinical pharmacists at the point of care, standardizing order sets, and using electronic prescribing with decision support can help intercept these errors before they reach patients. Clear allergy checks, weight-based dosing protocols, and barcode verification provide additional safeguards. Structured tools and culture change are critical for safer ED care. Expert developed emergency department safety checklists define key tasks at triage, assessment, treatment, and disposition to prevent "never events" such as wrong patient treatment, missed vital sign abnormalities, and equipment failures.

Team training that emphasizes communication, leadership, situational awareness, and effective workload distribution improves how staff respond to complex or deteriorating patients. Underpinning all these measures is a strong safety culture that encourages reporting, learning from incidents, and continuous improvement, enabling the ED to achieve its role as a reliable safety net for acutely ill and injured patients.

Key words: communication; emergency medicine; patient safety

Sažetak

Sigurnost bolesnika u hitnoj službi predstavlja veliki problem. Okruženje velikog izazova povezuje gužvu, brzo donošenje odluka i učestalu predaju bolesnika i podataka, što sve povećava rizik od pogrešaka. Uobičajene ugroze uključuju kašnjenja u dijagnostici, neuspjehe u komunikaciji, a posebno pogreške u primjeni lijekova, koje u nekim studijama pogađaju više od trećine bolesnika u medicinskoj službi. Gužva, višezadaćnost (engl. *multitasking*) i prekidi dodatno povećavaju vjerojatnost pogrešne identifikacije bolesnika i pogrešnih naloga. Sigurnost lijekova središnje je žarište strategije sigurnosti u medicinskoj službi. Sustavni pregledi literature pokazuju da se tijekom propisivanja i primjene lijekova događa veliki broj pogrešaka, pri čemu su pogreške u doziranju i primjeni lijeka najčešće.

Uključivanje kliničkih farmaceuta na mjestu pružanja skrbi, standardizacija naloga i korištenje elektroničkog propisivanja lijeka uz podršku u odlučivanju može pomoći u sprečavanju ovih pogrešaka prije nego što utječu na bolesnika. Jasne provjere alergija, protokoli doziranja temeljeni na tjelesnoj težini i provjera *barkodova* pružaju dodatne zaštitne mjere. Strukturirani alati i promjena kulture ključni su za sigurniju skrb u hitnoj službi. Stručno razvijene sigurnosne kontrolne liste hitnih odjela definiraju ključne

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zadatke u trijaži, procjeni i liječenju kako bi se spriječili nepoželjni ishodi poput pogrešnog liječenja, propuštenih poremećenih vitalnih pokazatelja i kvarova opreme. Timska obuka koja naglašava komunikaciju, vodstvo, situacijsku svijest i učinkovitu raspodjelu radnog opterećenja poboljšava način na koji osoblje reagira na bolesnike sa složenim stanjima ili one koji se naglo urušavaju.

Temelj svih ovih mjera je snažna sigurnosna kultura koja potiče prijavljivanje, učenje iz incidenata i kontinuirano poboljšanje, omogućujući hitnoj medicinskoj službi da ostvari svoju ulogu pouzdane sigurnosne mreže za akutno bolesne i ozlijeđene bolesnike.

Ključne riječi: hitna medicina; komunikacija; sigurnost bolesnika

Introduction

Patient safety in emergency departments (EDs) is challenged by overcrowding, time pressure, case complexity and system weaknesses that increase the risk of preventable harm. This narrative review summarizes key safety concerns in EDs, underlying contributory factors and evidence based strategies to improve safety, including the influence of ethical frameworks such as the Helsinki Declaration, medication safety technologies like pre-filled syringes, and the roles of safety culture and safety climate (1-9).

The ED is one of the most unpredictable and stressful hospital environments, where rapid decisions under uncertainty are routine and seconds can be crucial for survival. High patient acuity, frequent interruptions, and simultaneous management of multiple unstable patients make the ED particularly vulnerable to errors in assessment, diagnosis, treatment, and transitions of care. Reviews show that crowding, inadequate staffing, suboptimal teamwork, poor communication, and deficient incident learning systems are recurrent determinants of patient safety incidents in EDs worldwide. Understanding how these factors interact at the levels of individuals, teams and organizations is essential for designing interventions that can realistically improve safety in this complex setting (1-3,7). This review focuses on acute care delivered in hospital EDs and synthesizes recent evidence on major safety domains: safety culture and climate, clinical risk areas (diagnostic error, medication safety, infection prevention and procedural risks), environmental and organizational factors such as overcrowding, and cross-cutting strategies to strengthen safety management. The aim is a clinically oriented overview that can inform local quality improvement initiatives in emergency services, aligned with contemporary international patient safety recommendations and ethical declarations relevant to emergency and peri-anaesthetic care (6,8-10).

Discussion

This is a narrative, non-systematic review that uses a selective literature approach, suitable for an educational overview of patient safety in emergency medicine. Recent qualitative, quantitative and mixed methods studies, as well as systematic or scoping reviews focusing on patient safety, safety culture or safety climate in EDs and pre-hospital emergency care, were prioritized, particularly those published in the last decade. Key sources included studies of safety culture among emergency nurses and physicians, analyses of contributing factors to ED safety incidents, research on medication safety and pre-filled syringes, and international surveys of safety climate in emergency services (5-9).

We searched the Medline database through the publicly available PubMed interface in the time period from 2010 to 2025. All included literature was published in English or German. In this search, we were using Boolean search technique with the operators 'AND', 'OR' and 'NOT'. The inclusion criteria were review articles, retrospective observational studies and meta-analyses on risks, safety and communication under working conditions in ED. Exclusion criteria during the search were articles that were published in languages other than English or German, data available only in abstracts, editorials and letters to the editor. According to the terms within the list of *Medical Subject Headings (MeSH) of the Medicus Index*, we searched for the terms *patient safety, emergency medicine, communication, diagnostic errors and risk management.* Based on the processed data from the selected 21 papers, this review article was written.

Conceptually, the review is organized around three interrelated levels that influence patient safety: 1) individual and team behaviour (knowledge, skills, communication, adherence to safety standards); 2) local work systems (workflow design, protocols, equipment, information systems, including drug delivery systems such as pre-loaded syringes); and 3) organizational

context (culture, climate, leadership, staffing, crowding and policies for learning from incidents). Within this framework, we highlight prominent risk domains—medication safety, infection prevention, diagnostic reliability, environmental and ethical challenges—and map them to evidence based or promising interventions including those inspired by the Helsinki Declaration on Patient Safety in Anaesthesiology (8,10).

Safety culture and safety climate

Safety culture and safety climate are related but distinct constructs that are both central to understanding patient safety in emergency settings. Safety culture refers to the deeper, relatively stable shared values, beliefs and norms about safety in an organization "how we do things around here" including leadership commitment, learning orientation and just responses to error. Safety climate is the measurable snapshot of this culture at a given point in time, typically captured through staff surveys assessing perceptions of management support, teamwork, communication and safety policies (8,9). In EDs, studies indicate that staff perceive patient safety as fragile, shaped by competing pressures between rapid throughput and thorough, error free care. A scoping review exploring safety culture in emergency departments revealed that overcrowding, interruptions, and heavy workloads were identified as major risks. Staff frequently reported near misses and incidents, though these were not always officially documented.

Qualitative work among emergency nurses identified four broad themes undermining safety management: negligence of safety standards and precautions, disregard of ethical principles, professional challenges (such as inadequate training and role conflicts) and inefficient organizational management (1,2). International cross sectional studies of pre-hospital emergency personnel report generally moderate safety climate scores, with weaker perceptions in domains such as teamwork climate, management perception and working conditions. Organizational characteristics—including employment status, position type and work area—have a stronger influence on safety climate than individual factors, underscoring the impact of system design and leadership. Better perceived safety climate is associated with safer behaviour; higher safety awareness, competence and communication correlate with improved safety compliance and participation among emergency workers, whereas poor organizational environments are negatively linked to safety performance (6,8,9). Overall, the safety culture in many EDs appears characterized by high individual commitment to patient care but limited systemic support, inconsistent team communication, and underdeveloped mechanisms for collective learning. Strengthening both the underlying culture and the observable climate is therefore a key target for improving safety in emergency care (6,8).

Overcrowding, workload and environment

ED overcrowding, operating beyond optimal capacity is strongly associated with delays in time critical treatments, hallway care, and increased in hospital mortality. When demand exceeds capacity, clinicians must triage more aggressively, manage patients in non-designated spaces, and multitask under constant time pressure, all of which heighten the risk of omissions and errors. Overcrowding also erodes privacy and confidentiality, impairs communication with patients and families, and limits opportunities for supervision of junior staff (3,7). ED patient safety is influenced by both safety culture and safety climate, as well as overcrowding, workload, and environmental constraints, all of which interact to affect communication, teamwork, and the risk of errors and adverse events.

Environmental factors such as noise, poor physical layout, inadequate equipment availability and frequent interruptions further compound the impact of crowding. Staff describe working in cramped spaces with limited visibility of patients, which can delay recognition of deterioration and complicate safe performance of procedures. High turnover and boarding of admitted patients in the ED contribute to prolonged stays, increasing exposure to hospital acquired infections and adverse events. Together, these environmental stresses create conditions in which even experienced teams find it difficult to maintain consistently safe care (1-3,7).

Medication safety and pre-loaded syringes

Medication errors represent one of the most frequently reported categories of safety incidents in EDs. Errors occur at prescribing, dispensing and administration stages and include wrong dose, wrong drug, wrong route and omissions, often linked to time pressure, illegible orders, interruptions, and confusion between look alike/sound alike drugs. Incomplete medication reconciliation at triage or admission increases the risk of duplication, drug–drug interactions and omission of chronic therapies, especially in older patients with polypharmacy (3,11).

Pre-loaded and clearly labelled syringes have emerged as an important strategy to reduce medication related risk and treatment delays in emergency care. When clinicians draw up drugs from ampoules under time pressure, they are exposed to hazards such as glass cuts, contamination by glass particles, and misreading of small or smeared labels; similar looking ampoules can also be confused. Those syringes, produced under controlled conditions, are sterile, single use products with standardized labeling that clearly states drug name, concentration and expiry, thereby reducing selection and labelling errors (5,7,11).

Evidence from simulation studies show that colour coded, pre-filled medication syringes decrease both time to drug delivery and dosing error rates in simulated paediatric ED resuscitations. In one study, nurses took on average 156 seconds to start infusions using pre- filled syringes compared with 276 seconds when preparing infusions manually, a reduction of about 106 seconds, which is clinically relevant in shock or arrest. Pre-filled syringes also minimize dose preparation losses and help ensure that the patient receives the precise ordered dose, which is critical for high-risk medications such as vasopressors, sedatives and anticonvulsants. Although unit costs are higher, analyses suggest that their routine use in emergency departments may reduce total costs by preventing complications and occupational injuries associated with drug preparation errors (11).

Strategies such as electronic prescribing, barcode medication administration, standardized order sets and involvement of clinical pharmacists can work synergistically to improve medication safety in EDs when integrated into the existing workflow (5,11).

Infection prevention and standard precautions

Adherence to infection prevention and control measures is a core component of patient safety but is frequently compromised in emergency settings. Nurses and physicians report that hand hygiene, use of personal protective equipment (PPE) and aseptic technique during procedures can be neglected under workload and time pressure. In one qualitative study, participants explicitly identified "non hygienic bandaging", neglect of hygiene rules and unsafe transfers as manifestations of poor adherence to standard precautions in EDs (1,2).

The ED environment, with crowded waiting rooms and prolonged stays in shared spaces, facilitates transmission of respiratory and gastrointestinal pathogens if infection control measures are inconsistently applied. Inadequate isolation facilities, delayed recognition of infectious patients and limited staff training on updated infection control protocols further weaken defences. Strengthening infection prevention in EDs requires not only education but also redesign of workflows and environments to make the safe action the default—such as accessible hand rub dispensers, clear signage, standardized PPE stations at points of care, and rapid triage pathways for suspected infectious cases (5,7).

Diagnostic error and clinical decision making

Diagnostic error is an important but often under recognized source of patient harm in EDs, where clinicians must rapidly evaluate undifferentiated symptoms with limited information. Systematic reviews of ED safety incidents highlight missed or delayed diagnoses among the most serious events, including misrecognition of sepsis, myocardial infarction, stroke and serious trauma. Contributing factors include atypical presentations, incomplete histories due to communication barriers, insufficient observation time and cognitive biases such as anchoring and premature closure under time pressure (3,9).

Crowding and interruptions exacerbate diagnostic risk by limiting time for thorough assessment, physical examination and re-evaluation. In some settings, lack of immediate access to imaging or laboratory tests and delays in reporting results further increase diagnostic uncertainty. Interventions such as standardized triage protocols, clinical decision support tools, structured handover templates, and checklists for high-risk conditions have shown promise in reducing diagnostic errors, although implementation in EDs is variable (2,3,6,9).

Communication, teamwork, ethics and Helsinki Declaration

Effective interprofessional communication and teamwork are central determinants of safety in emergency care. Studies report that lack of effective teamwork, particularly during patient transfers and handovers, is a major weakness in ED safety management. Problems include unclear role allocation, hierarchical barriers, incomplete handover information and failure to speak up about safety concerns, especially in high intensity resuscitations and mass casualty events (1,2,4). Ethical challenges intersect with safety concerns when resource constraints, crowding and high workload force clinicians to make difficult prioritization decisions. Qualitative work describes instances of compromised informed consent, insufficient privacy, and limited communication with patients and families due to time constraints, all of which may undermine trust and lead to misunderstandings about care plans. Disregard of overcrowded spaces is perceived by staff as both a moral and a safety issue, since it can contribute to conflict, non-adherence and complaints (2,4).

The Helsinki Declaration on Patient Safety in Anaesthesiology, endorsed by European professional bodies, offers an ethical and practical framework that is highly relevant to emergency medicine. It recognizes that anaesthesiologists share responsibility for quality and safety across the perioperative process and in many emergency situations inside and outside the hospital where patients are most vulnerable. The Declaration promotes minimum monitoring standards, standardized protocols for high risk situations, availability of essential equipment and drugs, and institutional commitment to safety management systems (12-16).

For EDs, Helsinki based principles translate into expectations such as continuous physiological monitoring appropriate to the patient's condition, access to properly maintained resuscitation equipment, standard operating procedures for airway management, sedation and analgesia, and structured training in crisis resource management and team communication. The Declaration also emphasizes non punitive incident reporting, leadership responsibility for safety and regular audit of critical events, which align with recommendations for ED safety culture and learning from incidents. Integrating these principles into ED policies can thus provide a coherent ethical and professional framework linking anaesthesia, intensive

care and emergency medicine around shared patient safety goals (15,17). Finally, the Declaration of Helsinki defines international standards for the safety of sedation, anaesthesia and airway management, which are directly applicable in ED where such interventions are often carried out in emergency and high-risk situations.

Organizational management and incident learning

Inefficient organizational management is a recurring theme in studies of ED patient safety. Staff report that inadequate staffing levels, lack of experienced personnel, and insufficient support from hospital leadership contribute to burnout, turnover, and inconsistent application of safety protocols. In some departments, incident reporting systems exist but are underused due to perceptions that reporting is time consuming, leads to blame, or does not result in meaningful change (7,18).

A systematic review of learning from patient safety incidents in EDs highlights that while many contributing factors are recognized—such as communication failures, environmental constraints and human factors—structured mechanisms to translate incident analysis into system level improvements are often lacking. Successful learning requires non punitive reporting cultures, multidisciplinary morbidity and mortality reviews, and feedback loops that demonstrate to frontline staff how their reports lead to tangible changes in practice or equipment. Organizational leadership plays a crucial role in allocating resources, setting expectations, and modelling behaviours that prioritize safety over throughput when the two are in tension (19,20). ED safety is limited by organizational weaknesses, poor incident learning, and underused reporting systems, while leadership, structured feedback, and new tools like AI can support improvements.

Applications of Generative AI in Emergency Departments

Artificial intelligence is entering all areas of medicine and is therefore promising in EDs as well. For clinicians, generative AI has the potential to alleviate the burden of documentation by automating routine tasks. It can streamline searches within electronic health records (EHR), facilitating rapid access to relevant patient data. Additionally, AI tools can support medical decision-making, assisting clinicians in evaluating complex cases and improving the accuracy and efficiency of their clinical judgements. Beyond clinical use, generative AI demonstrates value in handling administrative tasks. It can optimise processes such as billing, coding, and insurance authorisation, contributing to improved operational efficiency within healthcare organisations (21).

Conclusion

Patient safety in emergency rooms is threatened by an interplay of human, technical and organizational factors, including overcrowding, high workload, diagnostic complexity, medication risks, infection control challenges, and weaknesses in teamwork, safety culture and safety climate. Studies from diverse settings show that frontline staff are acutely aware of these vulnerabilities, highlighting negligence of safety standards, ethical tensions, professional challenges, and inefficient management as major barriers to safe care. At the same time, there is growing evidence that structured interventions range from flow management and medication safety systems such as pre-filled syringes to team training, standardized handovers, and robust incident learning processes can meaningfully reduce risk when supported by strong leadership and a just culture.

The Helsinki Declaration on Patient Safety in Anaesthesiology provides a unifying ethical and professional framework that can guide safety improvements in EDs by emphasizing monitoring standards, equipment availability, crisis management training and non-punitive learning from incidents. For emergency departments seeking to improve patient safety, a pragmatic strategy is to prioritize a small number of high impact domains—crowding management, medication safety (including pre-loaded and labelled syringes), and communication at handover—while progressively building an organizational culture and climate that value transparency, learning and interprofessional collaboration. Ongoing research is needed to adapt and evaluate safety interventions specifically in ED and pre-hospital contexts, and to incorporate patient and family perspectives into safety initiatives, so that the speed and intensity of emergency care do not come at the cost of avoidable harm.

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