Journal of Rural Medicine

Original article

Accuracy of early shock recognition by paramedics: a multicenter prospective observational study in Japan

Rina Tanohata[1], Katsutoshi Saito[1], Takehiko Nagano[1], and Hidenobu Ochiai[1]

[1]*Department of Emergency, Critical Care, and Disaster Medicine, University of Miyazaki Hospital, Japan*

Abstract

Objective: Early recognition of shock status by paramedics significantly affects patient prognosis; however, its accuracy remains unclear. This study assessed the diagnostic accuracy of paramedics in classifying shock and the characteristics of misdiagnoses.
Materials and Methods: This multicenter prospective observational study compared the on-scene shock diagnoses of paramedics between July 2022 and June 2023 with those of physicians upon hospital arrival.
Results: The overall diagnostic accuracy for shock revealed substantial agreement (k=0.64), whereas diagnosis by category ranged from slight to moderate agreement (k=0.11–0.51). Patients without systolic hypotension were more frequently missed during diagnosis.
Conclusions: Enhanced clinical education is needed to improve the accuracy of shock diagnosis by paramedics.

Key words : paramedics, emergency medical services, shock diagnosis, clinical education

(J Rural Med 2025; 20(2): 125–131)

Introduction

Shock is characterized by tissue damage resulting from peripheral circulatory failure. In the early stages of shock, compensatory mechanisms maintain systemic perfusion; however, when these mechanisms fail, organ dysfunction occurs, ultimately leading to death. The in-hospital mortality rate for patients who experience shock in the pre-hospital setting is estimated at 33–52%[1], underscoring the critical need for accurate assessment and resuscitation to save lives[2]. However, the standardized criteria for the clinical diagnosis of shock remain unclear. The diagnosis of shock is based on a combination of the following indicators: unstable vital signs, pallor, prostration, perspiration, pulselessness, pulmonary deficiency (five signs of shock), blood gas analysis, ultrasonography, shock index, and quick sequential organ failure assessment score. Shock is classified into four categories based on its etiology: hypovolemic, cardiogenic, distributive, and obstructive, all requiring appropriate diagnosis and prompt treatment at a higher-level medical institution, given the need for different treatment strategies.

Paramedics are medical personnel who are usually the first responders to patients at an emergency scene. They are responsible for identifying critically ill patients and administering life-saving treatments. Accurate diagnosis of shock by paramedics has been reported to play a major role in patient prognosis[3], highlighting the critical role of paramedics and the importance of their presence during casualties. However, the accuracy of paramedics' diagnosis in patients with shock remains unclear. To our knowledge, no study has investigated the diagnostic accuracy of shock recognition by paramedics. This study aimed to investigate the accuracy of shock diagnoses by paramedics.

Received: November 11, 2024
Accepted: January 15, 2025
Correspondence: Rina Tanohata, Department of Emergency, Critical Care, and Disaster Medicine, University of Miyazaki Hospital, 5200 Kihara, Kiyotake, Miyazaki City, Miyazaki 889-1601, Japan
E-mail: rina_tanohata@med.miyazaki-ac.jp

Materials and Methods

Research participants

This multicenter prospective observational study included patients transported to 11 designated emergency medical facilities (three Emergency and Critical Care Centers and eight secondary emergency medical facilities) in Miyazaki Prefecture from July 1, 2022, to June 30, 2023. Patients aged <18 years, those with cardiopulmonary arrest, and those deemed unsuitable by the investigators were excluded.

Research flow

From the time the paramedics first encountered the patient at the emergency scene until they transferred care to a physician at a medical facility or in front of a hospital, they recorded their shock diagnosis on a predistributed survey form and submitted it to the receiving medical institution. Next, the medical staff at the facility recorded the physicians' examinations, laboratory findings, and diagnoses on the same survey form submitted by the paramedics. Finally, the principal investigator collected the survey forms and compared the shock diagnoses of the paramedics and physicians. In cases involving helicopter emergency medical services (HEMS) or physician-staffed ground emergency medical services (GEMS) at the scene of the emergency, the results of the physician's diagnosis and examination at the time of handover from paramedics to physicians were compared.

Survey questions

We collected information on the paramedics, injured persons, and medical facilities. Data regarding the paramedics included age, sex, paramedic history, and whether shock was diagnosed. In patients where shock was diagnosed, parameters such as the classification of shock, the basis for diagnosing shock, whether emergency medical care was provided, and whether the diagnosis was difficult were recorded. Patient data included age, sex, etiology, worst vital signs during the pre-hospital phase, and how the patient was transported. Data regarding the medical facilities included the certification status of the diagnosing physician by the board of the Japanese Association for Acute Medicine, whether shock was diagnosed, classification of shock if applicable, diagnosis, and results of blood gas analysis. Multiple options were available for shock classification and diagnostic criteria.

The primary endpoint was the accuracy of shock diagnosis by the paramedics. The secondary endpoints were the accuracy of the paramedics' shock classification and the characteristics of misdiagnosed patients. Among the misdiagnosed patients, undertriaged patients who deteriorated to life-threatening conditions were further analyzed based on the patients' diagnoses.

Definitions of shock and misdiagnosis groups (overtriage group and undertriage group)

The "shock group" included patients who were diagnosed with shock by both the paramedics and physicians. The patients diagnosed with shock by the paramedics but not the physicians were included in the "overtriage group", while those diagnosed as not having shock by the paramedics but diagnosed as having shock by the physicians were included in the "undertriage group".

Statistical analysis

Statistical analyses were performed using IBM SPSS (ver. 23) and EZR (ver. 1.68)[4]. Continuous variables were tested for normality using the Kolmogorov–Smirnov test, with normal distributions expressed as mean (standard deviation [SD]) and non-normal distributions as median (interquartile range [IQR]). The agreement between paramedics and physicians was expressed as a k-coefficient (Cohen's Kappa)[5].

A univariate analysis was performed to compare the items between the shock and undertriage groups. For continuous variables, the t-test was used for mean comparisons, and the Mann–Whitney U test was used for median comparisons. Fisher's exact test was used for nominal variables. Weighted logistic regression analysis using propensity scores and inverse probability of treatment weighting was used to evaluate the factors associated with robust estimation to prevent the underestimation of standard errors. Independent variables were entered using the enter method with reference to reported factors associated with misdiagnosis, including years of paramedic experience and patient's sex (female), age[6–9], and National Early Warning Score 2[10]. Statistical significance was set at $P<0.05$.

Ethical consideration and consent to participate

This study was approved by the Institutional Review Board of the University of Miyazaki Hospital (O-1147). Information on the implementation of this study is publicly available on the hospital website. A public notice document was posted to each collaborating institution.

Results

Survey forms were collected from 3,353 participants. Of these, 182 (5.4%) were excluded, and 3,171 (94.6%) were included in the analysis. Paramedics diagnosed shock in 455 (14.3%) patients, of which 261 (57.3%) diagnoses were confirmed by a physician. Of the 455 patients (14.3%) diagnosed with shock by paramedics, 194 (42.6%) were not confirmed by a physician (overtriage). Of the 2,716 patients (85.7%) not diagnosed with shock by paramedics, 53 (1.9%) were diagnosed with shock by a physician (undertriaged) (Figure 1).

The median (IQR) age of the paramedics was 38 (35–45) years, 3,169 (99.9%) were male, and the median experience as a paramedic was 8 (4–13) years. Overall, 455 patients (14.3%) were diagnosed with shock. Of these patients, 199 were diagnosed with hypovolemic shock, 145 with cardio-

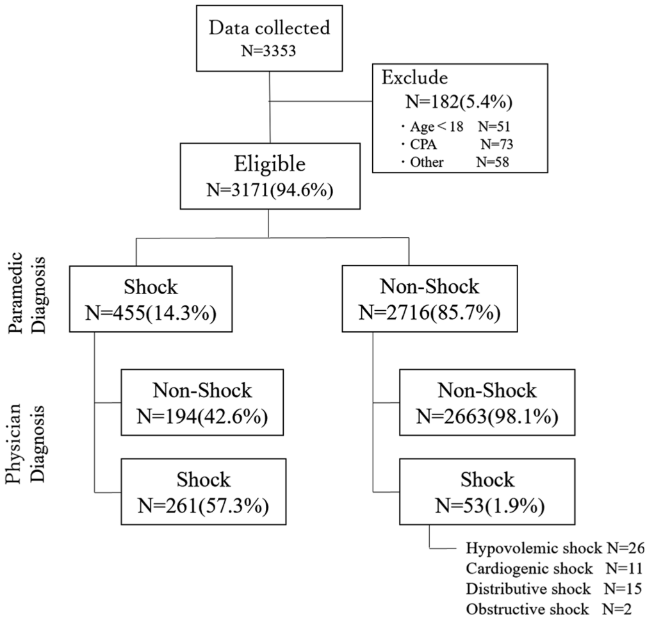

Figure 1 Study diagram.
CPA: Cardiopulmonary Resuscitation; Age <18: patients under 18 years of age; Other: cases deemed inappropriate by the study investigator. Shock: Number of patients diagnosed with shock; Non-Shock: Number of patients not diagnosed with shock.

Table 1 Basic data of 3,171 patients analyzed

Paramedics		
Background		
Age	median (IQR)	38 (35–45)
Male	n (%)	3,169 (99.9)
Years of experience as paramedics	median (IQR)	8 (4–13)
Diagnosis of shock	n (%)	455 (14.3)
Diagnosis of shock classification*		
Hypovolemic shock		199
Cardiogenic shock		145
Distributive shock		75
Obstructive shock		11
Unclassified		73
Patients		
Background		
Age	median (IQR)	76 (63–86)
Male	n (%)	1,706 (53.8)
Intrinsic diseases	n (%)	2,298 (72.4)
Transport		
Ambulance	n (%)	3,007 (94.8)
HEMS	n (%)	62 (1.9)
GEMS	n (%)	102 (3.2)
Physicians		
Background		
Board certified emergency physician	n (%)	1,129 (35.6)
Shock diagnosis	n (%)	314 (9.9)
Diagnosis of shock classification*		
Hypovolemic shock		154
Cardiogenic shock		72
Distributive shock		98
Obstructive shock		7

*Multiple responses allowed.
HEMS: Helicopter Emergency Medical Services; GEMS: physician-staffed Ground Emergency Medical Services.

genic shock, 75 with distributive shock, and 11 with obstructive shock. The median (IQR) age of the injured/ill patients was 76 (63–86) years, with 1,706 (53.8%) being male and 2,298 (72.4%) patients having preexisting medical conditions. The majority of the 3,007 (94.8%) patients with injuries were transported by ambulance (62 [1.9%] by HEMS and 102 [3.2%] by GEMS).

Physicians diagnosed 341 (9.9%) patients with 154 with hypovolemic shock, 72 with cardiogenic shock, 98 with distributive shock, and 7 with obstructive shock. (Table 1). Of the 3,171 patients assessed by physicians, 1,129 (35.6%) were examined by board-certified emergency physicians, and 135 (12%) were diagnosed with shock.

The paramedics' diagnosis of shock had a sensitivity of 83%, specificity of 93%, positive predictive value of 57%, negative predictive value of 98%, and agreement rate of k=0.64. The shock classification for hypovolemic shock showed 61% sensitivity, 93% specificity, 47% positive predictive value, 98% negative predictive value, and k=0.51; that for cardiogenic shock showed 75% sensitivity, 97% specificity, 37% positive predictive value, 99% negative predictive value, and k=0.48; that for distributive shock showed 39% sensitivity, 99% specificity, 51% positive predictive value, 98% negative predictive value, and k=0.42, and that for distributive shock showed 14% sensitivity, 99% specificity, 9% positive predictive value, and 99% negative predictive value, and k=0.11 (Table 2).

Overtriage was observed in 194 patients (42.6%). In the univariate analysis comparing the shock and overtriage groups, the overtriage group showed significantly more normal values, including a median on-scene consciousness level (Japan Coma Scale) of 1 (IQR, 0–10; P=0.003), median systolic blood pressure (SBP) of 95 mmHg (IQR, 77–130; P<0.001), median diastolic blood pressure of 61 mmHg (IQR, 49–82; P<0.001), and median SpO_2 value of 97% (IQR, 93–99; P=0.002). Furthermore, the overtriage group had more patients with neurological diseases (10 patients, 5.2%; P<0.001) and trauma (31 patients, 16%; P=0.04), with statistically significant differences observed in both groups. In contrast, 53 (1.9%) paramedics experienced undertriage. Twenty-six patients were diagnosed with hypovolemic shock, 11 with cardiogenic shock, 15 with distributive shock, and two with obstructive shock. In the univariate

Table 2 Accuracy of paramedics' shock diagnoses

	Sensitivity (%)	Specificity (%)	Positive predictive value (%)	Negative predictive value (%)	k*
Diagnosis of shock	83	93	57	98	0.64
Diagnosis of shock classification[‡]					
Hypovolemic shock	61	97	47	98	0.51
Cardiogenic shock	75	97	37	99	0.48
Distributive Shock	39	99	51	98	0.42
Obstructive shock	14	99	9	99	0.11

*k, Cohen's Kappa; <0: No agreement, 0.00–0.20: Slight agreement, 0.21–0.40: Fair agreement, 0.41–0.60: Moderate agreement, 0.61–0.80: Substantial agreement, 0.81–1.00: Almost perfect agreement.

[‡]Multiple responses allowed.

analysis comparing the shock and undertriage groups, the undertriage group demonstrated significantly higher values, including a median respiratory rate of 29 breaths/min (IQR, 20–32; P=0.019) and a median pulse rate of 110 bpm (IQR, 86–134; P=0.006), than the shock group. No statistically significant differences were observed for any specific diseases in the undertriage group (Table 3). Weighted logistic regression analysis identified SBP (odds ratio: 0.988, 95% confidence interval: 0.98–0.996, P-value=0.005) as a significant variable in the pre-hospital phase (Table 4).

Discussion

In this study, paramedics' diagnosis of shock showed substantial agreement with that of physicians, suggesting that paramedics can diagnose shock accurately, and this may contribute significantly to saving patients' lives. Although several studies have examined the accuracy of paramedics' diagnosis under various conditions, to our knowledge, no study has specifically evaluated the accuracy of paramedics' diagnosis of shock, indicating the novelty of our study.

The overall diagnostic accuracy for shock was high; however, the results varied from slight to moderate agreement for the different classifications. The diagnostic accuracy rates for cardiogenic and hypovolemic shocks were relatively high, whereas those for distributive and obstructive shocks were low. This may be due to the more recognizable modes of onset and typical symptoms associated with cardiogenic and hypovolemic shock. Distributive shock is characterized by skin flushing and warmth (warm shock), whereas obstructive shock is characterized by dyspnea and jugular vein distension. The difficulty in distinguishing these conditions from others with similar symptoms may have contributed to the lower diagnostic accuracy.

Paramedics play a critical role in patient prognosis when undertriage occurs. We observed that patients with a higher SBP had a greater risk of missed shock diagnoses. SBP is a crucial indicator of shock, with <90 mmHg generally considered the threshold for hypotension[11]. However, hypotension alone does not confirm shock in patients[1]. In the early stages of shock, compensatory mechanisms maintain perfusion and prevent hypotension. Thus, relying solely on blood pressure to diagnose shock may be insufficient, and a comprehensive assessment is crucial for an accurate diagnosis. Although these findings are widely recognized, this study revealed that patients with maintained blood pressure were still undertriaged, suggesting a potential reliance on blood pressure when diagnosing patients with shock. Paramedics should understand compensatory shock as a situation in which blood pressure remains within the normal range, even during shock. Additionally, a previous report[12] suggested that a SBP threshold of <100–110 mmHg, rather than <90 mmHg, considered a diagnostic criterion for shock, may be useful for identifying patients with shock. Therefore, the criteria for shock and SBP should be examined to ensure that patients with shock are appropriately evaluated.

Educating paramedics is essential for improving their accuracy in diagnosing patients with shock. Previous studies have reported that high diagnostic accuracy depends on the educational background and experience of the paramedics[13], suggesting that ongoing education and training are crucial. Although paramedics are medical professionals, they are unique in that they operate outside hospitals and must be able to arrive at diagnoses in challenging pre-hospital environments with limited equipment and resources. Therefore, to improve the accuracy of patient diagnoses even in limited environments, it is important to conduct clinical education in medical institutions where critically ill patients are transported. Paramedics at medical institutions must be trained to comprehensively evaluate the vital signs and physical findings of shock patients, and how they arrived at the diagnosis must be discussed in an educational setting. Additionally, paramedics must be educated in the emergency room and taught about shock patient management beyond the emergency room, including the treatment and progression of shock after hospitalization. The use of ultrasonography for diagnosing shock should also be considered. Rapid ultrasound in shock examination (RUSH)[14]

Table 3 Univariate analysis results for the shock group vs. the overtriage and undertriage groups

		Shock group (N=261)	Overtriage group (N=194)	Undertriage group (N=53)	Univariate analysis (P-value†)	
					Shock group vs. Overtriage group	Shock group vs. Undertriage group
Paramedics						
Age	Mean ± SD	40 ± 6	38 ± 7	40 ± 8	0.67	0.33
Male	n (%)	261 (100)	193 (99.4)	53 (100)	0.42	-
Years of experience as paramedics		7 (4–12)	7 (4–11)	9 (4–15)	0.34	0.86
Patient						
Age		80 (67–87)	77 (63–85)	76 (67–87)	0.33	0.23
Male	n (%)	154 (59)	126 (65)	36 (68)	0.21	0.28
Female	n (%)	105 (40)	66 (34)	17 (32)	0.2	0.27
Vital signs (pre-hospital)						
JCS		3 (0–100)	1 (0–10)	1 (0–3)	**0.003**	**0.001**
RP, /min		24 (20–30)	24 (20–30)	29 (20–32)	0.19	**0.019**
HR, /min		94 (70–120)	88 (72–107)	110 (86–134)	0.2	**0.006**
SBP, mmHg		82 (71–96)	95 (77–130)	109 (92–128)	**<0.001**	**<0.001**
DBP, mmHg		50 (41–63)	61 (49–82)	64 (51–80)	**<0.001**	**<0.001**
SpO_2, %		96 (90–99)	97 (93–99)	96 (88–98)	**0.002**	0.88
BT, °C		36.5 (36–38.5)	36.6 (36.1–37.1)	36.9 (36.5–37.9)	0.72	**0.005**
Hospital						
Board certified emergency physician	n (%)	135 (52)	83 (43)	24 (45)	0.07	0.45
Blood gas analysis						
Lactate (mmol/L)		4.2 (2.4–7.7)	2.4 (1.7–4.4)	3.56 (2.2–5.7)	**<0.001**	0.081
Intrinsic diseases	n (%)	213 (81.6)	150 (77.3)	46 (86.8)	0.29	0.43
Cardiovascular diseases	n (%)	68 (26.1)	45 (23.2)	12 (22.6)	0.51	0.081
Respiratory diseases	n (%)	23 (8.8)	22 (11.3)	5 (9.4)	0.43	0.43
Gastrointestinal diseases	n (%)	38 (14.6)	16 (8.2)	7 (13.2)	**0.04**	0.73
Infectious diseases	n (%)	55 (21.1)	11 (5.7)	12 (22.6)	**<0.001**	0.8
Neurological diseases	n (%)	0 (0)	10 (5.2)	0 (0)	**<0.001**	1
Other diseases	n (%)	29 (11.1)	46 (23.7)	10 (18.9)	**0.001**	0.85
Extrinsic diseases	n (%)	48 (18.4)	44 (22.7)	7 (13.2)	0.29	-
Trauma	n (%)	25 (9.6)	31 (16)	5 (9.4)	**0.04**	0.17
Other diseases	n (%)	23 (8.8)	13 (6.7)	2 (3.8)	0.48	0.43

†, Fisher's exact test. Mean ± SD. Median (IQR) minutes are expressed for each time value unless otherwise indicated. P-values in bold indicate statistical significance.

JCS: Japan Coma Scale; RP: respiratory rate; HR: heart rate; SBP: systolic blood pressure; DBP: diastolic blood pressure; SpO^2: oxygen saturation; BT: body temperature; GCS: Glasgow Coma Scale.

is useful for diagnosing shock and has demonstrated high diagnostic accuracy[15–17]. Enabling paramedics to perform ultrasound examinations at the scene of an emergency may save the lives of patients experiencing shock. Thus, paramedics should focus on acquiring adequate clinical education and collaborating with other medical staff members who examine patients in medical facilities to further improve the accuracy of shock diagnosis.

Limitations of the study

In this study, the definition of shock was based on the physician's diagnosis. Shock is a condition that is diagnosed comprehensively by considering various clinical signs and laboratory findings. The presence of a single sign of shock does not necessarily indicate the presence of shock itself. Additionally, elevated lactate levels may be caused by factors other than shock. Given these considerations, we recognized the potential for discrepancies between clinical shock diagnoses and isolated markers such as lactate levels. Therefore, we used the physician's diagnosis as the definition of shock, as it allows for a more accurate assessment by integrating clinical signs, lactate levels, and other findings.

However, there may be differences in the diagnosis of shock depending on whether the physician is a board-cer-

Table 4 Weighted logistic regression analysis results for shock group vs. undertriage group

		Shock group (N=261)	Undertriage group (N=53)	Odds ratio	95% CI	*P*-value†
Years of experience as paramedics		7 (4–12)	9 (4–15)	0.979	0.928–1.03	0.45
Female sex	n (%)	105 (40)	17 (32)	1.35	0.65–2.81	0.421
Patients' age		80 (67–87)	76 (67–87)	0.996	0.974–1.02	0.756
RR, /min*		24 (20–30)	29 (20–32)	0.962	0.913–1.01	0.154
HR, /min*		94 (70–120)	110 (86–134)	0.993	0.982–1	0.179
SBP, mmHg*		82 (71–96)	109 (92–128)	0.988	0.98–0.996	**0.005**

*, Vital signs (pre-hospital). †, Fisher's exact test. Median (IQR) minutes are expressed for each time value unless otherwise indicated. *P*-values in bold indicate statistical significance.

CI: confidence interval; RP: respiratory rate; HR: heart rate; SBP: systolic blood pressure.

tified emergency physician or their years of experience. In addition, this study did not assess the impact of paramedic interventions on patient outcomes. Certain patients may have stabilized by the time they were brought to the medical facility because of the paramedics' diagnosis of shock and medical intervention. Given this background, the accuracy of paramedics' diagnosis of shock may be even higher.

Conclusions

The accuracy of shock diagnosis by paramedics showed a high level of agreement with physicians. However, the accuracy of paramedics in diagnosing distributive and obstructive shock is low; therefore, adequate paramedic education is required. This is the first prospective observational study to report the accuracy of paramedics' diagnosis of shock. We believe it will improve the accuracy of paramedics' diagnosis and development of a targeted educational program.

Conflict of interest: The authors have no conflicts of interest to declare.

Funding information: This report did not receive any financial support.

Ethical considerations and consent to participate: Information about the implementation of this study was disclosed on the website of the University of Miyazaki Hospital for a certain period, and offers regarding nonparticipation were accepted (opt-out). The study protocol was approved by the Institutional Review Board of the University of Miyazaki Hospital (O-1147).

Consent for publication: This study does not contain any individual information. All authors reviewed the final version of the manuscript and provided consent for publication.

Availability of data and materials: The datasets generated and/or analyzed in this study are not publicly available because the study protocol was approved by the Institutional Review Board.

Author contributions: All the authors contributed significantly to this study. Rina Tanohata: Conceptualization, methodology, formal analysis, investigation, resources, data curation, validation, writing-original draft, writing-review & editing, project administration; Katsutoshi Saito, Takehiko Nagano: Conceptualization, methodology, formal analysis, investigation, resources, data curation, writing-original draft, writing-review & editing, visualization; Hidenobu Ochiai: Methodology, investigation, validation, supervision.

Acknowledgments

We would like to express our deepest gratitude to the medical and fire departments in Miyazaki Prefecture for their support of this research, as well as to the team members of the Department of Emergency, Critical Care, and Disaster Medicine, University of Miyazaki Hospital, for their guidance.

References

1. Holler JG, Bech CN, Henriksen DP, *et al*. Nontraumatic hypotension and shock in the emergency department and the prehospital setting, prevalence, etiology, and mortality: a systematic review. PLoS One 2015; 10: e0119331. [Medline] [CrossRef]
2. Patel S, Holden K, Calvin B, *et al*. Shock. Crit Care Nurs Q 2022; 45: 225–232. [Medline] [CrossRef]
3. Wilson C, Harley C, Steels S. Systematic review and meta-analysis of pre-hospital diagnostic accuracy studies. Emerg Med J 2018; 35: 757–764. [Medline] [CrossRef]
4. Kanda Y. Investigation of the freely available easy-to-use software 'EZR' for medical statistics. Bone Marrow Transplant 2013; 48: 452–458. [Medline] [CrossRef]
5. Cohen J. A coefficient of agreement for nominal scales. Educ Psychol Meas 1960; 20: 37–46. [CrossRef]
6. Rainer TH, Cheung NK, Yeung JH, *et al*. Do trauma teams make a difference? A single centre registry study. Resuscitation 2007; 73: 374–381. [Medline] [CrossRef]
7. Sturms LM, Driessen MLS, van Klaveren D, *et al*. Dutch trauma system performance: are injured patients treated at the right place? Injury 2021; 52: 1688–1696. [Medline] [CrossRef]
8. Xiang H, Wheeler KK, Groner JI, *et al*. Undertriage of major trauma patients in the US emergency departments. Am J Emerg Med 2014; 32: 997–1004. [Medline] [CrossRef]
9. Benhamed A, Fraticelli L, Claustre C, *et al*. Risk factors and mortality associated with undertriage after major trauma in a physician-led prehospital system: a retrospective multicentre cohort study. Eur J Trauma Emerg Surg 2023; 49: 1707–1715. [Medline] [CrossRef]
10. Smith GB, Redfern OC, Pimentel MA, *et al*. The National Early Warning Score 2 (NEWS2). Clin Med (Lond) 2019; 19: 260. [Medline] [CrossRef]
11. Vincent JL, De Backer D. Circulatory shock. N Engl J Med 2013; 369: 1726–1734. [Medline] [CrossRef]
12. Kristensen AK, Holler JG, Mikkelsen S, *et al*. Systolic blood pressure and short-term mortality in the emergency department and prehospital setting: a hospital-based cohort study. Crit Care 2015; 19: 158. [Medline] [CrossRef]
13. Koivulahti O, Tommila M, Haavisto E. The accuracy of preliminary diagnoses made by paramedics—a cross-sectional comparative study. Scand J Trauma Resusc Emerg Med 2020; 28: 70. [Medline] [CrossRef]
14. Perera P, Mailhot T, Riley D, *et al*. The RUSH exam: Rapid Ultrasound in SHock in the evaluation of the critically lll. Emerg Med Clin North Am 2010; 28: 29–56, vii vii. [Medline] [CrossRef]
15. Ramadan A, Abdallah T, Abdelsalam H, *et al*. Accuracy of echocardiography and ultrasound protocol to identify shock etiology in emergency department. BMC Emerg Med 2022; 22: 117. [Medline] [CrossRef]
16. Yoshida T, Yoshida T, Noma H, *et al*. Diagnostic accuracy of point-of-care ultrasound for shock: a systematic review and meta-analysis. Crit Care 2023; 27: 200. [Medline] [CrossRef]
17. Pietersen PI, Mikkelsen S, Lassen AT, *et al*. Quality of focused thoracic ultrasound performed by emergency medical technicians and paramedics in a prehospital setting: a feasibility study. Scand J Trauma Resusc Emerg Med 2021; 29: 40. [Medline] [CrossRef]