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# Novel ways of applying artificial intelligence in emergency medicine – literature review

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**ABSTRACT**

Artificial intelligence (AI) holds immense promise for revolutionizing emergency medicine, expediting diagnosis and treatment decisions. This review explores AI's wide-ranging applications in emergency care, ranging from managing out-of-hospital cardiac arrest (OHCA) to diagnosing fractures, spine injuries, stroke, and pulmonary embolisms, and even assisting in search and rescue missions with snake robots. In OHCA cases, AI aids in early detection, survival prediction, and ECG waveform classification, bolstering prehospital care efficiency. AI-powered digital assistants like the AI4EMS platform optimize diagnosis and patient prioritization, reducing overlooked cases of cardiac arrest and improving response times. Furthermore, AI algorithms enhance the diagnosis of conditions such as pneumothorax, pulmonary emphysema, and fractures by analysing medical images with exceptional accuracy, often outperforming human experts. In stroke and pulmonary embolism, AI expedites diagnosis through automated imaging analysis, enabling swift treatment. AI may enhance triage methods with independent systems, improving patient sharing and treatment quality while minimizing infection risks, especially during pandemics. Medical professionals generally welcome AI triage systems, acknowledging their potential to enhance healthcare efficiency. It is important to understand the scope of development of AI in order to make its application beneficial.

**KEY WORDS**

AI, triage, diagnosis, emergency

## INTRODUCTION

In the field of emergency medicine, where every second can decide a patient's life, advanced technologies based on artificial intelligence are attracting more and more attention. In this context, Artificial intelligence (AI) is becoming a promising tool that can support doctors in quickly interpreting symptoms and making accurate diagnostic decisions. AI does not have one universally accepted definition but is usually described as a research area focusing on the analysis of computer systems capable of solving tasks that require the use of human intelligence. Therefore, we can establish that AI is a set of sciences rather than a discipline itself. This technology draws inspiration from the natural cognitive processes and functions occurring in the human brain. It aims to create a computer system that works like human intelligence [1].

Thanks to the ability to quickly analyse large data sets, AI can help identify rare diseases, interpret laboratory test results, and generate therapeutic proposals. Additionally, the ability to interact with patients in real-time can facilitate the collection of relevant information about their health status and disease history, which is crucial in emergency cases [2].

AI methods are revolutionizing the diagnosis of fractures, enabling the rapid detection of even unusual and difficult to access cases, which significantly reduces the risk of missing them in patients with multiple injuries or after a serious injury. It is an important tool supporting the work of rescuers, making it easier to make the right decisions and further treatment of the patient before reaching the hospital [3].

One of the most important aspects of AI is deep learning. Deep learning is a type of advanced machine learning that uses neural networks to process and analyse large amounts of data. These neural networks are organized into several layers that detect progressively more complex patterns and features in the data. Deep learning can be used for a variety of tasks, such as image classification, speech recognition, language translation, text analysis, and even medical diagnosis. Due to the ability to automatically detect and learn from large data sets, deep learning has become a promising tool in the development of artificial intelligence in medicine [4].

In the medical field, GPT-based chatbots can be used to shorten conversations with patients, aid in disease diagnosis, suggest treatments, and provide medical education [5].

## AIM

This paper examines a range of potential applications of AI in emergency medicine analysis, both in established and novel contexts.

## REVIEW AND DISCUSSION

### OUT-OF-HOSPITAL CARDIAC ARREST

The use of AI to support the early care of patients with out-of-hospital cardiac arrest (OHCA) has received increasing interest in recent years, with a significant increase in research since 2019.

In a review by Toy et al. of 173 cases, in 54 (31%), AI showed a beneficial effect on diagnosis. The main areas of AI application are the classification of electrocardiogram (ECG) results, early detection at the control room level and prediction of survival outcomes. Three main categories of research using AI in out-of-hospital care have been identified: early detection of OHCA, prediction of return of spontaneous circulation (ROSC) and survival, and classification of ECG waveforms. The dynamic nature of prehospital conditions requires rapid data analysis and prediction of outcomes, potentially increasing the effectiveness of out-of-hospital care [6].

Al-Dury et al. used machine learning techniques to confirm that the main predictors of survival in OHCA are initial rhythm, age, time to start cardiopulmonary resuscitation, duration of EMS response, and location of out-of-hospital cardiac arrest. It is worth noting that some traditional factors, such as gender, have shown minimal significance in predicting survival outcomes [7].

Elola et al. developed two architectures of deep neural networks designed to detect the heart rate during out-of-hospital cardiac arrest using short ECG segments. These architectures classify rhythms according to their pulseless electrical activity or pulse-generating rhythm. This ECG-based solution, which can be adapted to any defibrillator/monitor, offers a promising opportunity to improve the accuracy of pulse detection during OHCA, potentially reducing interruptions in chest compressions and improving patient outcomes [8].

A significant proportion of OHCA cases remain undiagnosed during a telephone conversation with a medical dispatcher. Most people are unable to effectively communicate the seriousness of the situation to a rescuer. Rafi et al. developed a machine learning system to recognize OHCA cases based on the phonetic characteristics of callers' voices. The study analysed data from emergency calls to a call centre in Rennes, France, between 2017 and 2019. AI was used to extract predictor variables through computer-automated phonetic analysis, including fundamental frequency, formants, intensity, and various vocal parameters. Integration of these acoustic parameters into decision support systems can improve early recognition and response to OHCA, thereby potentially improving patient outcomes [9].

### AI4EMS PROJECT

A voice-controlled digital assistant has been created to help diagnose and prioritize patients in emergencies. The abbreviation AI4EMS is an acronym for Artificial intelligence for Emergency medical services. The AI4EMS platform uses machine learning techniques to recognize symptoms, supporting medics in making the right decisions. This technology is based on algorithms developed based on thousands of medical interviews. Data collected by Danish paramedics shows that AI4EMS software can recognize cardiac arrest within 44 seconds, recognize symptoms 25% faster than humans, and reduce the number of undetected cardiac arrests by 43%. By integrating speech recognition and machine learning technologies, the AI4EMS platform enables real-time analysis of emergency calls and helps assess the problem based on available parameters [10].

Using AI, specifically real-time natural language processing, AI4EMS software actively analyses call content, helping call takers recognize signs of serious illness, such as cardiac arrest. The developed algorithms are based on extensive data from previous medical interviews and look for patterns of verbal and non-verbal communication, including conversational tone and breathing signs [11].

### DIAGNOSIS OF PNEUMOTHORAX

CheXNeXt deep learning algorithm demonstrates effectiveness comparable to radiology specialists in identifying various chest pathologies based on chest radiographs. These technological advances hold promise for improving healthcare delivery by potentially increasing the accuracy of interpretation of chest X-rays. Successful implementation of such advances in real-world clinical settings requires further clinical trials in diverse populations [12].

Hong et al. examined the effectiveness of a deep learning-based computer-aided detection (CAD) system in improving the detection of pneumothorax on chest radiographs after percutaneous transthoracic needle biopsy. The study compared the diagnostic accuracy of chest radiographs interpreted using CAD with those interpreted without CAD. The results indicated that the CAD group showed higher sensitivity, negative predictive value, and overall accuracy compared to the non-CAD group. Increased sensitivity was detected in the diagnosis of less extensive pneumothorax (<10% and 10%-15%) in the CAD group. A lower percentage of patients in the CAD group required subsequent drainage catheter placement, suggesting a potential clinical benefit of the CAD system in reducing unnecessary interventions [13].

A meta-analysis by Sugibayashi et al. assessed the effectiveness of deep learning (DL) models in diagnosing pneumothorax and compared it with physician competence. The analysis shows that DLs and physicians have comparable accuracy in detecting pneumothorax on chest radiographs. DL showed a pooled sensitivity of 84% and specificity of 96%, and physicians showed slightly higher sensitivity (85%) and specificity (98%). The study also explored the potential clinical applications of DL diagnostics, such as patient triage and judgment, highlighting its role in improving the speed and accuracy of pneumothorax detection, particularly in emergency departments and intensive care units [14].

Kim et al. used a deep learning approach to classify lung diseases on chest radiographs, aiming to increase the efficiency and accuracy of computer diagnostic systems. Research conducted on datasets from the US National Institutes of Health and Cheonan University Hospital Soonchunhyang shows promising results in verifying diseases including pneumonia, pneumothorax, and tuberculosis. The authors emphasize the potential of deep learning techniques to revolutionize the diagnosis of lung diseases in X-ray images, emphasizing the importance of data augmentation and learning in achieving the accuracy of computer diagnosis [15]. Studies suggest that the implementation of a deep learning-based CAD system can improve the detection of pneumothorax on chest radiographs after lung biopsy procedures [12, 13, 14, 15].

## AI TRIAGE

The AI triage method works independently and replaces classic rescue triage thanks to the use of artificial intelligence. This solution improves the efficiency of patient sharing, streamlining, and speeding up help for those most in need, and reduces the burden on paramedics. Additionally, by shortening patients' waiting time, this method improves the quality of treatment through an individual approach to each patient. During the pandemic, AI triage additionally reduced the risk of contact infections [16].

The results of surveys among medical staff showed that almost half of respondents preferred only AI triage (45.2%), about one third expressed acceptance of both AI triage and classic triage (31.9%), and 22.9% of respondents preferred only classic triage. The overall acceptance rate of AI triage was 77.1%, which indicates the positive response of medical staff to this solution [17].

The introduction of the AI triage method can bring significant benefits to the healthcare system, improving operational efficiency, shortening patient waiting times, and minimizing the risk of infections, especially during crisis periods such as a pandemic. However, it is important to constantly monitor and improve this solution to ensure its effectiveness and compliance with the needs of patients and medical staff [18, 19].

## DIAGNOSIS OF PULMONARY EMPHYSEMA

Nagaraj at al. presented automatic deep learning based on minimum intensity projection (minIP) low-dose computed tomography (LDCT) images for the classification and detection of pulmonary emphysema. Using minIP as a specific diagnostic technique, the unsupervised DL algorithm can effectively diagnose atypical cases commonly encountered in LDCT screening for lung cancer [20].

The main causes of emphysema are smoking or α -1-antitrypsin deficiency. Diagnosis of this condition relies mainly on imaging. An automated emphysema quantifier based on AI supports this. This perfectly correlates with the Tiffeneau index, based on spirometry results. Thanks to this, it can be effectively used for diagnosis, staging and monitoring patients for long periods [21].

It is worth noting that emphysema can lead to significant impairment of lung function, which affects the quality of life of patients. The introduction of an automated tool based on AI can significantly facilitate and speed up the diagnosis process and help patients have faster access to appropriate treatment. However, there is a need for continuous improvement of this tool to ensure its effectiveness and compliance with the latest medical standards [22].

There is great interest in developing methods to automatically distinguish COPD from healthy people. Ahmed et al. discuss a 3D deep learning technique for classifying COPD and emphysema based solely on volume annotations. They demonstrated the impact of transfer learning on the classification of emphysema, using knowledge transferred from a previously trained model for the classification of COPD [23].

## FRACTURE DIAGNOSIS

AI methods enable quick detection of fractures in unusual and hard-to-find locations, which significantly reduces the risk of missing a fracture in patients with multiple injuries or after massive trauma. This helps rescuers work efficiently, make decisions and further deal with the patient before reaching the hospital. The most used AI method was convolutional neural networks (CNN). The accuracy of fracture identification in the seven studies ranged from 83 to 98. The most used AI method in diagnosing fractures is CNN, which are characterized by high efficiency and accuracy. Accuracy in identifying fractures in seven studies ranged from 83 to 98 percent, demonstrating the potential of these tools in detecting injuries [24].

Thanks to the use of AI, doctors and paramedics can quickly and precisely identify any fractures, even those that are difficult to identify clinically. This allows for faster decisions to be made regarding further treatment, including possible stabilization of the patient and preparation for transport. This eliminates the risk of delays in aiding and enables quick intervention in cases where time is crucial for the treatment outcome [25].

The introduction of AI methods for fracture diagnosis brings significant benefits for patients, rescuers, and medical staff, improving the efficiency and precision of diagnosis and contributing to faster and more effective treatment of injuries [26].

## SPINE INJURIES

The use of AI enables rapid and automated diagnosis of cervical spine injuries and rapid assessment of vertebral compression fractures. Thanks to AI algorithms that analyse images from radiological examinations, doctors can effectively identify potential cervical spine injuries, which significantly speeds up the diagnosis process. In the case of severe spinal injuries, such as vertebral compression fractures, prompt evaluation is crucial to immediately implement appropriate treatment and minimize the risk of complications. AI also enables the detection of subtle details in imaging tests that may be difficult for humans to see, leading to more precise injury diagnosis [27].

Automating this process allows doctors to focus on interpreting results and making therapeutic decisions, instead of wasting time manually analysing each image. Additionally, AI can be used to predict complications and assess the risk associated with cervical spine injuries. Thanks to machine learning and the analysis of large clinical data sets, AI can identify prognostic factors and support doctors in making decisions regarding further therapeutic procedures. As a result, the use of AI in the diagnosis and treatment of cervical spine injuries contributes to shortening the time needed for assessment and therapy planning, which may be important for patients, especially in the case of sudden and serious spine injuries [28, 29].

### STROKE

Stroke patients require immediate clinical and imaging assessment to ensure rapid assistance and implementation of treatment procedures. AI methods accelerate and improve acute stroke imaging, significantly increasing the efficiency and accuracy of stroke diagnosis. Particularly in the case of stroke, time is of the essence, and fast and precise imaging can be crucial for the effectiveness of treatment [26]. AI-based technologies, such as image processing algorithms and neural networks, can automatically analyse computed tomography or magnetic resonance imaging images, helping doctors identify damaged areas and assess the extent of a stroke. Additionally, AI can be used to detect large vessel occlusions on computed tomography angiograms, which can quickly identify patients eligible for recanalization therapy, such as thrombolysis or mechanical thrombectomy. The use of AI in stroke diagnosis not only speeds up the diagnosis process but can also contribute to reducing the risk of complications and improving clinical outcomes through quick and targeted implementation of appropriate treatment [30].

AI technology is widely used in acute stroke imaging, including both ischemic and haemorrhagic subtypes, where early identification plays a key role in initiating timely interventions to reduce morbidity and mortality; assists in many aspects of stroke management, including the detection and segmentation of infarcts or haemorrhages, classification, identification of large vessel occlusions, early assessment of the Alberta Stroke Program early computed tomography score and prognosis, and new techniques such as convolutional neural networks are very promising to perform these imaging-based tasks efficiently and accurately [31, 32].

### PULMONARY EMBOLISM

AI methods prove to be extremely helpful in cases of acute pulmonary embolism. Currently, three programs are available that not only detect pulmonary embolism but also perform computed tomography angiograms of the pulmonary arteries. Thanks to this, it is possible to make a quick diagnosis and efficiently triage patients. Analyses of the performance of these AI methods in the case of pulmonary embolism show high sensitivity and specificity, reaching up to 85% [33].

Additionally, these programs have additional features, such as allowing emergency team members to access patient test results and allowing clinicians to view key images from angiograms demonstrating clots. Thanks to this, paramedics can quickly make decisions based on test results, and doctors have easy access to important information, which speeds up the diagnostic process and therapeutic decision-making [34].

The use of AI in the diagnosis of pulmonary embolism brings significant benefits, improving the efficiency and accuracy of diagnosis and enabling rapid medical intervention. These advanced tools can significantly improve patient clinical outcomes, especially in emergency cases where time is of the essence. However, continuous improvement and monitoring of these methods is necessary to ensure their effectiveness and compliance with the latest medical standards [35].

### SNAKEBOTS

A slightly different aspect of emergency medicine in which AI can be used is in dangerous rescue search and rescue operations. Snake robots, equipped with sensors, can be used to transport tools to areas that are dangerous or inaccessible to humans, removing the need for direct human intervention [36]. People in critical situations receive support through SAR operations, but these activities are difficult and dangerous even for experienced rescuers. Therefore, there is an increased interest in using technology to minimize the risk for both victims and rescuers [37].

Snake robots can operate as multi-agent systems, which gives them high flexibility and adaptability. They are also able to use existing infrastructure for movement. Thanks to different gait patterns, snake robots can perform a variety of tasks without the need for additional modifications. Their modular structure allows them to be adapted to various means of transport, which makes them versatile in rescue operations [38].

Snake robots are a promising choice due to their robust construction and resilience in rescue operations. Additionally, they can be equipped with sensors and cameras that enable the assessment of the condition of people in danger and provide rescuers with environmental data in real-time. This data can be analyzed by AI, allowing a comprehensive plan of action to be generated in a matter of minutes. AI can also analyze various rescue options and choose the best course of action, tailored to the situation. This allows you to quickly identify threats and make informed decisions during a rescue operation [39, 40].

## CONCLUSIONS

The integration of artificial intelligence (AI) into emergency medicine has demonstrated remarkable potential to revolutionize various aspects of patient care and rescue operations. From the rapid diagnosis of life-threatening conditions such as out-of-hospital cardiac arrest (OHCA) and pulmonary embolism to the precise identification of fractures, spinal injuries, and strokes, AI technologies have significantly enhanced the efficiency, accuracy, and speed of medical interventions. Moreover, AI-driven solutions like AI triage methods have not only optimized patient prioritization and resource allocation but also minimized the risk of infections, particularly during crises like pandemics. The advancements in AI, particularly in deep learning algorithms, have enabled the development of sophisticated tools capable of analyzing complex medical data sets, interpreting imaging studies, and predicting clinical outcomes with high precision. Furthermore, the utilization of AI extends beyond traditional diagnostic modalities, encompassing innovative applications such as snake robots in search and rescue operations, where AI-driven analysis facilitates swift decision-making and ensures the safety of both rescuers and victims. However, while AI presents immense opportunities for enhancing emergency medical care, ongoing monitoring, refinement, and adherence to medical standards are essential to maximize its effectiveness and ensure patient safety. Continued research and collaboration between healthcare professionals, technologists, and regulatory bodies are crucial for harnessing the full potential of AI in emergency medicine while addressing challenges such as data privacy, algorithm biases, and ethical considerations.

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**CONFLICT OF INTEREST**

The Authors declare no conflict of interest.



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