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## RATOWNICTWO MEDYCZNE

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Z.M. Przesmyckiego 29
05-510 Konstancin-Jeziorna, Poland
tel. +48 604 776 311
a.luczynska@wydawnictwo-aluna.pl

**Managing Editor**
Agnieszka Rosa
tel. +48 600 600 938
a.rosa@wydawnictwo-aluna.pl

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# PATRONAGES

# MEDIA PATRONAGES

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ORIGINAL ARTICLE

# Impact on the emotional state of a patient with an acute myocardial infarction at the stage of providing emergency care

Irina Holovanova, Grygori Oksak, Maksym Khorosh, Inna Bielikova, Natalia Lyakhova, Oleksandr Havlovsky

DEPARTMENT OF PUBLIC HEALTH WITH MEDICAL AND OCCUPATIONAL EXPERTISE, POLTAVA STATE MEDICAL UNIVERSITY, POLTAVA, UKRAINE

## ABSTRACT

**Aim:** To study the emotional management of a patient with acute myocardial infarction at the stage of emergency medical care.

**Material and methods:** Using a special questionnaire, we interviewed 150 patients with AMI and 150 of their caregivers. The study was conducted in 2020-2022 on the basis of the Poltava Regional Center for Emergency Medical Care.

**Results:** Analyzing the patient's responses regarding the dominant emotional reactions during different stages, it is clear that at the initial stages there is a strong negative emotional background - 98% of patients experience fear and anxiety. In the subsequent stages, from the moment of pain relief to hospitalization in the cardiac intervention department, the dominant emotional background constantly changes from negative to positive and vice versa. Based on the respondents' answers, we noted 2 main psychological and physical phases: the patient alone with his companion; the patient together with the EMT medical staff. We developed an emotion map of the route of a patient with AMI, which included an intervention in the form of emotional support by the EMD medical staff.

**Conclusions:** Based on the data obtained from the survey of patients and their relatives regarding the emotional picture of acute myocardial infarction, it is clear that the actions of medical professionals aimed not only at directly providing medical care to the patient, but also at explanatory work to stabilize the emotional background are extremely important.

## KEY WORDS

emotional map, acute coronary syndrome, emergency medical care

## INTRODUCTION

WHO has classified acute myocardial infarction as one of the most important non-communicable diseases due to the excessive burden on the quality of life and health of the population - not only the elderly, but also people of working age. In the European Union, more than 4 million people die from cardiovascular diseases every year [1]. Diseases of the circulatory system are one of the most common pathologies in the structure of general morbidity of the population of Ukraine and occupy one of the leading places in the structure of primary disability and general mortality of the population, which constitutes one of the most serious threats to the national security of the country. Diseases of the circulatory system cause global socio-economic losses for the population of Ukraine [2, 3]. Diseases of the circulatory system account for 67% of the mortality structure and 23% of the disability structure of the Ukrainian population, therefore the treatment of myocardial infarction is extremely important, considering that it is one of the main causes of premature mortality and disability of the population at the global, regional and national levels. [4, 5, 6, 7]. In Ukraine, with 48,000 patients, 20% of patients die from acute myocardial infarction annually, while in European countries - 5% [8].

The population of Ukraine is experiencing increased stress due to the situation in their country, which may make them more susceptible to acute coronary events [9]. A myocardial infarction can be a traumatic experience, causing anxiety, depression, and symptoms of post-traumatic stress disorder after the event. High levels of perceived stress and depression are not only risk factors for cardiovascular disease, but also contribute to adverse outcomes such as recurrent myocardial infarction, poor general well-being, and increased mortality after acute coronary syndrome [10].

Hospitalization of patients with acute coronary syndrome is carried out in accordance with the order of the Ministry of Health of Ukraine dated September 28, 2017 No. 1181 "On approval of the Procedure for organizing the provision of medical care and hospitalization of patients with acute coronary syndrome with ST segment elevation by emergency medical teams." Important provisions of this document are the time of transportation: from the arrival of the ambulance crew to the hospitalization of the

**Table 1.** Questionnaire for assessing the emotional status of a patient with acute myocardial infarction or his relatives at different stages of emergency medical care.

| Stages of the patient's route | Negative emotions | | | | | Positive emotions | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Fear | Anxiety | Grief | Doubts | Embarrassment | Security | Concentration | Hope | Courage | Confidence | Relief |
| Stage I. Sudden onset of symptoms | | | | | | | | | | | |
| Stage II. Call to emergency medical services | | | | | | | | | | | |
| Stage III. Arrival of emergency medical team | | | | | | | | | | | |
| Stage IV. Making a diagnosis | | | | | | | | | | | |
| Stage V. Pain relief | | | | | | | | | | | |
| Stage VI. Conveying the decision of the emergency medical team` staff to hospitalize the patient | | | | | | | | | | | |
| Stage VII. Patient consent | | | | | | | | | | | |
| Stage VIII. Transportation | | | | | | | | | | | |
| Stage IX. Cardiointervention department | | | | | | | | | | | |

patient in the department (within 120 minutes from the arrival of the emergency medical team to the place of call to the hospitalization of the patient in the hospital for percutaneous coronary interventions) [11].

## THE AIM

The aim of our study was to study the emotional management of a patient with acute myocardial infarction at the stage of emergency medical care.

## MATERIAL AND METHODS

Using a special questionnaire (Table 1), we interviewed 150 patients with acute myocardial infarction and 150 of their caregivers. The study was conducted in 2020-2022 at the Poltava Regional Center for Emergency Medical Care and Disaster Medicine and the Poltava Regional Clinical Hospital named after Sklifasovsky. Because the time leading up to a patient's hospitalization is extremely short, patients were interviewed retrospectively about how they experienced each stage from the onset of symptoms to their admission to tertiary care. Considering that every patient in an acute condition needs outside help, we also interviewed their relatives or close people who were there for them during that difficult time.

The emotional map outlining the patient journey in cases of acute coronary syndrome was developed using Pieter Desmet's framework, which focuses on assessing emotional responses to external stimuli [12]. This framework was modified to capture patients' emotional states, summarized in a single word for each stage of the clinical process [13]. To achieve this, we conducted a survey involving patient-relative pairs who participated in the hospitalization process, gathering insights into their emotions during the onset of symptoms and the hospitalization period.

Statistical processing was carried out using the Microsoft Excel 2016 software package.

## RESULTS

The generalized results of the survey of the emotional state of patients with acute coronary syndrome and their caregivers/relatives are presented in Table II. As can be seen from the table, a significant percentage of respondents (up to 98%) experienced such negative emotions as fear and anxiety. At the same time, only a small part of both patients and their relatives reported the presence of positive emotions (Table 2).

Analyzing the patient's responses regarding dominant emotional reactions during different stages, it is clear that at the initial stages (emergence of symptoms (Stage I) call to the EMS service (Stage II)) a strong negative emotional background is observed - 98% of patients

**Table 2.** Distribution of responses of patients and their relatives regarding emotional state during transportation.

| Stages of the patient's route | Patient | | Relatives | |
|---|---|---|---|---|
| | Emotion | Abs (%) | Emotion | Abs (%) |
| Stage I. Sudden onset of symptoms | Fear | 147 (98) | Fear | 147 (98) |
| | Anxiety | 147 (98) | Anxiety | 147(98) |
| | | | Embarrassment | 147 (98) |
| Stage II. Call to emergency medical services | Fear | 147 (98) | Fear | 147 (98) |
| | Anxiety | 147 (98) | Anxiety | 147(98) |
| | | | Embarrassment | 147 (98) |
| Stage III. Arrival of emergency medical team | Security | 24 (16) | Confidence, hope | 45 (30) |
| Stage IV. Making a diagnosis | Fear of death | 147 (98) | Grief | 144 (96) |
| | Anxiety | 147 (98) | | |
| Stage V. Pain relief | Relief | 120 (80) | Hope | 114 (76) |
| Stage VI. Conveying the decision of the emergency medical team` staff to hospitalize the patient | Doubts, fear | 84 (56) | Doubts, embarrassment | 96 (64) |
| Stage VII. Patient consent | Courage | 42 (28) | Recollection | 57 (38) |
| Stage VIII. Transportation | Fear | 126 (84) | Doubts | 114 (76) |
| Stage IX. Cardiointervention department | Hope | 24 (14) | Hope | 30 (20) |

experience fear and anxiety. At the third stage – the moment of the ambulance arrival, some patients showed a change in their emotional background in a positive direction, but at the moment of diagnosis (Stage IV) a high negative emotional background is again observed – 98% of patients note fear of death and anxiety. In subsequent stages, from the moment of pain relief (Stage V) to hospitalization in the cardiac intervention department (Stage IX), the dominant emotional background constantly changes from negative to positive and vice versa (Fig. 1).

Analyzing the responses of the patient's relatives (carers) regarding the dominant emotional reactions during different stages, it is clear that at the initial stages (Stage I-II) there is a strong negative emotional background - 98% of patients experience fear and anxiety, as well as confusion. In general, the dynamics of positive and negative emotional experiences are similar in vector to the emotional picture of patients (Fig. 2).

Based on the respondents' responses, we identified two key psychological and physical phases: patient alone with his/her companion – this phase is characterized mainly by the expression of negative emotions; patient with emergency medical care (EMC) personnel – this phase shows a slight transformation of negative emotions into positive ones.

Considering that in critical situations, human behavior is mainly driven by emotions, we turned to the concept of "dual-process models" that describe the relationship between emotions and cognitive abilities (Fig. 3) [13].

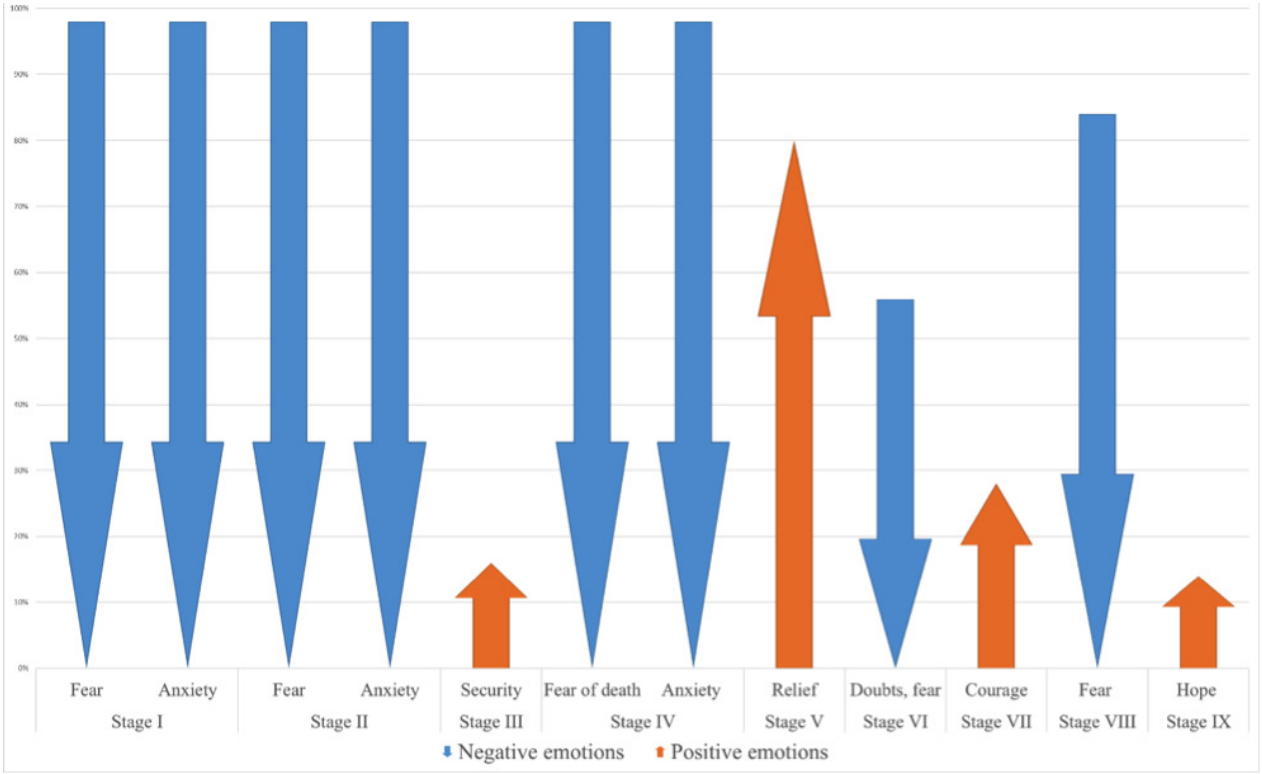


**Fig. 1.** Dominant emotions in a patient with acute myocardial infarction at different stages of emergency medical care.

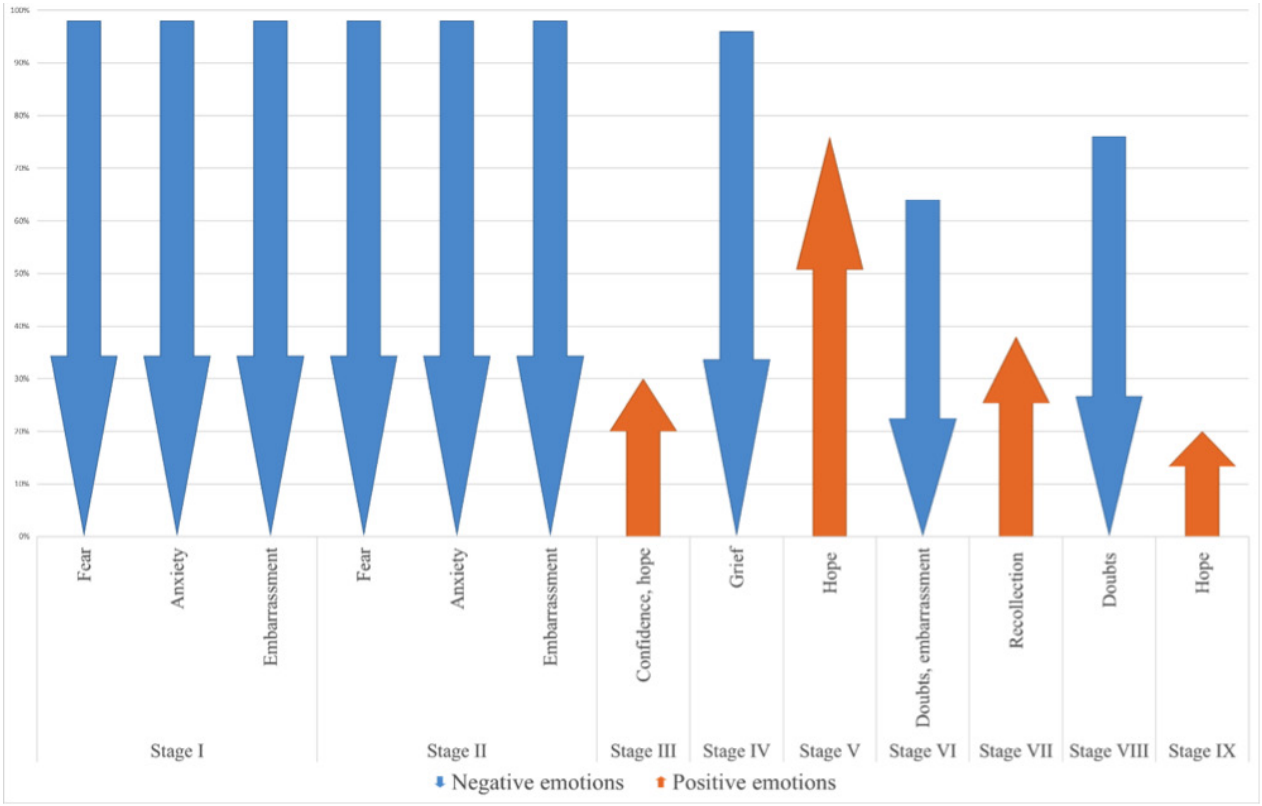


**Fig. 2.** Dominant emotions in relatives of a patient with acute myocardial infarction at different stages of emergency medical care.

According to this model, emotions go beyond cognition, influencing decision-making through:

- Decrease in cognitive abilities, which is manifested in a weakening of the ability to think rationally;
- Intensification of emotional response, which can lead to an exaggeration of emotional reactions.

At the same time, cognition is able to suppress emotions by exercising cognitive control through emotion

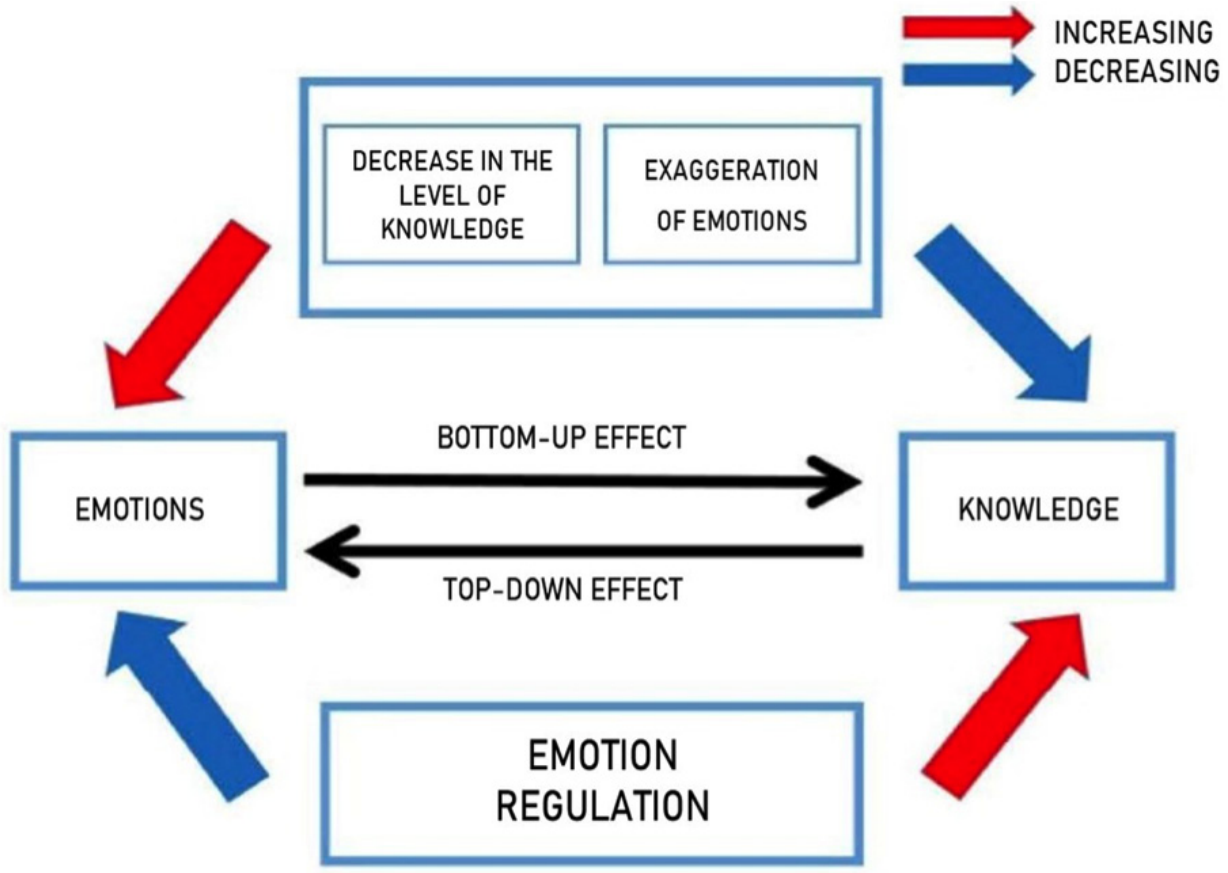


**Fig. 3.** A dual-processor model of the relationship between emotions and cognitive abilities.

regulation strategies. Thus, decision-making is the result of the interaction between emotions and cognition.

Based on the above, we developed a detailed map of the emotional route of a patient with acute myocardial infarction (AMI), which integrated a key intervention - emotional support from emergency medical personnel (Fig. 4). The central element of this intervention is the communication of a medical professional, who explains to the patient and his companion in an accessible and understandable form each stage of the diagnostic and treatment process. These actions are aimed at reducing the level of anxiety and fear, which usually dominate in crisis situations, and the gradual transformation of these negative emotions into more positive ones.

By improving the emotional state, medical personnel simultaneously stimulate the patient's cognitive abilities. This allows the latter to better understand their prospects, more objectively perceive information about the need for cardiac intervention and make informed decisions. As a result, such a model of interaction modifies the patient's behavioral response: instead of uncertainty and chaos, composure and trust appear.

Thus, this approach not only helps stabilize the patient's emotional state, but also significantly improves his adherence to medical recommendations, which is critical for the successful implementation of cardiac interventions and the overall outcome of treatment.

## DISCUSSION

Timely diagnosis, on the one hand, as well as timely referral of patients for emergency medical care in case of suspected acute coronary syndrome, and ensuring territorial accessibility through optimization of the network of medical institutions within the hospital district, will allow optimizing the patient's route and delivering the patient to cardiac intervention in a timely manner.

The patient's route is clearly described both in the unified protocol and in the works of foreign authors, where great importance is attached to the pre-hospital stage, hospitalization of the patient by emergency medical services [15, 16]. This is a purely logical objective state of hospitalization and the patient's route, starting from the onset of pain, ending with hospitalization and cardiac intervention [17]. At the same time, the subjective, emotional state of a patient diagnosed with acute myocardial infarction remains ignored [18, 19]. In the work of Havik O [20], the emotional state of patients who had suffered an acute myocardial infarction was investigated. In this work, the author showed that the main emotions

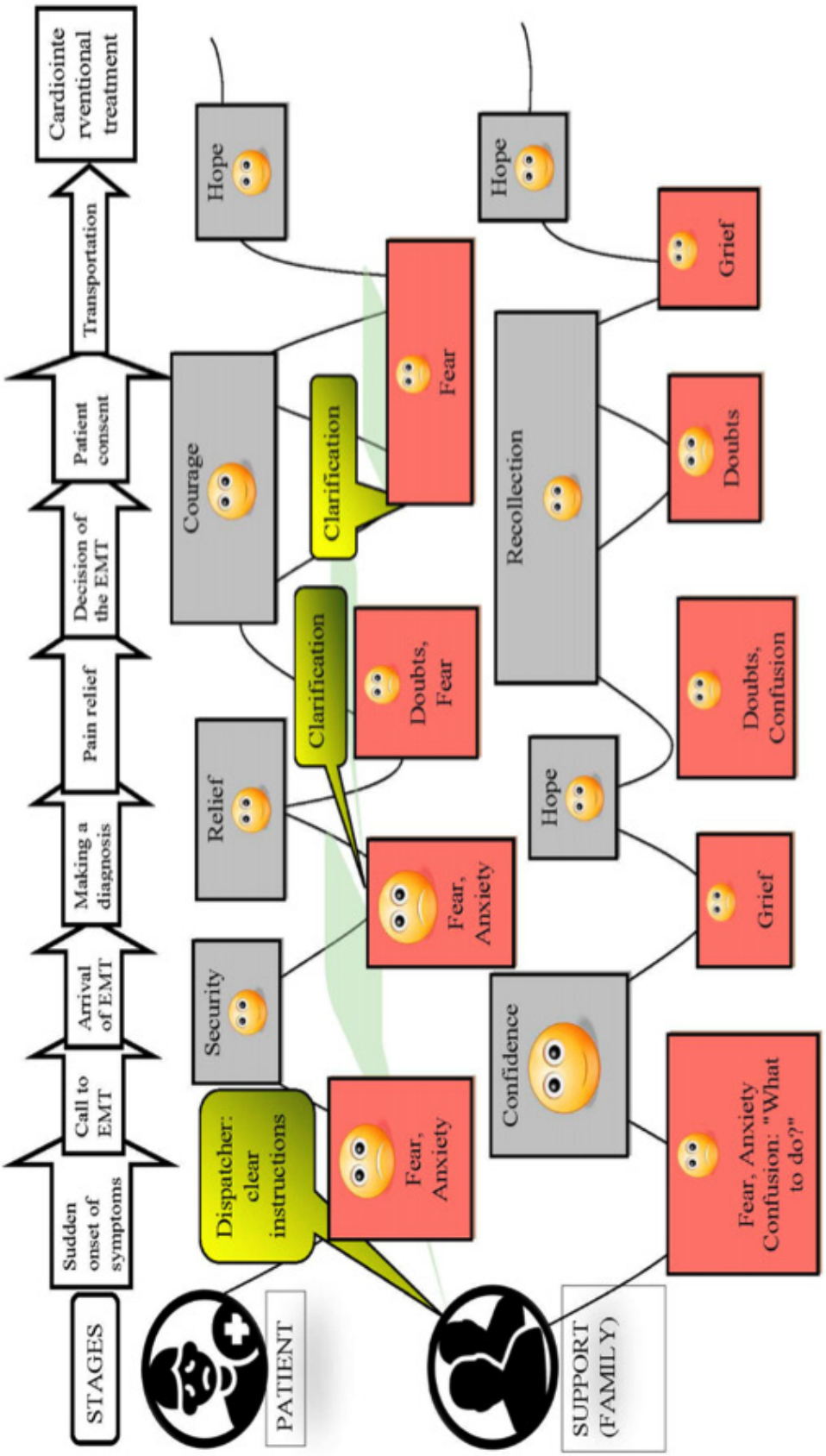


**Fig. 4.** Emotion map of the route of a patient with acute myocardial infarction.

were sadness, anxiety, and irritability, which is a negative emotional background and is consistent with our results. Coull A et al. [21] showed that fear is a common emotion for patients with acute myocardial infarction, and an important area of work with such patients is psychological support to achieve behavioral stabilization changes. A meta-analysis conducted by Dreyer, Rachel et al. in 2021 and included the results of 17 case studies on the emotional status of patients with acute myocardial infarction [22]. According to their results, the importance of a positive emotional background for the successful course of acute myocardial infarction is emphasized and the importance of managing the emotional reaction to the event is emphasized. Important importance has been given to the emotional state of the patient during rehabilitation [23] after a cardiovascular event, namely AMI [24, 25].

However, the literature does not sufficiently address the emotional state of the patient during hospitalization. Previous studies have shown that the emotional state of the patient arriving for cardiac intervention is of great importance [26]. On the one hand, negative emotions increase the risk of complications and the occurrence of acute myocardial infarction, and on the other hand, they determine the behavior of the person and relatives or loved ones who are nearby at this critical moment for health [27, 28].

## CONCLUSIONS

Based on the data obtained, it can be argued that a positive emotional background can have a beneficial effect on the successful cardiosurgical treatment of a patient with acute myocardial infarction. Based on the data obtained from the survey of patients and their relatives regarding the emotional picture of acute myocardial infarction, it is clear that the actions of medical professionals aimed not only at directly providing medical care to the patient, but also at explanatory work to stabilize the emotional background are extremely important.

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**CONFLICT OF INTEREST**

The Authors declare no conflict of interest.

**ADDRESS FOR CORRESPONDENCE**

Maksym Khorosh
Department of Public Health with Medical and Occupational Expertise,
Poltava State Medical University, Poltava, Ukraine
e-mail: indarion0@gmail.com

**ORCID AND CONTRIBUTION**

Irina Holovanova - 0000-0002-8114-8319 ⒶⒺ
Grygori Oksak - 0000-0003-0179-3439 Ⓕ
Maksym Khorosh - 0000-0002-2083-1333 ⒷⒸⒹ
Inna Bielikova - 0000-0002-0104-3083 ⒷⒸⒹ
Natalia Lyakhova - 0000-0003-0503-9935 ⒷⒸⒹ
Oleksandr Havlovsky - 0000-0002-0310-0766 ⒶⒺ



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ORIGINAL ARTICLE

# Instrumental airway unblocking in the practice of Polish firefighters - nationwide observation of firefighting and rescue interventions

Łukasz Dudziński[1], Łukasz Czyżewski[2], Tomasz Kubiak[3]

[1]DEPARTMENT OF MEDICAL RESCUE, JOHN PAUL II UNIVERSITY IN BIAŁA PODLASKA, BIALA PODLASKA, POLAND
[2]DEPARTMENT OF GERIATRIC NURSING, WARSAW MEDICAL UNIVERISTY, WARSAW, POLAND
[3]DEPARTMENT OF HEALTH SCIENCES, POZNAN MEDICAL ACADEMY OF APPLIED SCIENCES MIESZKO I, POZNAN, POLAND

## ABSTRACT

**Aim:** A retrospective analysis of the interventions conducted by entities of the National Firefighting and Rescue System (NFRS) involving instrumented airway management in the years 2016–2022.

**Material and Methods:** The study utilized data from the Decision Support System of the State Fire Service (DSS-SFS), provided by the Operational Planning Office. Incidents from 01.01.2016; 00:00 to 31.12.2023; 23:59 were analyzed. Quantitative data were described. Correlations and differences with a significance level of $p < 0.05$ were considered statistically significant. The analysis was anonymized for both the victims and the responders involved in the interventions.

**Results:** During the observation period, firefighters carried out 3.75 million interventions. Medical rescue operations were conducted in 1.3 million interventions (34.6%). A statistically significant upward trend was observed from 2016 to 2022 in the frequency of the following: restoring or maintaining airway patency ($p < 0.001$), restoring airway patency ($p < 0.001$), use of a resuscitator ($p < 0.001$), and use of a ventilator ($p = 0.016$).

**Conclusions:** The data obtained (annual totals) on the use of medical rescue equipment (resuscitator, ventilator) and emergency procedures (restoring and maintaining airway patency) indicate frequent dispatching of firefighters to medical incidents. Firefighters' involvement underscores their importance as a complementary force in medical emergencies, bridging gaps in EMS coverage and providing life-saving interventions in critical situations.

## KEY WORDS

National Firefighting and Rescue System, supraglottic methods, airway management, qualified first aid, medical rescue

## INTRODUCTION

Airway clearance and maintenance in prehospital rescue is a priority task for emergency services. In critical situations, this procedure is vital for both immediate survival and the patient's potential for recovery. This applies to both civilian rescue operations and battlefield rescue, where airway obstruction is the second most common cause of potentially survivable death [1, 2].

In Poland, the leading entities in medical rescue interventions are those within the National Emergency Medical System (NEMS): Emergency Medical Teams (EMT) and the Helicopter Emergency Medical Service (HEMS). Firefighters from the National Firefighting and Rescue System (NFRS) support NEMS units, as all firefighters are trained in qualified first aid (QFA). This set of emergency procedures addresses care for both traumatic and non-traumatic casualties across all age groups. Additionally, firefighting vehicles are equipped with rescue kits, including medical devices.

The training system for Polish firefighters in QFA allows them to obtain and maintain their certification for a period of three years. After this period, recertification is required for all firefighters, except those with medical education, who maintain their qualifications through professional medical training or practical experience in healthcare facilities or EMS units [3-5].

Medical dispatcher deploys firefighters due to the unavailability of ambulances or a longer ambulance response time compared to the firefighters' arrival time. Such incidents are termed Isolated Medical Rescue Incidents (IMRI) and represent a specific subtype of Medical Rescue Actions (MRA) performed by firefighters. These incidents fall under the remit of EMS, but urgent NFRS intervention is determined by a health deterioration or life-threatening condition in situations such as:

- the inability to immediately dispatch a EMT,
- the EMT response time being longer than that of the firefighters,
- firefighter intervention requested by bystanders or initiated directly upon observing a threat by firefighters [6, 7].

Firefighters are dispatched to two categories of incidents: fires and non-fire-related incidents, referred to as local threats (LC). In both categories, firefighters are prepared to execute medical rescue procedures [8, 9].

**Table 1.** Sections 16 and 17 of the "Incident Report" form: Area concerning equipment used and type of actions performed - completed by the Rescue Operation Commander (ROC).

| Section 16 | Type of Rescue Actions Performed | X |
|---|---|---|
| 1-33. | Actions not directly related to Qualified First Aid procedures | |
| 34. | Restoring or maintaining airway patency | |
| 35. | Performing external cardiac massage | |
| 36. | Controlling external bleeding and dressing wounds | |
| 37. | 100% oxygen therapy or ventilation | |
| 38. | Immobilizing fractures, suspected fractures, and dislocations | |
| 39. | Cooling burns | |
| 40. | Protecting against heat loss | |
| 41. | Performing anti-shock measures | |
| 42. | Providing psychological support to injured or endangered individuals | |
| **Section 17** | **Actions Conducted with the Use of Equipment** | **X** |
| 1-25 | Items not directly related to Qualified First Aid (QFA) procedures | |
| 26. | Dressing kit | |
| 27. | Airway management device | |
| 28. | Stretchers, immobilization equipment | |
| 29. | 100% oxygen therapy | |
| 30 | SIf-inflanting bag | |
| 31. | Ventilator | |

X - Mark placed next to a specific item if it was used during the action - completed by the Incident Commander

*Source: Rules for Recording Events in the Decision Support System of the State Fire Service, Operational Planning Office. SFS Main Headquarters. Warsaw 2023 [12].*

An important factor in the prehospital chain of survival during sudden cardiac arrest is early defibrillation in Automated External Defibrillator (AED) mode and ensuring airway clearance and patency. Both procedures are performed by firefighters in the absence of Emergency Medical Teams (EMT), with the time to intervention being crucial. Firefighters' rescue kits include supraglottic airway devices (SAD) suitable for all age groups. All organizational units of the fire brigade, including fire trucks (deployed for rescue and firefighting interventions) have the same list of equipment in the field of emergency medical services, so they can use Blind Insertion Airway Devices (BIAD) to the same extent [7, 10, 11].

## THE AIM

A retrospective analysis of interventions by entities within the National Firefighting and Rescue System utilizing supraglottic airway devices between 2016 and 2022 to lead assessment of the role of medical rescue operations.

## MATERIAL AND METHODS

### STUDY DESIGN

The data for analysis was provided by the Operational Planning Office (OPO) with the consent of the Chief Commander of the State Fire Service. This consent was obtained on 23 May 2022. The observations cover the years 2016-2022 in Poland. The study utilized data from the DSS-SFS, which archives all firefighter interventions. The quantitative analysis was entirely anonymized (no personal data, addresses, event dates, or rescue service codes). Ethical committee approval was not sought due to the retrospective and anonymous nature of the study.

### STATISTICAL ANALYSIS

Quantitative variables were presented as mean values ± standard deviation, while some results (localized in Table 3) were presented as median and interquartile range (IQR). The Kolmogorov-Smirnov test was applied to assess the normality of distributions. A one-way analysis of variance (ANOVA) was used to characterize comparative years and voivodeships. Proportions in groups locations of incident were assessed with one-way Friedman's ANOVA on ranks test. Statistical analysis was performed using Statistica 13 software (StatSoft Inc., Tulsa, OK), with the significance level set at $p<0.05$.

### DATA DOWNLOAD PROCEDURE

The State Fire Service keeps records of all interventions in the form of a database DSS SFS, including de-

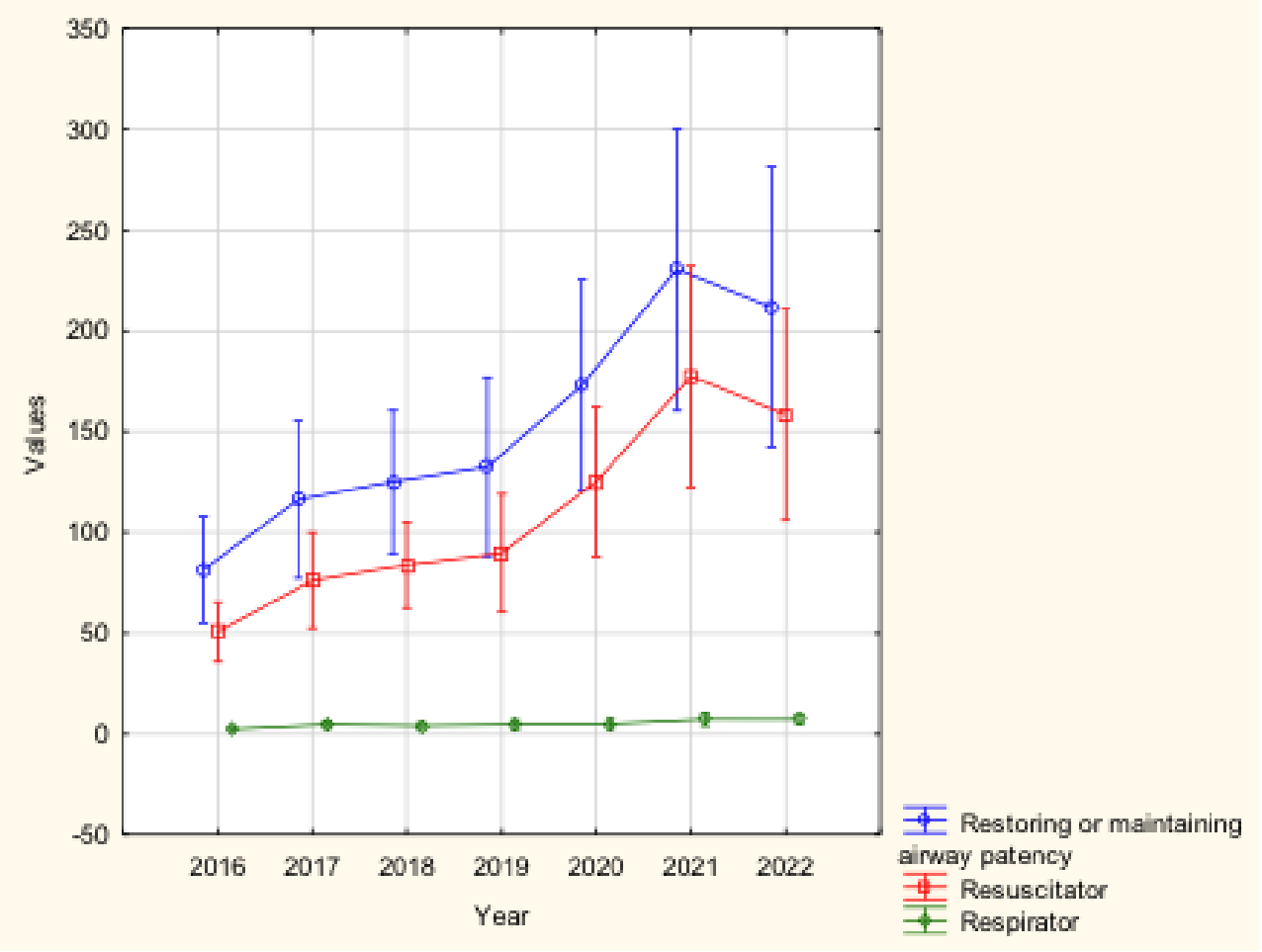


**Fig. 1.** Analysis of rescue procedures performed between 2016 and 2022.

tailed statistics on the involvement of forces and resources, equipment used, procedures implemented, equipment used, specialized equipment, fire trucks, and floating equipment. The data also include the location of events, the size of the area covered by rescue and firefighting operations, the type of area, the type of facility, the number of injured people, injured firefighters, and the participation of cooperating services.

Statistics are made on the basis of event reports divided by location: country, voivodeship, district, and also take into account operational times, consumption of materials and fire extinguishing agents. From available databases, the authors searched for data related to the implementation of QFA procedures for Polish regions in specific time frames.

INCLUSION CRITERIA FOR ANALYSIS

1. Events in which firefighting units performed Medical Rescue Actions (MRA).
2. Events occurring within the observation period: 01 January 2016 (00:00) to 31 December 2022 (23:59).
3. Searches in the DSS database according to categories related to the study's aim, focusing on the type of actions performed and equipment used.

The equipment utilized during these actions, as documented by the State Fire Service, is detailed in Table 1.

## RESULTS

During the observation period, firefighters carried out 3.75 million interventions, broken down by year as follows: 2016: 446,8 th; 2017: 519,9 th; 2018: 502 th; 2019: 512,5 th; 2020: 583,2 th; 2021: 579,7 th; 2022: 608,8 th. MRO were performed in 1.3 million interventions (34.6% of total). According to the data of the Central Statistical Office, the entities of the NEMS intervened in the years 2016-2022 a total of 21.5 million times (Mean 3.07 million; SD 0.15 million) [13]. The comparison of the scale of interventions is consistent with the purpose of the services. The IMRI activities carried out by firefighters are auxiliary activities for the NEMS, constituting a small percentage of the demand for interventions related to emergencies.

The analysis conducted on nationwide data from 2016–2022 revealed a statistically significant upward trend in the frequency of the following:

1. Restoring or maintaining airway patency ($P<0.001$)
2. Use of a resuscitator ($P<0.001$)
3. Use of a ventilator ($P=0.016$) (Fig. 1).

The p-values reflect differences within years of observation.

The observed results regarding ventilator usage reflect the standards described in the 2021 Principles of Medical Rescue Organization in NFRS, which introduced

**Table 2.** Analysis of activities and events in relation to the year of implementation.

| Year | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | All | P |
|---|---|---|---|---|---|---|---|---|---|
| Rest. or maint. airway patency | 82 ± 50 | 116 ± 73 | 125 ± 67 | 133 ± 83 | 173 ± 98 | 230 ± 131 | 212 ± 131 | 153 ± 105 | <0.001 |
| Self-inflating bag | 51 ± 28 | 76 ± 44 | 84 ± 40 | 90 ± 55 | 125 ± 70 | 177 ± 103 | 159 ± 98 | 109 ± 79 | <0.001 |
| Respirator | 2 ± 2 | 5 ± 3 | 4 ± 3 | 5 ± 4 | 5 ± 4 | 7 ± 6 | 7 ± 5 | 5 ± 4 | 0,016 |
| MRO in Fire | 1243 ± 816 | 1207 ± 636 | 1170 ± 695 | 1129 ± 605 | 932 ± 567 | 920 ± 513 | 1026 ± 587 | 1089 ± 632 | 0,669 |
| MRO in Local threats | 8438 ± 4132 | 10160 ± 5251 | 10988 ± 5557 | 11183 ± 6181 | 9922 ± 5680 | 12772 ± 6965 | 10698 ± 5722 | 10594 ± 5677 | 0,522 |
| All MRO (Fire + Local threats) | 9681 ± 4881 | 11368 ± 5831 | 12158 ± 6200 | 12312 ± 6726 | 10854 ± 6205 | 13691 ± 7451 | 11724 ± 6271 | 11684 ± 6205 | 0,698 |

MRO - medical rescue operations

The p-values reflect differences within years of observation.

**Table 3.Division of incidents into voivodeships in 2016-2022.**

| | Restoring or main. airway patency | Self-inflating bag | Respirator | MRO- Fire | MRO - Local threats |
|---|---|---|---|---|---|
| DOLNOŚLĄSKIE | 256 ± 114 | 201 ± 104 | 12 ± 5 | 1705 ± 527 | 15682 ± 1403 |
| KUJAWSKO-POMORSKIE | 126 ± 53 | 89 ± 39 | 3 ± 2 | 817 ± 85 | 8900 ± 1626 |
| LUBELSKIE | 68 ± 21 | 47 ± 15 | 3 ± 2 | 681 ± 92 | 6925 ± 868 |
| LUBUSKIE | 76 ± 33 | 59 ± 21 | 4 ± 3 | 580 ± 115 | 4335 ± 547 |
| ŁÓDZKIE | 166 ± 56 | 124 ± 52 | 6 ± 2 | 1649 ± 325 | 13268 ± 1843 |
| MAŁOPOLSKIE | 197± 64 | 133 ± 63 | 3 ± 2 | 1101 ± 181 | 12542 ± 1073 |
| MAZOWIECKIE | 327 ± 105 | 206 ± 86 | 9 ± 3 | 2290 ± 422 | 22314 ± 4302 |
| OPOLSKIE | 94± 40 | 67 ± 36 | 4± 2 | 462 ± 76 | 5039 ± 851 |
| PODKARPACKIE | 108 ± 37 | 76 ± 35 | 2 ± 1 | 638 ± 61 | 8494 ± 963 |
| PODLASKIE | 54 ± 12 | 41 ± 11 | 2 ± 1 | 530 ± 104 | 4347 ± 694 |
| POMORSKIE | 204 ± 64 | 146 ± 54 | 7 ± 4 | 1163 ± 139 | 12174 ± 1774 |
| ŚLĄSKIE | 204 ± 77 | 139 ± 63 | 6 ± 4 | 2390 ± 125 | 19011 ± 3233 |
| ŚWIĘTOKRZYSKIE | 47 ± 25 | 30 ± 17 | 1 ± 1 | 609 ± 129 | 5164 ± 1002 |
| WARMIŃSKO-MAZURSKIE | 107 ± 36 | 79 ± 28 | 3 ± 2 | 776 ± 195 | 8411 ± 810 |
| WIELKOPOLSKIE | 311 ± 116 | 221 ± 103 | 8 ± 6 | 1251 ± 141 | 16602 ± 2257 |
| ZACHODNIOPOMORSKIE | 105 ± 52 | 80 ± 47 | 7 ± 6 | 788 ± 81 | 6302 ± 1109 |
| **All** | **153+ 105** | **109 ± 79** | **5 ± 4** | **1089 ± 632** | **10594 ± 5677** |
| **P** | **<0.001** | **<0.001** | **<0.001** | **<0.001** | **<0.001** |

MRO - medical rescue operations

The p-values reflect differences within voivodeships

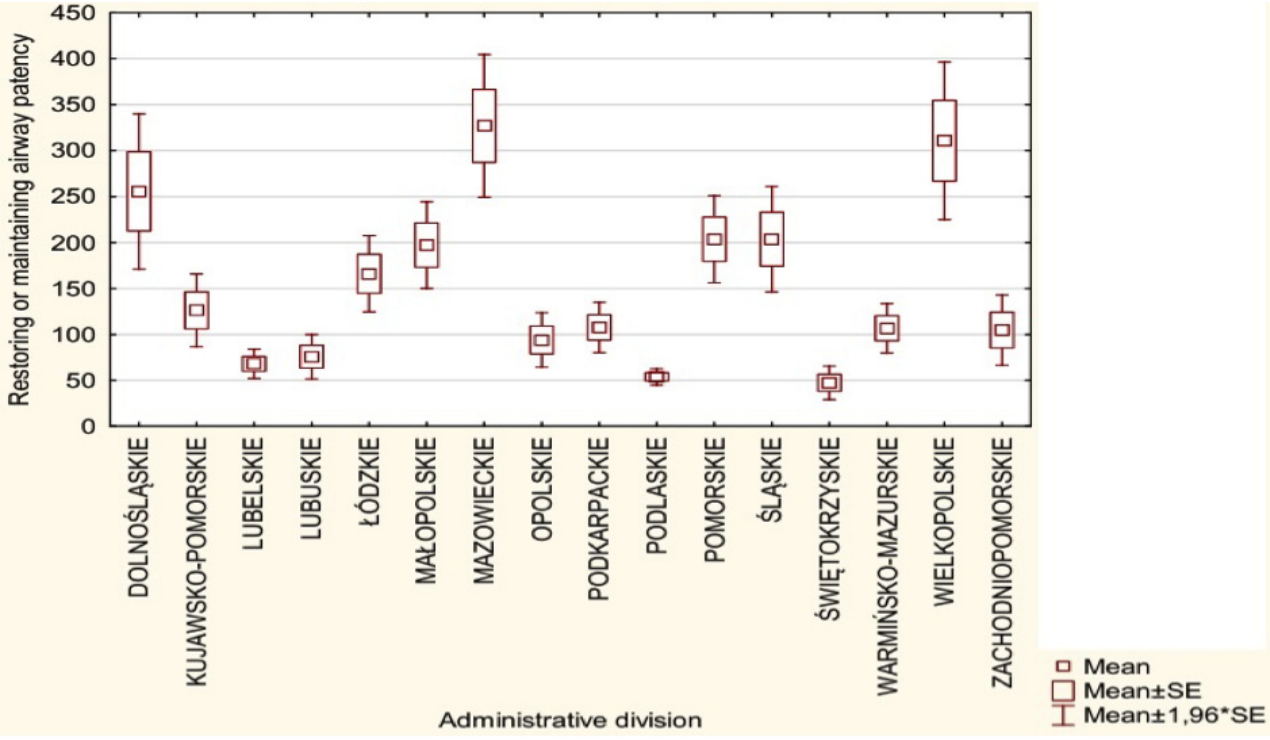


**Fig. 2.** Frequency of restoring or maintaining airway patency by voivodeship.

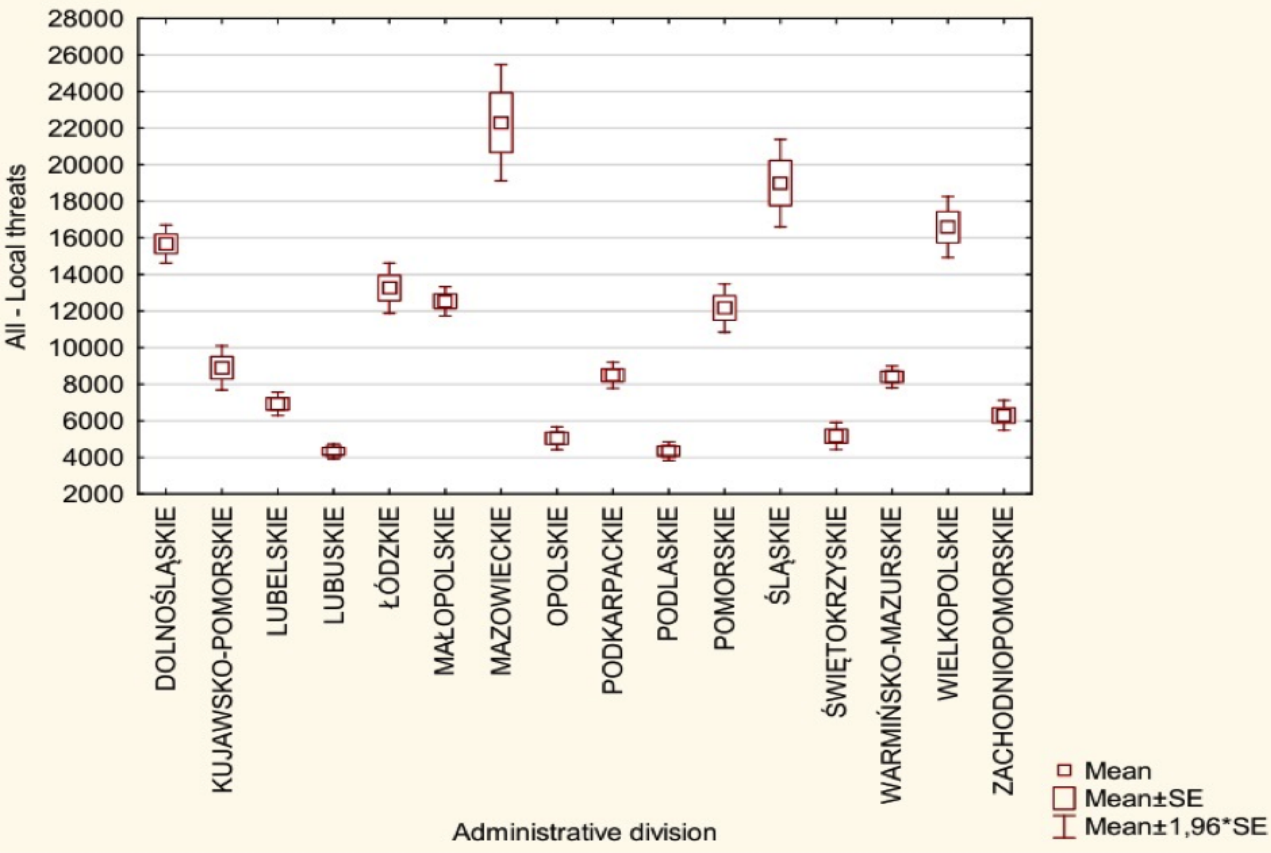


**Fig. 3.** Frequency of local threat interventions by voivodeship.

**Table 4.** Analysis of equipment usage by location throughout the analysis period for local hazards and fires

| | Restoring or main. Airway patency | Self-inflating bag | Respirator |
|---|---|---|---|
| Public use facilities | 21 (1-56) | 12,5 (1-35) | 0,5 (0-2) |
| Residential facilities | 223,5 (109-622) | 178,5 (89-515) | 10 (1-25) |
| Production facilities | 7,5 (1-20) | 5,5 (1-17) | 0 (0-1) |
| Storage facilities | 2,5 (0-8) | 2,5 (0-7) | 0 (0-1) |
| Means of transport | 310,5 (7-889) | 143,5 (4-469) | 5 (0-23) |
| Forest | 4 (1-18) | 2,5 (0-13) | 0 (0-1) |
| Crops, agriculture | 22 (6-65) | 16 (4-54) | 1 (0-2) |
| Other objects | 149,5 (5-430) | 115 (5 – 330) | 6 (0-22) |
| **P** | **<0.001** | **<0.001** | **<0.001** |

The p-values reflect differences within location of incident

the transport ventilator as mandatory equipment for Specialist Rescue Groups (SRG) within the State Fire Service (SFS). The number of these groups increased annually, reaching 194 nationwide by the end of the observation period (2022) [14].

In contrast, no unidirectional trend was observed in medical rescue activities related to fire incidents (P=0.669) or local threats (P=0.522) (Table 2).

The analysis of results by voivodeships from 2016–2022 demonstrated statistically significant differences between regions in: restoring or maintaining airway patency (P<0.001), use of a resuscitator (P<0.001), use of a ventilator (P<0.001) (Table 3).

Table 3. Division of incidents into voivodeships in 2016-2022.

Firefighters from the Mazowieckie Voivodeship most frequently performed actions to restore or maintain airway patency (327 ± 105) (Fig. 2). Firefighters from the Wielkopolskie Voivodeship most often used a resuscitator (221 ± 103). Firefighters from the Dolnośląskie Voivodeship most frequently used a ventilator (12 ± 5). The Śląskie Voivodeship recorded the highest number of interventions related to fires (2390 ± 125), while the Mazowieckie Voivodeship had the most interventions for local threats (22,314 ± 4302) (Fig. 3). The p-values reflect differences within voivodeships.

The application of procedures for restoring or maintaining airway patency (P<0.001), using a resuscitator (P<0.001), and using a ventilator (P<0.001) was found to depend on the location of the incident: Restoring or maintaining airway patency was most frequently performed in transport vehicles 310.5 (7–889), use of a resuscitator a ventilator was most common in residential buildings, with median values of 178.5 [89–515] and 10 [1–25], respectively (Table 4). The p-values reflect differences within location of incident.

Table 4. Analysis of equipment use by location throughout the analysis period for local threats and fires.

## DISCUSSION

This study covers the entire population of Polish firefighters and emergency medical interventions. Due to the different equipment of firefighters described in foreign studies, reference was made to the possibility of using SAD during interventions. The number of studies that fit thematically our analysis is limited due to the different rescue systems in other countries and the location of firefighters in these systems, as well as the system of QFA procedures not present to such an extent in other countries. The utilization of ventilators during interventions in own study is primarily linked to operations involving Specialist Rescue Groups (SRG). These units are deployed when the scale of threat or complexity of operations exceeds the capabilities of regular State Fire Service (SFS) units. Ventilator use is critical during the evacuation of victims from areas inaccessible to other emergency services, including EMT. Examples of such environments include: caves, depressions in terrain, water areas, sites of structural or natural disasters. SRG teams specialize in fields such as water rescue, sonar operations, chemical and ecological incidents, technical rescue, high-altitude operations, and search and rescue [14-16].

The numbers presented in our study indicating the use of supraglottic methods in the scale of each analyzed year are significant, considering the short time of irreversible effects of hypoxia in obstruction or respiratory arrest. Confirmation can be found in the analyses of other researchers. When airway obstruction occurs, timely intervention to restore and secure the airway is crucial. SAD's available to firefighters, offer an effective alternative to endotracheal intubation, which is considered the "gold standard" for airway management [17].

For Polish firefighters to effectively use the procedure of maintaining a clear airway, regular simulation exercises during the shift, external training or participation in scientific projects are essential. A 2024 study assessed the qual-

ity of ventilation using supraglottic devices among Polish firefighters. Involving 112 participants, the study compared the quality of ventilation using a resuscitator under two conditions: without real-time feedback, and with real-time monitoring assistance displayed on a screen [18].

Investing in high-quality rescue equipment that provides real-time corrective feedback could improve intervention effectiveness and outcomes for victims in life-threatening situations. Beyond equipment, the practical skills and knowledge of rescue personnel are critical. In Poland, these competencies are maintained through a structured system of training, certification, and recertification of QFA every three years [8, 19]. The training system of Polish firefighters in terms of medical rescue may be reflected in our results, which indicate frequent use of supraglottic methods in each year of analysis in all regions of Poland (Table 3). The number of interventions requiring airway clearance and ventilation may be influenced by sociodemographic factors, but this was not the subject of our observation.

Bieliński evaluated the knowledge of QFA practitioners in categories such as airway management, ventilation, and oxygen administration. The study analyzed how knowledge retention was influenced by the time elapsed since the last QFA course or recertification. Findings highlighted areas of insufficient knowledge over time following recertification. In our assessment, factors beyond the three-year certification cycle, such as location of the firefighter unit and annual number of interventions, play a significant role. Units with a higher volume of deployments may demonstrate better practical proficiency due to the frequent application of QFA procedures in real-world scenarios [20].

Research highlights the effectiveness of airway clearance using suction devices included in firefighters' rescue kits as a supplement to supraglottic airway methods. A Polish study compared the effectiveness of suction devices available in fire trucks and ambulances. The secondary objective was to provide practical reinforcement of procedural knowledge related to airway management equipment [21]. Such scientific activities focusing on medical rescue within firefighter populations are essential. They serve as a valuable supplement to standard training and certification schedules, enhancing practical skills among rescue personnel.

We also drew attention to other Polish and foreign studies referring to the results we obtained. As Bielecka observed, SAD methods are employed not only by firefighters but also by other rescue service formations [22]. International literature confirms the adoption of device-assisted methods by firefighters in various contexts. Bolland et al. [23] described U.S. firefighters' interventions using SAD, ventilation, defibrillation, and resuscitative pharmacotherapy. Verma et al. [24] highlighted the use of supraglottic methods by military paramedics during simulated emergency evacuations. Andersen et al. [25] studied 502 Norwegian firefighters performing airway management with SAD during cardiopulmonary resuscitation in cases of out-of-hospital cardiac arrest among adults. Our study showed significance in the variable location of the incident in the category of maintaining airway patency ($P<0.001$). This is confirmed by other studies that show the diversity of locations of firefighters' interventions divided into urban areas, non-urban areas and the variety of buildings [26-28].

LIMITATIONS

1. Lack of medical documentation: As a supplementary unit to the Emergency Medical System (EMS), the State Fire Service (SFS) does not maintain detailed medical records. The authors were unable to ascertain specific reasons for using ventilators, manual ventilation kits, or airway management procedures.
2. Clinical detail limitations: The database did not provide clinical information such as medical diagnoses from International Statistical Classification of Diseases and Related Health Problems (ICD-10), causes of health emergencies, event mechanisms, basic vital parameters, or sociodemographic characteristics of victims (e.g., gender, age, medical history) [29].
3. Quantitative data analysis: The available data were limited to the frequency of equipment use and procedural application (e.g., airway management, manual ventilation, mechanical ventilation). Analysis was confined to monthly and annual event scales, intervention types Fire or LT, regional breakdowns (voivodeships), and location classification per the DSS-SFS system.

## CONCLUSIONS

Firefighters play a critical role in prehospital emergency care, providing significant support to the EMS. Their contributions align with the chain of survival principles during out-of-hospital cardiac arrest (OHCA). Annual usage data for medical rescue equipment (resuscitators, ventilators) and procedures (airway management and maintenance) demonstrate frequent deployment of firefighters for medical interventions. Firefighters' involvement underscores their importance as a complementary force in medical emergencies, bridging gaps in EMS coverage and providing life-saving interventions in critical situations.

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**CONFLICT OF INTEREST**
The Authors declare no conflict of interest.

**ADDRESS FOR CORRESPONDENCE**
Łukasz Czyżewski
Zakład Pielęgniarstwa Geriatrycznego, Wydział Nauk o Zdrowiu
Warszawski Uniwersytet Medyczny, Poland
e-mail: lukasz.czyzewski@wum.edu.pl

**ORCID AND CONTRIBUTION**
Łukasz Dudziński - 0000-0002-8255-7608 ABDEF
Łukasz Czyżewski - 0000-0001-9473-9954 CEF
Tomasz Kubiak - 0000-0002-7305-2288 AB



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# Intravenous lidocaine as a key driver of successful pain therapy management. Current prospects and trends

Krzysztof Florczak[1], Dawid Jakóbczak[2], Mateusz Wilk[3]

[1]EMERGENCY SERVICES, EMERGENCY MEDICAL CENTRE IN OPOLE, OPOLE, POLAND
[2]EMERGENCY MEDICAL SERVICES, EMERGENCY MEDICAL CENTRE IN OPOLE, OPOLE, POLAND
[3]COLLEGIUM MEDICUM, WSB UNIVERSITY IN DABROWA GORNICZA, DABROWA GORNICZA POLAND

## ABSTRACT

Pain in its entirety is an unpleasant experience, both emotional and physical, and has a negative impact on the healing process. In the practice of medical staff, patients who experience pain or have a doloric component constitute a significant percentage of the number of interventions. The publication aims to present the concept of pain, types and characteristics as well as the process of nociception and the issue of off-label therapy related to the use of lidocaine, which is a multimodal therapy drug. This publication will present current trends and works containing the effective use of lidocaine. Pain that often varies in intensity, location or has a broad cause is a challenge for medical staff, especially in the face of complex and chronic pain. Based on a review of the latest medical literature, the authors would like to draw medical attention to expanding knowledge about pain, its nature and its formation. This has a decisive impact on reducing inflammation, shock and improving patient comfort. Therefore, the appropriate use of a multimodal strategy and adjuvant drugs is the method of choice, especially for patients reporting cancer pain, where the use of opioid drugs is significant. Also in colicky or neurogenic ailments, lidocaine is an effective drug that helps control pain. As an aid in the situation of using the drug, the authors of the article propose recommendations for the safe use of lidocaine. After reading this work, the reader at the scene of the incident should consider the adequacy of the supply of the described drug and know the mechanisms that govern pain as a process.

## KEY WORDS

lidocaine, pain, multimodal therapy, coanalgesia, pharmacotherapy

## INTRODUCTION

It is indisputable that healthcare professionals encounter pain patients on a regular basis. As healthcare professionals, doctors, nurses and paramedics are equipped with the necessary tools and expertise to effectively manage pain. As part of their training, medical students are required to complete a course in clinical pharmacology. This subject covers pain, pain management and the appropriate use of pharmacotherapy. The same is true of training programmes for nurses and paramedics. The International Association for the Study of Pain defines pain as An unpleasant sensory or emotional experience associated with actual or potential tissue damage, or expressed in terms of such damage (1986). The pain is typically caused by a specific stimulus that initiates damage. The literature distinguishes between two categories of pain based on duration: acute, which has a duration of less than three months, and chronic, which has a duration of more than three months. In addition to the aforementioned criteria, the pain classification takes into account the pain location. Somatic pain is defined as a sensation associated with the perception of nociception from superficial tissue structures, including the skin, muscles, and osteoarticular system. It is acute, localised and typically straightforward for the patient to describe. Visceral pain is a diffuse, poorly demarcated sensation that is difficult for the patient to localise. It arises through nociception from organs located inside body cavities. A further classification is that of the aetiology of pain. This includes pain associated with inflammation, tissue trauma, neuropathic and neoplastic pain [1]. Another publication emphasises the importance of an appropriate approach to pain and effective pharmacotherapy. It demonstrates the significance and relevance of pain polytherapy, correct knowledge of the additive effect and drug synergism of effective analgesia and coanalgesia [2]. It is essential to provide an appropriate combination of medications to effectively manage pain, particularly chronic pain that triggers inflammatory responses.[3] Additionally, the treatment procedures employed were not always aligned with the patient's current condition and reported pain on the NRS scale. In a paper published in Anaesthesiology and Emergency Medicine, Kosinski et al. examined the pain scores of patients encountered by paramedics on the scene. In nearly 1,600 trips in the Kraków region (the Małopolskie Province), questions about pain and its intensity were assessed. In almost 26% of all trips, the question about pain as a sensation was asked together with an assessment of its intensity. However, in almost 29% of paramedic charts, there was a lack of pain assessment and recording in the documentation. This resulted in inadequate or ineffective analgesia [4]. According to Polish

legislation, the patient has an inalienable right to pain treatment. This is guaranteed by the Act of 6 November 2008 on Patients' Rights and Patients' Rights Ombudsman, which was amended (Journal of Laws 2017, item 836) by adding a new regulation, Article 20a, stating that every patient has the right to this regardless of having insurance [5]. It should be noted that patients reporting pain are not limited to those experiencing acute pain. They also include those suffering from chronic diseases or cancer, as well as the elderly. When treating this population group, pharmacotherapy must take into account both the pathomechanism of pain and the type and route of administration of analgesics, as well as the risk of adverse effects. Personalisation of management is essential, with the patient and their specific complaints being the primary focus[6]. In the geriatric population, the vast majority of patients suffer from chronic pain, with one in two over the age of 65. The authors attribute this to inappropriate pharmacotherapy, the use of monotherapies and the special pharmacodynamics and pharmacokinetics of drugs in the geriatric population [7]. As one of the basic symptoms in medicine, pain is a major challenge for modern medicine. There is no doubt that its proper management, especially of chronic pain, significantly improves the quality of life of patients and their families in all aspects of life. In the monograph Chronic Pain. A clinical and psychological approach, the scientific team led by Wojciech Leppert discusses the assessment and diagnosis of pain, as well as co-analgesic and multimodal treatment of the entire pain-related process [8]. Nociception is the process by which nerve receptors respond to potentially damaging stimuli, such as mechanical, chemical, thermal damage or those resulting from inflammation or infection. These responses are then transmitted to higher centres of the CNS, such as the periaqueductal grey matter or thalamus, where they are made aware of by the patient. This process is essential for survival and minimising tissue and organ damage. Nociceptors are responsible for detecting stimuli when tissue damage occurs. There are three main types of pain receptors: high-threshold mechanoreceptors (HTM), which respond to mechanical deformation, pinching or pricking; and polymodal mechanical heat nociceptors (PMNs), which respond to a range of noxious stimuli, including pressure, temperature extremes (<8°C and >42°C) and chemical mediators (known as allogens). These can be exogenous (e.g. capsaicin) or endogenous and may be released by damaged cells as a result of noxious stimulation (bradykinin, serotonin, P substance, histamine, prostaglandins, leukotrienes, cytokines, H+, K+ ions). PMNs are the most prevalent pain receptors. It is notable that they do not undergo stimulus adaptation and also demonstrate sensitisation to repeated pain stimuli, which can lead to hyperalgesia. Additionally, there are silent receptors, which only activate when there is tissue inflammation.

There are two main categories of nociceptor fibres, which are distinguished by their fibre structure. Aδ-type fibres transmit impulses produced in response to mechanical and thermal stimuli. They are myelinated fibres with a large diameter and high impulse conduction velocity (up to 20 m/s). They facilitate the perception of an initial, acute pain sensation, which is clearly localised in terms of its anatomical location and is of a somatic nature. C-type fibres conduct impulses generated in response to thermal, mechanical and chemical stimuli. They are non-myelinated fibres, with a small diameter and a resulting low conduction velocity (0.5-2 m/s). They are responsible for the transmission of dull, poorly localised visceral pain. Anatomically, they are mainly a component of the ascending sympathetic nervous system [9, 10].

Afferent neurons are responsible for transmitting nociceptive impulses from peripheral receptors via the spinal-thalamic tract (spinothalamic tract). A first-order neuron (C or Aδ fibre) transmits potentials from the nociceptor to the substantia gelatinosa (Rexed lamina II) or nucleus proprius (Rexed laminae III, IV and V) in the dorsal horn of the spinal cord. In the posterior year of the spinal cord, a first-order neuron forms a synaptic connection with a second-order interneuron [11]. The second-order interneuron crosses into the anterior spinal cord and then runs in the spinal-thalamic pathway (mainly lateral) up to the thalamus. A third-order neuron transmits impulses to the somatosensory cortex. Only those sensations that have passed through the thalamus are perceived by the patient [12].

The pain impulse pathway is slightly different for nociception from the facial region. A first-order neuron (C or Aδ) transmits potentials from the facial nociceptors to the trigeminal nucleus. Most of this sensory information is transmitted to the brain via the trigeminal nerve, but a small number of sensory neurons of the pharynx and ear pass through the lingual-pharyngeal (NC IX) and vagus (NC X) nerves. Independently of the cranial nerve, all sensory afferent fibres synapse with second-order neurons in the trigeminal nucleus, the equivalent of the dorsal horn of the spinal cord. Second-order neurons travel to the thalamus to transmit impulses to the somatosensory cortex via third-order neurons [11, 13].

## THE AIM

The objective of this paper is to provide a comprehensive overview of the current state-of-the-art on lidocaine, its applications and research directions that may influence development and innovation in this area. The paper will review current trends in the use of lidocaine in medicine, and discuss new formulations, application techniques as well as potential therapeutic applications. It will also address challenges related to the safety and efficacy of lidocaine and future research directions that may contribute to a better understanding of its mechanisms of action and the development of new clinical opportunities.

## MATERIAL AND METHODS

In order to achieve the stated objective, the review paper will be based on a literature analysis including a review of available scientific publications on lidocaine, including

clinical trials, meta-analyses and review articles from recent years, with the focus being on studies in anaesthesiology, pharmacology and pain medicine. Databases such as PubMed, Scopus, Web of Science and Google Scholar will be used to identify the most current and relevant research papers on lidocaine applications. A critical analysis of the quality of the publications will then be attempted, taking into account the methodology, results and conclusions, in order to identify the strengths and weaknesses of current research.

## REVIEW AND DISCUSSION

Lidocaine is a sodium channel blocker classified as a type Ib antiarrhythmic agent and is also an amide local anaesthetic. The FDA has approved its use for local and regional anaesthesia, as well as for the treatment of ventricular arrhythmias. In Poland, it is available in ampoule form, Lignocain 2%, 20 mg/ml solution for injection, in manufacturer-dependent volumes [14]. The toxicity and pharmacokinetics of lidocaine have been known since the 1940s. Following clinical studies, it was developed in conjunction with adrenaline. It has been established that the maximum safe dose of lidocaine without adrenaline is 3 mg kg-1, while with adrenaline in a 0.5-2% solution injected into well-circumscribed tissue (e.g. during intercostal nerve block) it is 7 mg kg-1. After local administration, lidocaine is not metabolised by muscle or fat structures. It is absorbed by blood vessels whose flow is slowed by the effects of adrenaline, causing the capillaries to constrict as the substance is introduced at a pressure greater than that prevailing in the capillaries. Both topical and intravenous lidocaine is transported to the liver. There it is degraded into metabolites by the CYP 3A4 enzyme of cytochrome P-450: MEGX-monoethylglyoxylidine, GX-glyoxylidine. The kidneys are responsible for the removal of these substances. Drugs containing cytochrome P-450 enzyme inducers, such as phenobarbital, rifampicin and phenytoin, can boost the metabolism of lidocaine, which may impair its effect. Furthermore, in cases where lidocaine is part of the pharmacological treatment plan, it is essential to ascertain whether the patient is taking any medications that may inhibit isoenzyme activity, such as erythromycin or ketoconazole, which are serotonin reuptake inhibitors. Under such circumstances it is necessary to either discontinue the drugs or, if this is not possible, reduce the maximum dose by 20-30%. The final step in the excretion of lidocaine is its removal by the kidneys [15].

In a clinical trial for adults, lidocaine was used to treat both acute and chronic pain conditions, including but not limited to neuropathic pain, headache and renal colic, as well as post-operative pain. The authors concluded that systemic lidocaine was more effective than placebo in controlling neuropathic pain. However, the study included patients with different types of neuropathic pain syndromes, making it unclear whether lidocaine is more effective for some types of neuropathic pain compared to others. Furthermore, the evidence is not as strong when lidocaine is compared with other drugs (ketamine, morphine and amantadine) used to treat neuropathic pain [16]. The use of lidocaine to control cancer-related pain yielded mixed results. An analysis of the data from the 11 patients with cancer-related neuropathic pain who were administered a lidocaine infusion at a dose of 5 mg/kg revealed no significant improvement in pain intensity. On the other hand, a case series detailed the successful use of lidocaine by continuous infusion for the treatment of intractable pain in six hospice patients at home with a mean dose of 44 mg/hour (range 10-80 mg/hour) [17]. Two retrospective reviews describe the effective use of lidocaine by continuous infusion (dose range 1-4 mg/min for 2-15 days) for the treatment of chronic headache in adults. One study describes the use of the drug in the treatment of chronic daily headache associated with overuse of previous pharmacotherapy, with a observed reduction in the average number of days with headache per month from 29 to 15 after lidocaine infusion [18]. The case studies describe the use of intravenous lidocaine (dose range 1.3 mg/kg/hr to 3.3 mg/kg/hr) for the treatment of short-term unilateral neuralgic headache. The results demonstrate variable efficacy, with some patients noting minimal benefit and most noting significant benefit only during the lidocaine infusion. Lidocaine has been demonstrated to be more effective than a placebo in the treatment of acute migraine or headaches applied by the emergency ward when administered at a dose of 1 mg/kg for a period of 2 minutes. A small randomised single-blind study demonstrated that chlorpromazine was significantly more effective than lidocaine (boluses of 50 mg to a maximum of 150 mg) in the treatment of acute headache. Additionally, the study showed that lidocaine and dihydroergotamine had similar effects on pain scores in patients with acute headache [18].

Lidocaine has been the subject of study in patients with renal colic, both as a standalone treatment and in conjunction with opioids. A randomised, double-blind study was carried out to compare the efficacy of intravenous lidocaine (1.5 mg/kg) with that of a placebo. The results demonstrated that lidocaine produced a more pronounced reduction in pain intensity than morphine within the first 30 minutes ($P = 0.0001$) [16]. A further study compared the efficacy of lidocaine (1.5 mg/kg) and morphine (0.1 mg/kg) with that of morphine alone (0.1 mg/kg) in the treatment of renal colic. There was a reduction in pain scores across both groups, although the differences between them were not statistically significant. However, the combination of lidocaine and morphine resulted in a faster resolution of pain. Furthermore, the authors observed a notable decrease in the duration of nausea-free time in the lidocaine/morphine group compared to the morphine-only group. Intravenous lidocaine infusions have demonstrated the potential to reduce opioid consumption during the postoperative period, particularly in patients undergoing abdominal surgery. Additionally, lidocaine infusions have been shown to shorten the duration of postoperative bowel obstruction and decrease the length of hospital stay by 8–24 hours [17].

A series of case studies demonstrate the efficacy of continuous intravenous lidocaine administration in the treatment of dinutuximab-induced neuropathic pain in patients with neuroblastoma. Furthermore, case series and expert opinion articles illustrate the successful use of continuous intravenous lidocaine for intractable cancer pain. The doses used for these indications range from 0.5 to 2 mg/kg/hour by continuous infusion, with or without a saturating dose of 1 to 2 mg/kg over 30 minutes. One case study describes a dose escalation to 3.8 mg/kg/hour after more than two months of intravenous lidocaine therapy for severe neuropathic pain due to terminal cancer. However, such high doses should only be considered in extreme circumstances where the benefits outweigh the risk of toxicity and the patient continues to receive pain relief with dose escalation [18].

A small randomised controlled trial demonstrated the efficacy of continuous intravenous lidocaine therapy in the treatment of postoperative pain in children. The study involved 12 paediatric patients (aged 1-6 years) who were administered perioperative lidocaine at a dose of 1.5 mg/kg/hour. The infusion was initiated with a bolus of 1.5 mg/kg 20 minutes before incision and continued until six hours after surgery. Lidocaine levels were monitored and no patient reached levels >5 micrograms/ml. Patients receiving intravenous lidocaine had a significantly shorter length of stay and significantly lower opioid consumption compared to the placebo group. The expert opinion also supports the use of lidocaine for postoperative pain control [19]. It is thought that the administration of lidocaine affects a number of other clinically relevant outcomes, including wound healing, analgesia, coagulation, postoperative cognitive impairment and bowel obstruction. By characterising the beneficial effects of intravenous lidocaine administered in the perioperative period, lidocaine may provide a safe and alternative strategy to epidural analgesia to improve perioperative outcomes [18].

Furthermore, a retrospective review of cases in adolescents demonstrated the efficacy of intermittent intravenous lidocaine administration in the treatment of various types of chronic pain, including headache, neuropathy, sickle cell disease and skeletal pain. In this study, 15 patients underwent a total of 58 infusions, with a reduction in pain intensity reported after 41 of these. A 2018 retrospective review outlined the use of continuous lidocaine in refractory migraine in 26 paediatric patients. Following the administration of a saturating dose of lidocaine 3 mg/kg over 90 minutes, a continuous infusion was initiated at 1 mg/kg/hour (range 1.125-2.25 mg/kg/hour with titration). The average time to achieve a 50% reduction in pain scores was 16 hours (±12 hours), with complete resolution achieved in 28 out of 31 patients after an average of 19 hours (± 19 hours). Unfortunately, 16 out of the 31 patients experienced a recurrence of pain at the time of discharge, but the pain intensity was significantly lower than at the time of admission [19].

Lidocaine is also applied to the treatment of cancer pain. A continuous infusion of lidocaine at a dose of 4-5 mg/kgmc, with an infusion lasting 30 to 80 minutes, has been shown to reduce pain sensation by at least 50% [20].

Meta-analyses indicate that intravenous lidocaine at doses up to 1.5 mg/kgmc intravenous bolus has a significantly reducing effect on the incidence of cough induced by opioid administration. However, doses as low as 0.5 mg/kgmc iv. bolus with an effective antitussive may reduce the incidence of adverse effects [21].

It is essential to bear in mind that even very low doses of lidocaine (even 40 mg of intra-venous bolus) can cause seizure disorders [22]. It is imperative that intravenous infusions of lignocaine are carried out under conditions of access to resuscitation drugs and equipment to monitor the patient and secure the airway (including instrumented).

LAST – Local Anaesthetic Systemic Toxicity

LAST is the systemic toxicity of a local anaesthetic drug. It results from exceeding the maximum plasma concentration of LMZ. Classically, LMZs were thought to act by binding to and inhibiting voltage-gated sodium channels, suppressing action potential propagation along nerves. In fact, all widely used LMZs are amphipathic (have hydrophobic properties and hydrophilic groupings), making them capable of binding hydrophilic proteins (solubilised in the cytosol) and hydrophobic proteins (solubilised in the lipid bilayer of the cell membrane or organelle) [23]. To be more precise LMZ has been demonstrated to bind with voltage-gated potassium and calcium channels, as well as sodium channels. This inhibits intracellular signal transduction following G-protein activation. By inhibiting voltage-gated calcium channels, LMZ slows down cardiac automaticity (bradycardia) and conduction (blocks). Similarly, inhibiting voltage-gated sodium and potassium channels slows action potential propagation and repolarisation, promoting tachycardia before asystole has occurred [24].

LAST symptoms originate from the cardiovascular system and the central nervous system. CNS symptoms include tingling around the mouth and on the tongue, a metallic taste in the mouth, ringing in the ears, and a feeling of light-headedness. This is followed by slurred speech, muscle tearing, loss of consciousness, convulsions, coma and respiratory arrest. Cardiovascular symptoms include myocardial suppression, arrhythmias, particularly conduction blocks and cardiac arrest. Importantly, clinically we may be confronted with two types of LAST, the so-called Fast LAST, in which symptoms appear within minutes of drug administration, and the so-called Slow LAST, in which symptoms may appear half an hour after drug administration or even later [25].

The guidelines explicitly state the necessity of monitoring the patient during anaesthetic supply and for meticulous observation following the supply. In the event of LAST, the key element is the intravenous supply of 20% lipid emulsion at an initial bolus dose of 1.5 ml/kgmc, followed by the initiation of a continuous intravenous infusion of 15 ml/kgmc/h (0.25 ml/kgmc/min). Should there

be no improvement, it is recommended that further intravenous boluses be administered. A further 1.5 ml/kgmc should be administered at 5 and 10 minutes, with the infusion rate increased to 30 ml/kgmc/h (0.5 ml/kgmc/min). In the event of tachyarrhythmia, it is imperative to refrain from administering beta-blockers and Ca-blockers. Similarly, when treating hypotension, it is crucial to avoid supplying vasopressin. In the case of SCA, it is essential to reduce adrenaline boluses to a maximum of 1mcg/kgmc and prepare for prolonged resuscitation, lasting up to 1.5-2 hours [26, 27].

CONCLUSIONS

There is clear evidence that lignocaine used in multimodal therapy has a significant effect on pain rating and intensity compared with placebo, particularly in the early phases of pain onset. There is also some evidence that it has additional effects on other important clinical outcomes, such as improved gastrointestinal function, reduced nausea and opioid requirements. Analyses of available studies have shown that intravenous lidocaine is particularly useful as an adjunct to multimodal therapy in the management of colic pain. It is therefore reasonable to use it in terms of the work of hospital wards as well as pre-hospital medicine as a complementary medicine during pharmacological interventions. A full medical history, thorough anamnesis, medical records and full monitoring of vital signs appear essential. These procedures will minimise possible side effects, resulting in a full spectrum of pain relief. When intravenous lidocaine is administered, the patient should be closely monitored, especially from the LAST risk perspective.

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**CONFLICT OF INTEREST**

The Authors declare no conflict of interest.

**ADDRESS FOR CORRESPONDENCE**

Dawid Jakóbczak
Emergency Medical Services,
Emergency Medical Centre in Opole,
Opole, Poland
e-mail: jakobczakmedic@gmail.com

**ORCID AND CONTRIBUTION**

Krzysztof Florczak - 0009-0001-1885-1028 ABDEF
Dawid Jakóbczak - 0009-0008-2979-4429 AD
Mateusz Wilk - 0000-0002-2561-7774 AD



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# Ventilation in cardiac arrest

Jacek Wawrzynek, Łukasz Mścisz

DEPARTMENT OF MEDICAL RECSUE, FACULTY OF MEDICAL SCIENCES IN ZABRZE, MEDICAL UNIVERSITY OF SILESIA, KATOWICE, POLAND

**ABSTRACT**

Ventilation during cardiopulmonary resuscitation (CPR) is essential for achieving optimal oxygenation and carbon dioxide elimination. Numerous studies and analyses are conducted on the best ventilation strategy in cardiac arrest, but there are no specific guidelines addressing many aspects of ventilation. International resuscitation organizations only indicate the frequency of breaths and oxygen concentration during resuscitation. This study aims to present the possibilities and limitations of ventilation with a self-inflating bag and a ventilator during resuscitation, discussing current recommendations and medical knowledge regarding the selection of volume, ventilation frequency, positive end-expiratory pressure (PEEP), peak pressure, and mechanical ventilation mode. Conducting advanced standard resuscitation in a two-person team is challenging and often requires the use of equipment such as mechanical chest compression or a ventilator. The use of a ventilator during resuscitation is widely discussed in the medical community and has on the one hand many proponents, and on the other many opponents. Additionally, the article highlights the quality and effectiveness of defibrillation during resuscitation and justifies the strategy of regular disconnection of the respiratory system.

**KEY WORDS**

mechanical ventilation, cardiac arrest, resuscitation, ventilator

## INTRODUCTION

Key elements influencing the survival of sudden cardiac arrest include high-quality chest compressions, rapid and high-quality defibrillation if indicated, and ventilation. Current international guidelines do not provide detailed instructions on the best mechanical ventilation strategy during resuscitation. Resuscitation ventilation guidelines only specify the frequency of breaths and the oxygen concentration used. There is no expert consensuson the ideal ventilation mode, tidal volume, inspiratory: expiratory (I:E) ratio, or PEEP (Positive End Expiratory Pressure) during resuscitation [1].

In the Polish emergency medical system, teams usually consist of two people authorized to perform medical rescue activities. Teams are composed in any configuration of paramedics or emergency nurses. Teams with a doctor are three-person and constitute about 10% of all teams. It is common practice to dispatch a second rescue team or fire brigade to assist in cardiac arrest. The professional qualifications of paramedics and emergency nurses in Poland allow for endotracheal intubation and the use of supraglottic devices such as a laryngeal mask or laryngeal tube in cardiac arrest patients. The personnel are authorized to use a ventilator. Sudden cardiac arrest accounts for 0.54% of all emergency medical team interventions in Poland (16,289 out of 3,015,800 interventions in people over 12 years of age annually).

## REVIEW AND DISCUSSION

### VENTILATION WITH A BVM (BAG VALVE MASK)

Ventilation with a Self-Inflating Bag Breath Frequency Since 2005, the European Resuscitation Council guidelines have clearly defined the ventilation frequency (f – frequency) after instrumental airway management as 10 breaths per minute. The American Heart Association guidelines also indicate a frequency of 10 breaths per minute. Interestingly, the European guidelines only specified the frequency of asynchronous ventilation in the pediatric population in 2021, indicating that the frequency of 10 breaths per minute is intended for patients over 12 years of age. The recommended breath frequency is not based on strong recommendations or high-quality evidence. Many researchers are attempting and analyzing ventilation with a faster frequency, demonstrating its greater effectiveness [2, 3].

### TIDAL VOLUME

A self-inflating bag for an adult has a volume of about 1500 ml, and a pediatric bag about 500 ml. The tidal volume (TV) of classic ventilation is based on 6-8 ml/kg of ideal body weight. Available simulation study results describing the parameters obtained with a self-inflating bag during ventilation indicate that the volumes generated by medical personnel are not appropriate. In analyses, the volumes generated are most often too large. Some researchers, seeking a solution to the problem of excessive volumes, propose ventilating adults with pediatric bags. There are studies that both support and warn against using a pediatric resuscitation bag for adult patient ventilation. Siegler, Dafilou and other authors demonstrated that ventilating an adult patient with a pediatric bag generates parameters closer to normal compared to an adult bag [4, 5]. Justice et al. showed that regardless of the type of bag, the volumes generated by medical personnel in

prehospital care are too small [6]. When ventilating with a self-inflating bag after instrumental airway management, to achieve the correct frequency, audible or visual signals indicating the need to take a breath can be helpful [7]. A technical difficulty is measuring the actual volume delivered to the patient during bag ventilation.

VENTILATION WITH A VENTILATOR

The use of a ventilator during resuscitation is highly controversial. One of the reviews indicates that using a ventilator during resuscitation is justified with limited personnel, but if the number of people capable of ventilating with a self-inflating bag is sufficient, ventilation should be performed manually [8].

VENTILATION MODE

Modern mechanical ventilators are equipped with a function to detect the patient's spontaneous breath (trigger). After the patient reaches the set trigger level, the ventilator will assist the patient's spontaneous breathing effort. During resuscitation, the mechanical ventilator may mistakenly interpret chest compressions as an attempt at spontaneous breathing by the patient, thereby generating a higher breath frequency. In the simplest devices, this problem does not occur – they do not have any synchronization with the patient's own breath and ventilate in IPPV/CMV (Intermittent Positive Pressure Ventilation/Continuous Mandatory Ventilation) mode or an analogous scheme without a trigger. In modern devices, a "cardiac arrest" mode may be available, and in this case, the ventilator will disable the trigger and start ventilation with averaged settings (e.g., VT 500 ml, f 10/min). It is important to remember that when using a ventilator during cardiac arrest ventilation, the volume-controlled mode (VC – Volume Control) should be used. A modern and approved ventilation strategy is Chest Compression Synchronized Ventilation (CCSV). This mode ventilates the patient with small volumes (TV 100-200 ml) at a rate consistent with the chest compression frequency. This strategy provides effective oxygenation and carbon dioxide elimination without generating high pressures in the airways. Limited studies indicate that this ventilation scheme is not inferior to IPPV/CMV mode ventilation [9, 10].

I:E RATIO

No clinical studies have examined the inspiratory: expiratory ratio in invasively ventilated patients during resuscitation ventilation [1].

PEAK PRESSURE

During asynchronous ventilation, the opposing forces of compressions and ventilation can result in an increase in peak airway pressure by nearly 30 cm H2O compared to synchronous ventilation or ventilation after the return of spontaneous circulation [11-13]. Setting the peak pressure at 40 cm $H_2O$ is a safe and acceptable value during resuscitation. It should be noted that the self-inflating bag also has a high-pressure valve, which in adult bags is usually set at 60 cm $H_2O$.

POSITIVE END-EXPIRATORY PRESSURE (PEEP)

By using the PEEP function during ventilation, the pressure in the airways does not drop to relative zero after the exhalation phase, keeping the alveoli constantly open. For ventilators without a potentiometer to regulate this value, PEEP of specified values can be achieved using a valve placed in the respiratory circuit. The valve, usually mushroom-shaped, is mounted to the exhalation port at the end of the tube delivering the mixture to the patient. A mechanical PEEP valve can also be attached to a self-inflating bag using a special adapter. One of the reviews indicates that using at least 5 cm $H_2O$ PEEP during resuscitation appears to be beneficial. Such a PEEP value positively affects oxygenation and carbon dioxide elimination without negatively impacting the circulatory system. It has also been proven that using PEEP positively affects the return of spontaneous circulation [1, 11, 14, 15].

DISCONNECTING THE VENTILATION SYSTEM

Disconnection of the system using PEEP increases chest impedance, thereby reducing the effectiveness of defibrillation [16]. It is reasonable for the quality of defibrillation during cardiac arrest to disconnect the ventilation system at the moment of defibrillation, ensuring the exhalation phase and reducing airway pressure. This strategy also helps limit the risk of autoPEEP development and is therefore applicable in non-shockable rhythms. It seems justified to systematically disconnect the ventilation system during resuscitation (e.g., during rhythm analysis every 2 minutes) regardless of the rhythm's nature.

## CONCLUSIONS

The use of a ventilator during resuscitation is justified with a shortage of medical personnel, but it should not be routine practice. Bag ventilation requires the operator to maintain a strict ventilation schedule and appropriate tidal volume. During ventilation, the highest available oxygen concentration in the mixture should be aimed for, and PEEP can be used. It is worth disconnecting the ventilation system to reduce chest impedance during defibrillation and limit the risk of autoPEEP.

BASIC PARAMETERS DURING VENTILATOR VENTILATION IN CARDIAC ARREST

Mode: IPPV/CMV. If the volume mode has a trigger – disable it.
Frequency: 10/min
Tidal Volume (TV): 6-8 ml/kg of IDEAL BODY WEIGHT
$FiO_2$: 1.0 (no air mix, 100%)
PEEP: 5 cm $H_2O$

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## CONFLICT OF INTEREST

The Authors declare no conflict of interest.

## ADDRESS FOR CORRESPONDENCE


Jacek Wawrzynek
Department of Medical Recsue,
Faculty of Medical Sciences in Zabrze
Medical University of Silesia
Katowice, Poland,
e-mail: jwawrzynek@sum.edu.pl


## ORCID AND CONTRIBUTION


Jacek Wawrzynek - 0000-0002-8739-3438 ⒶⒷⒹⒺⒻ
Łukasz Mścisz - 0009-0007-9080-1264 ⒹⒺⒻ




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REVIEW ARTICLE

# Yes or no for extracorporeal cardiopulmonary resuscitation? Part 2. Results

Jakub Hubert Będkowski[1], Magdalena Augustyn[2]

[1]DEPARTMENT OF MEDICAL EDUCATION, JAGIELLONIAN UNIVERSITY MEDICAL COLLEGE, CRACOW, POLAND
[2]DEPARTMENT OF EMERGENCY MEDICAL SERVICES, JAGIELLONIAN UNIVERSITY MEDICAL COLLEGE, CRACOW, POLAND

## ABSTRACT

Part 2 of article it is a collection of results of studies on the effectiveness of ECPR (extracorporeal cardiopulmonary resuscitation) and comparative studies of ECPR vs. CCPR (conventional cardiopulmonary resuscitation). Subsections presents: prospective randomised control trails; meta-analyses of randomised control trails; review of prospective and retrospective studies based on national or regional centers databases; conclusions of meta-analyses and systematic reviews retrospective studies and literature reviews comparing ECPR vs. CCPR. The data show the current state of knowledge about the effectiveness of ECPR and the analysis of results. A review of data from national databases and centers databases shows the scope and popularity of ECPR in the world. Apart from effectiveness, some studies also point to factors determining the effectiveness of ECPR. Part 2 of the article, together with part 1, constitutes a base for the readers, preparing them for analysis of the following issues: decision-making, logistics, trends and discussion around ECPR to form a yes or no opinion for ECPR.

## KEY WORDS

extracorporeal cardiopulmonary resuscitation (ECPR), out-of-hospital cardiac arrest (OHCA), in hospital cardiac arrest (IHCA), refractory cardiac arrest (RCA)

## INTRODUCTION

The incidence of unexpected cardiac arrest (CA) is high. Survival to hospital discharge after CA is low. Searching of methods improves cardiopulmonary resuscitation (CPR), started research with use extracorporeal membrane oxygenation (ECMO). The application of venoarterial ECMO (VA ECMO) during CA is extracorporeal cardiopulmonary resuscitation (ECPR). Does it work?

## THE AIM

The article reviews the current literature in the field of ECPR, paying particular attention to: results of studies on the effectiveness of ECPR and comparative studies of ECPR versus CCPR (conventional cardiopulmonary resuscitation) to create a database for the reader, who expects an answer on the question: yes or no for ECPR?

## MATERIAL AND METHODS

The MEDLINE database (full access) was searched for the terms "ECPR" and for the dates 01/01/2018 to 31/12/2023 (5 years), paying particular attention to: results of prospective randomized control trails (RCTs), metaanalyses of prospective randomized control trails; results of retrospective studies (metaanalyses, systematic reviews, comparative studies, individual studies with a large sample).

## REVIEW

### REVIEW OF PROSPECTIVE RANDOMISED CONTROL TRAILS

By the end of 2023, 4 RCTs, were conducted that aimed to compare the effectiveness of ECPR vs. CCPR, or whose results allow for comparison of the effectiveness of ECPR *vs*. CCPR. Below presented goals, methods and results of RCTs comparing ECPR vs. CCPR, found in MEDLINE database for the dates 01/01/2018 to 31/12/2023 (5 years).

The first RCT compared effectivenes ECPR *vs*. CCPR, "ARREST" (Yannopoulos D. et al., Minnesota USA, single center, open label). The study included adults aged 18-75 years, OHCA (out-of-hospital cardiac arrest) with refractory VF (ventricular fibrillation), no ROSC (return of spontaneous circulation) after three shocks, automated CPR (cardiopulmonary resuscitation), and an estimated transfer time ≤ 30 min. Patients were randomly assigned to ECPR or CCPR on hospital arrival. The researchers assessed survival to hospital discharge as the primary outcome. As secondary outcomes assessed safety, survival, and functional assessment at hospital discharge at 3 months and 6 months after discharge. Since August 2019 to June 2020 assessed 36 patients. 6 patients was excluded, 30 were randomly assigned to CCPR n=15 or to ECPR n=15 (1 patient in the ECPR were excluded before discharge) [1]. In result, survival to hospital discharge in 1 (7%) of 15 patients in CCPR group compared with 6 (43%) of 14 patients in ECPR group (6-month survival was significantly better in the

ECPR group). Investigators concluded that ECPR in patients with OHCA and refractory VF significantly improved survival to hospital discharge compared with CCPR [1]. The study was terminated at the first preplanned interim analysis by the National Heart, Lung, and Blood Institute after unanimous recommendation from the Data Safety Monitoring Board after enrolling 30 patients because the posterior probability of ECMO superiority exceeded the prespecified monitoring boundary [1]. Results of first RCT compared ECPR vs. CCPR were beneficlan for ECPR.

Next one RCT, „EROCA - extracorporeal cardiopulmonary resuscitation for refractory out-of-hospital cardiac arrest)" (Hsu C. H. et al., Michigan, USA in a 2-tiered EMS with an ECPR-capable primary destination hospital). The study included adults with refractory cardiac arrest (RCA) with shockable rhythm or witnessing OHCA. If the predicted emergency call time to arrive time to emergency department (ED) interval was ≤ 30 min., was expedited transport or standard care. The researchers, as the primary outcomes assess the proportion of subjects with emergency call to ED arrival ≤ 30 min and ED arrival to ECPR flow ≤ 30 min. From 151 emergency calls (OHCA), 15 were enrolled. 5 of 12 subjects randomized to expedited transport had an ED arrival time of ≤ 30 min. and 5 were eligible for and treated with ECPR. 3 of 5 ECPR treated patients had flow initiated in ≤ 30 min of ED arrival. No patients in either group survived with a good neurologic outcome [2]. Researchers conducted the ECPR for refractory OHCA trial did not meet predefined feasibility outcomes for selecting OHCA patients for expedited transport and initiating ECPR in the ED [2].

Next one RCT the "Praque OHCA" (Belohlavek J. et al., Praque Czech Republic, single center, planned sample size of 285 patients). The aim was to determine whether an ECPR in adults with refractory OHCA improves favorable neurological outcomes (FNO). To research included adults with a witnessed OHCA of presumed cardiac origin without ROSC. Since March 2013 to October 2020 enrolled 256 patients. Patients were observed until death or 180 day. In ECPR group (124) mechanical compression was initiated, followed by intra arrest transport to a cardiac center for ECPR. CCPR group (132) was continued on site in the standard strategy. Researchers, as the primary outcome assess survival with a good neurologic outcome (CPC 1-2) at 180 days after randomization. As a secondary outcomes they evaluate neurologic recovery at 30 days (defined as CPC 1-2 at any time within the first 30 days) and cardiac recovery at 30 days (defined as no need for pharmacological or mechanical cardiac support for at least 24 hours) [3]. The trial was stopped at the recommendation of the data and safety monitoring board when prespecified criteria for futility were met. 256 patients (100%) completed the trial, 39 patients (31.5%) in the ECPR group and 29 (22.0%) in the CCPR group survived to 180 days with good neurologic outcome. At 30 days, neurologic recovery had occurred in 38 patients (30.6%) in the ECPR group and in 24 (18.2%) in the CCPR group and appropriately cardiac recovery had occurred in 54 (43.5%) and 45 (34.1%) patients [3]. In the first statistical analysis, ECPR strategy did not significantly improve survival with FNO at 180 days compared with CCPR, it was estimate that the trial was possibly underpowered to detect a clinically relevant difference [3]. In the second statistical analysis, ECPR was associated with improved 180-day survival in patients without prehospital ROSC [4]. This study, due to its large sample, was widely hailed as a breakthrough in favor of ECPR.

Last RCT „INCEPTION" (Suverein M. M. et al., conducted in the Netherlands). RCT assigned patients with OHCA to receive ECPR or CCPR. Included adults (18 and 70 years old), had received bystander CPR, had an initial ventricular arrhythmia, and did not have ROSC within 15 minutes after CPR had been initiated. The primary outcome of RCT was survival with a FNO (defined as a CPC 1-2) in 30 days. Researchers underwent 160 patients randomization, 70 were receive ECPR and 64 receive CCPR. 26 patients who did not meet the inclusion criteria at hospital admission were excluded. At 30 days, 14 patients (20%) in the ECPR group were alive with a FNO, as compared with 10 patients (16%) in the CCPR group. The number of serious adverse events per patient was similar [5]. In results, patients with refractory OHCA, ECPR and CCPR had similar effects on survival with a FNO [5]. The results of RCTs are divergent, some in favor of ECPR, some showing no advantage of ECPR over CCPR. The discrepancy in results prompted meta-analysis of RCTs comparing ECPR *vs*. CCPR.

## REVIEW OF META-ANALYSES OF RANDOMISED CONTROL TRAILS

Below presented goals, methods and results of meta-analyses including RCTs comparing ECPR vs. CCPR, found in MEDLINE database for the dates 01/01/2018 to 31/12/2023 (5 years).

Scquizzato T. et al. searched MEDLINE, Embase, and the Cochrane Central Register of Controlled Trials up to February 2023, for RCTs comparing ECPR *vs*. CCPR in adults with refractory OHCA. Through a database review, they found and meta-analyzed 4 RCTs. They analysed data and concluded that ECPR *vs*. CCPR increased survival with FNO at the longest follow-up available for all rhythms 59/220 27% *vs*. 39/213 18% and overall survival at the longest follow-up available was similar 61/220 25% *vs*. 34/212 16% [6]. The investigators concluded that ECPR compared with CCPR increased survival with FNO in adults with refractory OHCA, especially when the initial rhythm was shockable. [6].

Cheema H. A. et al. searched electronic databases until March 2023 for RCTs comparing ECPR with CCPR in OHCA patients. Total of 4 RCTs were included to their analyse. Researchers, as the results of meta-analysis showed no statistically significant benefit of ECPR regarding mid-term survival; they found significant improvement with ECPR in mid-term FNO, and conclude, that no significant difference between ECPR and CCPR in long-term survival and long-term FNO. Aditionally, they noticed an increased incidence of adverse events in the ECPR group [7]. In sum-

mary, ECPR in OHCA patients was not associated with improved survival or long-term FNO but did improve FNO in the mid-term [7].

The comparison of ECPR *vs*. CCPR was also have done by Yuko K. et al., who systemic search for RCTs comparing the efficacy of ECPR *vs*. efficacy of CCPR for OHCA until February 2023, as the end points were 6-month survival, and 6-month and short-term (in-hospital or 30-day) survival with FNO (CPC - cerebral performance category scale - 1-2). They identified 4 RCTs including a total of 435 patients. Data analyses showed, there was a tendency towards improved 6-month survival and 6-month survival with FNO in ECPR although; and results did not reach statistical significance. They reported that ECPR was associated with a significant improvement in short-term FNO without heterogeneity [8].

**Table 1.** The characteristics of the participants in each RCT [8].

| | ARREST 2020 | | EROCA 2021 | | OHCA 2022 | | INCEPTION 2023 | |
|---|---|---|---|---|---|---|---|---|
| | ECPR | CCPR | ECPR | CCPR | ECPR | CCPR | ECPR | CCPR |
| Participiants (n) | 15 | 15 | 12 | 3 | 124 | 132 | 70 | 64 |
| Age, mean age (SD or IOR) | 59 (10) | 58 (11) | 62 (8) | 61 (8) | 59 (48-66) | 75 (47-65) | 54 (12) | 57 (10) |
| Males, n(%) | 14 (93) | 11 (73) | 8 (67) | 2 (67) | 102 (82) | 110 (83) | 63 (90) | 57 (89) |
| White, n(%) | 5 (33) | 2 (13) | 9 (75) | 3 (100) | – | – | – | – |
| **Medical history** | | | | | | | | |
| CAD, n (%) | 2 (13) | 4 (27) | – | – | 17 (16) | 17 (21) | 7 (12) | 6 (11) |
| PCI, n (%) | 1 (7) | 1 (7) | – | – | – | – | 5 (8) | 5 (9) |
| CABG, n (%) | 2 (14) | 1 (7) | – | – | – | – | 2 (3) | 4 (7) |
| CHF, n (%) | 1 (7) | 0 (0) | – | – | 11 (10) | 5 (6) | 4 (6) | 2 (4) |
| Diabetes mellitus, n (%) | 3 (20) | 3 (20) | – | – | 19 (18) | 17 (21) | 10 (16) | 6 (11) |
| Hypertension, n (%) | 2 (13) | 5 (33) | – | – | 47 (44) | 42 (51) | 24 (55) | 15 (45) |
| Hyperlipidemia, n (%) | 1 (7) | 2 (13) | – | – | – | – | 10 (31) | 15 (48) |
| CKD, n (%) | 0 (0) | 2 (13) | – | – | 3 (3) | 2 (3) | – | – |
| Current smoking, n (%) | 1 (7) | 4 (27) | – | – | – | – | 20 (57) | 18 (55) |
| Obesity, n (%) | 0 (0) | 1 (7) | – | – | – | – | – | – |
| **Initial laboratory values** | | | | | | | | |
| pH, median (SD or IQR) | 6.9 (0.9) | 7.0 (0.11) | – | – | 6.93 (6.8-7.1) | 7.03 (6.9-7.2) | 6.97 (0.16) | 6.88 (0.16) |
| Lactate, median (SD or IQR)(mmol/l) | 11. (4.5) | 10.7 (3.1) | – | – | 12.5 (9.2-16) | 10.4 (7.5-13.5) | 13 (5) | 14 (4) |
| **Situation of CA** | | | | | | | | |
| CA at home, n (%) | 7 (47) | 7 (47) | 10 (83) | 2 (67) | 42 (34) | 34 (26) | 31 (44) | 24 (38) |
| Witnessed CA, n (%) | 11 (73) | 13 (87) | – | – | 124 (100) | 132 | | |
| Bystander CPR, | (100) | 68 (97) | 63 (98) | | | | | |
| n (%) | 13 (87) | 12 (80) | – | – | – | – | 61 (88) | 52 (85) |
| Time from OHCA to ECLS initiation, mean time (SD or IQR) (min) | 59 (28) | – | 66 (16.7) | – | 61 (55-70) | 62 (51-73) | 74 (63-87) | – |
| **Initial cardiac rhythm** | | | | | | | | |
| VF, n (%) | 15 (100) | 15 (100) | 5 (42) | 3 (100) | 72 (58) | 84 (64) | 70 (100) | 64 (100) |
| PEA, n (%) | 0 (0) | 0 (0) | 4 (33) | 0 (0) | 21 (17) | 24 (18) | 0 (0) | 0 (0) |
| Asystole, n (%) | 0 (0) | 0 (0) | 3 (25) | 0 (0) | 31 (25) | 24 (18) | 0 (0) | 0 (0) |
| **Cause of CA** | | | | | | | | |
| Acute MI, n (%) | – | – | – | – | 64 (52) a | 63 (48) a | 51 (73) | 52 (81) |
| **Study characteristics** | | | | | | | | |
| Follow-up period, n (month) | 6 | 3 | 6 | 6 | | | | |

*The values stand for the numer (%) of cases in which the causes of OHCA were acute coronary syndrome.

CABG - coronary artery bypass grafting; ECLS - extracorporeal life support; IOR - interquartile range; OHCA - out of hospital cardiac arrest; CA - cardiac arrest; PCI - percutaneus coronary intervention; PEA - pulseless electrical activity; SD - standard deviation; VF - ventricular fibrilation; MI - myocardial infraction

They concluded that the meta-analysis of RCTs revealed that there was a tendency towards better mid-term neurological outcomes in ECPR and that ECPR was associated with a significant improvement in short-term FNO compared with CCPR (Table 1) [8].

Another meta-analysis was undertaken by Gomes D. A. et al. Systematic search of databases (PubMed, CENTRAL, and Scopus) to March 2023, included RCTs compared ECPR *vs*. CCPR for OHCA, and outcomes defined as survival with a FNO (CPC 1-2), the short and 6 months periods of time, and mortality. As a result of the review, the researchers included 3 RCTs, with a total of 418 patients. In conclusion, ECPR was associated with a non-statistically significant higher rate of survival with a FNO at the shortest period of time (26.4% *vs*. 17.2%) and at 6 months (28.3% *vs*. 18.6%). The mean absolute rate of in-hospital mortality was not significantly lower in the ECPR group [9]. In summary, they reported that ECPR was not associated with a significant improvement in survival with FNO in refractory OHCA patients [9].

A systematic review and meta-analysis was also performed by Kruit N. et al. They searched the databases (Medline, Embase, and PUBMED) for all RCTs and observational trials (4 studies were included). They evaluate, that a total of 222 patients receiving prehospital ECPR. The primary outcome was survival at hospital discharge. Data analyse show, that overall survival at discharge was 23.4%. The quality of evidence was assessed as low. The overall risk of bias was assessed to be serious, with confounding being the primary source of bias [10]. In summary, researchers conclude, that no definitive conclusions can be made as to the effectiveness of prehospital ECPR in RCA [10].

The results of meta-analyses of RCTs compared ECPR *vs.* CCPR are partly convergent and partly divergent. 1 of 5 meta-analyses recognize the higher efficacy of ECPR *vs*. CCPR. 1 of 5 meta-analyses indicate that ECPR was associated with a significant improvement in short-term FNO compared with CCPR. 2 of 5 meta-analyses indicate higher mid-term neurological outcomes in ECPR. 2 of 5 meta-analyses define, that ECPR in OHCA patients was not associated with improved survival or long-term FNO but did improve FNO in the mid-term or ECPR was not associated with a significant improvement in survival with FNO in refractory OHCA patients. 1 of 5 meta-analyses summarize, that no definitive conclusions can be made as to the efficacy of prehospital ECPR in RCA. Despite the high statistical value, the results of meta-analyses do not provide an unequivocal answer to the question: yes or no for ECPR. The results of prospective and retrospective reviews, with data based on national or regional centers databases, may be helpful in answering this question.

## REVIEW OF PROSPECTIVE AND RETROSPECTIVE STUDIES BASED ON NATIONAL OR REGIONAL CENTERS DATABASES

Bougouin W. et al., analysed registry of OHCAs in the Paris region since May 2011 to January 2018. The main outcomes of analyse was compare survival at hospital discharge with and without ECPR and to identificate factors associated with survival for patients treated ECPR. Based on the analysis of 13191 CA cases, they showed that survival was 8% in 525 patients in ECPR group and 9% in 12666 patients in CCPR group. They use statistical analysis, and summary, that ECPR was not associated with hospital survival. Aditionnaly noticed, that ECPR factors associated with hospital survival were: initial shockable rhythm, transient ROSC before ECMO, and prehospital ECPR [11]. Their obserwation evaluate, that in population's registry, 4% of OHCAs were treated with ECPR, which was not associated with increased hospital survival. They summed up, early ECPR may improve outcomes, the initial rhythm and transient ROSC before ECPR can be positive predictive factors [11]. The study draws attention to the time factor determining the success of ECPR, and circumstances occurring during CPR that have a positive impact on effectiveness.

Choi Y. et al., analyse a nationale OHCA registry of South Korea. They identified adult OHCA patients who underwent CPR at the ED since 2013 to 2020. As a primary outcome, they assessed a good neurological recovery at discharge. Researchers identified 11839 patients, 484 received ECPR. They have done 1:4 time-dependent propensity score matching, included 458 patients in the ECPR group and 1832 patients in the CCPR group. As result, they concluded, that in the matched cohort, ECPR was not associated with good neurological recovery, and addictionally, in the stratified analyses according to the time, ECPR started 45 min. after ED arrival was associated with FNO [12]. In summary, they noticed, ECPR itself was not associated with good neurological recovery, but early ECPR was positively associated with good neurological recovery [12]. This is another study that points to the time factor determining the success of ECPR.

Nee J. et al., have done prospective cohort study (analyse of university hospital center and ECPR program for OHCA, 24/7 ECPR service at the Charité in Berlin). On base of report of 254 patients admitted from August 2014 to December 2017. Total 254 patients were transferred with ongoing CPR (30 patients showed or developed ROSC after admission). In ED were checked exclusion criteria for ECPR, 126 patients were eligible for ECPR. In results, 18 patients survived, 15 with a good neurological outcome (CPC 1-2) [13]. Researchers compared survivors and non-survivors, and notice, that in ECPR group, survivors had significantly: shorter low flow time 58 min *vs*. 90 min.; lower lactate levels on admission 95 mg/dL *vs.* 143 mg/dL; less severe acidosis on admission pH 7.2 *vs.* 7.0. Binary logistic regression analysis identified latency to ECPR and low pH as independent predictors for mortality [13]. The study by Nee J. et al. indicates that reducing low flow time is important for the success of ECPR, and factors such as lactate level and pH can be taken as criteria of patient selection.

Liu Yinget et al., conduct retrospective survey about the usage of ECPR in China (analyse Chinese Society of Extracorporeal Life Support Registry Database) includ-

ing patient selection, initiation and management of ECPR patient outcome, and compared the status since 2017 to 2020. They identified all patients treated with ECPR from January 2017 to December 2020. The database were surveyed of all adult cases defined as documented RCA who suffered CA and did not respond to CCPR, which were reported from 42 ECMO centers (19 provinces in China). 11 ECPR centers in 2017 and 42 centers in 2020 uploaded information. A total of 577 patients experienced ECPR, 365 (63.3%) patients removed from ECMO successfully, 175 (30.3%) discharged alive. Data showed, that treated cases increased gradually year by year (33 cases in 2017, and 274 cases in 2020). The survival rate also increased (24.2% in 2017 *vs*. 33.6% in 2020) [14]. The etiology of ECPR was analysed (AMI, valvular heart disease and cardiomyopathy, severe pneumonia and sepsis, PE, acute myocarditis, malignant arrhythmia, and others). Patients with myocarditis and pulmonary embolism had higher survival rates of 46.4% (13/28) and 48.5% (16/33), respectively. In contrast, patients with severe infection and sepsis had the lowest survival rate of 18.0% [14]. Comparison of etiology and survival, may help professionals for practice define selection criteria to create ECPR programs. Researchers summary, ECPR was used widely over years in patients who failed to ROSC under CCPR in China. An average survival rate is 30.3%. Centers with ≥20 cases had a higher removal rate from ECMO [14].

Hadaya J. et al., analysed National Inpatient Sample (USA), for all patients admitted after OHCA and who experienced IHCA from 2005 to 2014 (excluded patients carrying a pregnancy, with DNR (do not resuscitat) orders or trauma-related diagnoses). By used multivariable logistic regression they try to find identify predictors of ECPR survival. A total number 1624827 patients were identified. ECPR increased from 77 to 564 per 100000 OHCA, and 60 to 632 per 100000 IHCA. Survival patients treated ECPR for OHCA and IHCA increased. Researcher noticed, that age, year of arrest, cardiac rhythm, and the presence of a potentially reversible etiology including MI (myocardial infraction) and PE (pulmonary embolism), were predictive of ECPR utilization. Age, rhythm CA, and location of CA were predictive of survival to discharge [15]. That informations are important to create inclusion and exclusion criteria for ECPR. Aditionally, they noticed, that mortality for ECPR decreased. Younger age, shockable rhythm, and OHCA location were predictive of survival or utilization. In conclusions, ECPR use increases, it is critical to define selection criteria that maximize the benefits of ECPR [15]. This is another large retrospective study that highlights factors that influence the success of ECPR.

Ohbe H. et al., analysed a nationwide inpatient database in Japan (retrospective cohort study). Researchers aims were to assess the association between low flow time duration and survival to discharge. They filtered all IHCA patients ≥ 18 years old who received ECPR during hospitalization since July 2010 to March 2018 and found 303319 cases of IHCA. 9844 (3.2%) received ECPR in 697 hospitals during the study period and 9433 were eligible to study. The overall survival to discharge rate was 20.5% [16]. Additionaly, researcher evaluate, the estimated survival to discharge rate was markedly decreased by approximately 20% during the first 35 minutes of low-flow duration, and noticed is questionable to wait for the first 10 -20 minutes of CA without preparing for ECPR [16]. This retrospective study on a large sample once again drew attention to the key factor of time.

Scquizzato T. et al., analysed refractory OHCA patients treated with ECPR since 2013 for 2022 at IRCCS San Raffaele Scientific Institute in Milan in Italy and assessed adictionaly survival and neurological outcome to hospital discharge. Researcher found, out of 307 consecutive OHCA patients were treated with ECPR, 17% survived and 9.4% had FNO. Survival and FNO increased to 51% and 28% when initial rhythm was shockable and low-flow time ≤60 minutes and decreased to 9.5% and 6.3% when low-flow exceeded 60 minutes [17]. Aditionally, they analysis show, that shockable rhythm, shorter low flow time, intermittent ROSC and signs of life were associated with better outcomes. Survival reached 10% after treating 104 patients [17]. They summarized that patients with initial shockable rhythm, intermittent ROSC, signs of life, and low flow ≤60 minutes had higher success of ECPR for refractory OHCA, favorable outcomes were possible beyond 60 minutes of low-flow, especially with concomitant favorable prognostic factors and generally outcomes improved as the case-volume increased and ECPR is performed in supporting treatment in high volume CA centers [17]. Study indicate on the importance of the selection criteria and factors and circumstances affecting the success of the procedure (shockable rhythm, shorter low flow time, intermittent ROSC and signs of life). This emphasizes that the size of and the number of CA should be taken into account when creating ECPR programs.

In summary, retrospective studies on large samples indicate many factors that affect the success and effectiveness of ECPR as a resuscitation procedure and as an ECPR program.

## CONCLUSIONS OF META-ANALYSES AND SYSTEMATIC REVIEWS RETROSPECTIVE STUDIES AND LITERATURE REVIEWS

During the creation of the article database, many literature reviews comparing ECPR *vs.* CCPR were found. Researchers analysing the data responsively, come to conclusions that indicate what elements to pay attention to when making decisions: yes or no for ECPR?

Below, we present the researcher's conclusions, from meta-analyses and systematic reviews, contained in Pubmed (Medline) resources for the dates 01/01/2018 to 31/12/2023 to draw additional attention to possible factors influencing decision-making for or against ECPR.

Jer Wei Low C.et al., conclude, that their findings suggest that ECPR could be considered for eligible patients with IHCA, although further research into patients with OHCA is warranted [18]. Geisendrees C. et al. noticed, that despite a current scarcity of data, a survival advantage

for ECPR treatment in selected OHCA patients must be assumed, and expect other high-quality studies, as indicated to evaluate if and to what extent resource-intensive ECPR programs can be comprehensively established [19]. Twohig C. J. et al. concluded, that ECPR is a sophisticated treatment option which may improve outcomes in a selected patient population in RCA [20]. Miraglia D. and others analysis suggests that VA ECMO used as ECPR may improve long-term FNO and survival when compared to the best standard of care in a selected patient population [21], and they add it is imperative for well-designed RCTs to obtain a higher level of scientific evidence to ensure optimal outcomes for CA patients [21].

Analysis of literature of Alfalasi R. et al. indicate, that ECPR was associated with improved CPC at 3 and 6 months following arrest, and suggesting its benefit in long-term functional status in OHCA survivors when compared to CCPR [22]. Positively, ECPR also defines Ontario health technology assessment as a method - for adults treated for RCA, ECPR may improve survival and likely improves long-term neurological outcomes compared with CCPR marking, that for adults with RCA, ECPR may be cost- effective compared with CCPR [23].

Finally, analyse of Bartos J. A. and others, conclude, that ECPR was associated with improved FNO survival at all CPR durations <60 minutes despite severe progressive metabolic derangement [24] to sum it up - CPR duration remains a critical determinate of survival [24].

## DISCUSSION

There are 4 RCTs comparing ECPR *vs.* CCPR. The sample sizes of the all RCTs (ARREST 2020 ECPR n=15, CCPR n=15; EROCA 2021 ECPR n=12, CCPR n=3; OHCA 2022 ECPR=124, CCPR=132; INCEPCTION ECPR n=70, CCPR=64, respectively) indicate that the RCTs compared a total of ECPR n=221 vs. CCPR n=214 (total 435).

The results of RCTs comparing ECPR vs. CCPR are mixed, indicating that ECPR improved survival to hospital discharge compared with CCPR or ECPR and CCPR had similar effects on survival with a FNO.

The results of the RCTs were subjected to meta-analyses. The results of meta-analyses formulate divergent conclusions about the advantage of ECPR vs. CCPR, as: ECPR compared with CCPR increased survival with FNO in adults with refractory OHCA or ECPR in OHCA patients was not associated with improved survival or long-term FNO but did improve FNO in the mid-term or ECPR was not associated with a significant improvement in survival with FNO or said, that no definitive conclusions can be made as to the efficacy of ECPR in RCA.

The results of prospective and retrospective studies based on national or regional center databases indicate that regionally, in countries such as France, South Korea, United States of America, Japan, China, ECPR programs are used quite widely, while the observation results focus on factors predicting ECPR effectiveness, without comparing them with CCPR results. Scientists, attempting meta-analyses and systematic reviews, retrospective studies and literature reviews comparing ECPR vs. CCPR and indicate discrepancies. Findings suggest that ECPR could be considered for eligible patients with IHCA, although further research into patients with OHCA is warranted.

ECPR may improve outcomes in a selected patient population in RCA; analysis suggests that VA ECMO used as ECPR may improve long-term FNO and survival when compared CCPR in a selected patient population. Therefore, it is imperative for well-designed RCTs to obtain a higher level of scientific evidence to ensure optimal outcomes for CA patients.

## CONCLUSIONS

There is a lack of RCTs comparing ECPR vs. CCPR in general, and there is a lack of RCTs comparing ECPR vs. CCPR in particular with a sufficiently large sample size to clearly demonstrate the superiority of one method over the other.

The RCTs compared ECPR vs. CCPR are limited due to the small number of studies themselves and sample size limitations. The results of the limited RCTs of ECPR vs. CCPR are inconsistent. The limited studies and inconsistent results do not provide a basis for formulating clear guidelines for the use of ECPR, but only allow for the formulation of recommendations for selected patients where ECPR may be considered as a last-resort therapy.

Retrospective studies draw attention on selection criteria and factors and circumstances that have influence on the effectiveness of ECPR. Use of ECPR increase.

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**CONFLICT OF INTEREST**

The Authors declare no conflict of interest.

**ADDRESS FOR CORRESPONDENCE**

Jakub Hubert Będkowski
Department of Medical Education
Jagiellonian University Medical College,
ul. Medyczna 7, 30-688, Kraków, Poland;
e-mail: jakub.bedkowski@uj.edu.pl

**ORCID AND CONTRIBUTION**

Jakub Hubert Będkowski - 0000-0003-4836-6522 ⒶⒷⒹⒺⒻ
Magdalena Augustyn - 0009-0003-9855-6145 ⒶⒷⒺⒻ



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# Problems in the actions of medical responders regarding older adults in the context of COVID-19: yesterday, today, and tomorrow

Kinga Cogiel[1], Małgorzata Osikowicz[1], Magdalena Kronenberg[2], Katarzyna Janik[3], Tomasz Męcik-Kronenberg[4,5]

[1]MULTI-SPECIALIST DISTRICT HOSPITAL S.A. NAMED AFTER DR. B. HAGER, TARNOWSKIE GORY, POLAND
[2]STUDENT RESEARCH GROUP AT THE CHAIR AND DEPARTMENT OF PATHOMORPHOLOGY FACULTY OF MEDICAL SCIENCES IN ZABRZE, MEDICAL UNIVERSITY OF SILESIA, ZABRZE, POLAND
[3]UNIVERSITY DENTAL CENTER OF THE SILESIAN UNIVERSITY IN KATOWICE, BYTOM, POLAND
[4]DEPARTMENT OF PATHOMORPHOLOGY, FACULTY OF MEDICAL SCIENCES IN ZABRZE, MEDICAL UNIVERSITY OF SILESIA, ZABRZE, POLAND
[5]COLLEGIUM MEDICUM NAMED AFTER DR WŁADYSŁAW BIEGAŃSKI, JAN DŁUGOSZ UNIVERSITY, CZESTOCHOWA, POLAND

**ABSTRACT**

The article analyzes the challenges faced by paramedics in providing care for geriatric patients, especially in the context of the COVID-19 pandemic. As the population ages, there is a significant increase in the number of seniors requiring emergency interventions, which is linked to their complex health needs and high rates of comorbid chronic diseases. Clinical practice demands an individualized therapeutic approach that considers the functional and cognitive limitations of patients, often manifested as frailty syndrome. During the COVID-19 pandemic, geriatric patients faced an increased risk of severe disease progression, leading to delays in seeking medical assistance and poorer treatment outcomes. The article also addresses the inadequate preparation of medical personnel to work with patients during a health crisis and highlights the need for new protocols and guidelines for geriatric care. Furthermore, it emphasizes the importance of interdisciplinary education and investment in modern technologies, such as artificial intelligence, to enhance the effectiveness of emergency medical services. Looking ahead, a key priority will be adapting the healthcare system to better meet the specific needs of geriatric patients, which involves comprehensive assessments and a holistic approach to diagnostics and treatment.

**KEY WORDS**

Emergency Medical Service, COVID-19, geriatrics, elderly care, AI in healthcare, older adults

## INTRODUCTION

### AGING OF SOCIETY

The World Health Organization (WHO) states that old age is divided into "young old," which includes individuals aged 60 to 75, "old age," which encompasses the age range of 75 to 90, and "longevity," which is over 90 years old. The global increase in average life expectancy has significantly contributed to the rise in the population of older individuals worldwide [1]. For example, in the United States, over 49 million people, accounting for about 15% of the population, are currently 65 years or older, and this number is expected to double by 2050. The issue of aging society affects all developed countries. UN forecasts predict that by 2030, the percentage of the population in Europe aged over 65 will reach 23.8% [2].

In the context of aging indicators, one cannot forget about Japan, which stands out with the fastest aging society and the highest projected life expectancy at birth. Forecasts suggest that by 2050, older adults will constitute 35.7% of the total population [3]. In Poland, the group of individuals aged 65 and over is also increasing – in 2023 it grew to over 7.5 million, representing 20.1% of the total population [2]. The most alarming forecast comes from the US Census Bureau, which predicts that by 2034, the population aged 65 and older will exceed the population under 18 for the first time in history. It is also anticipated that, within a few years, the number of geriatric patients admitted to emergency departments will increase, with one-third of them already being seniors [4]. Various diseases in older adults lead to a rise in outpatient visits and hospitalizations, resulting in higher costs and greater consumption of medical resources [9]. Consequently, the well-being of older populations has become a public health priority in many countries and, above all, a significant challenge [1,2,4].

### THE SIGNIFICANCE OF EMERGENCY MEDICAL RESPONDERS' ACTIONS IN SENIOR CARE

Every day, emergency medical teams respond to numerous incidents requiring assistance for individuals in need: acute cases, exacerbations of chronic conditions, physical injuries, and psychological disturbances [5]. In relation to elderly individuals, emergency medicine currently recognizes this population as one with specific needs, requiring distinct diagnostic and therapeutic approaches [6]. Seniors represent a group particularly vulnerable to sudden health deterioration due to factors such as age, multimorbidity, polypharmacy, and weakened immune systems [7]. Studies indicate that geriatric patients account for 12–24% of all hospital admissions in Emergency Departments, with an upward trend anticipated for the future [8]. Other research shows that 58% of patients require transportation to the Emergency Department because on-site interventions by medical teams often cannot be concluded at the scene and require hospital transfer for further diagnostics, specialist consultations, and health monitoring [5,7]. The age group of 60–74 years received the highest number of services both before and after the COVID-19 pandemic. Moreover, elderly individuals are particularly prone to injuries [9]. Emergency medical responders provide professional assistance in cases of injuries among older adults [5], but they sometimes face critical decisions as age-related issues can lead to disability or even death [5,7]. During the COVID-19 pandemic, additional challenges arose for medical personnel, as this age group displayed an exceptionally high susceptibility to severe disease progression and its potential consequences [8,9].

### CHARACTERISTICS OF THE GERIATRIC PATIENT

Elderly individuals are among the groups with the highest rate of Emergency Department visits. A pivotal moment occurred in the early 1990s when emergency medicine physicians recognized that older patients represent a distinct group requiring specific evaluation and individualized therapeutic approaches [6,8]. Caring for this patient group in the Emergency Department presents clinical challenges such as multimorbidity, atypical symptom presentation, polypharmacy, risks of drug interactions, and improper use of both prescribed and over-the-counter medications [7,10].

Statistics indicate that injuries are the most dangerous incidents for seniors, accounting for one in five deaths in individuals over 75 years of age, which constitutes 40% of trauma-related fatalities in this population [11]. Falls represent 10–15% of Emergency Department visits. Pre-pandemic studies conducted in the UK, the US, and Canada revealed varying percentages of fall-related incidents, with 30%, 12%, and 20%, respectively. The length of hospital stays for older adults varies, ranging from short-term stays to outcomes that may result in long-term functional limitations [12]. An increase in the number of older adults in the population appears to be the primary factor contributing to the growing frequency of injuries among seniors [13].

Among the most commonly diagnosed conditions in this patient group are cardiovascular diseases, including hypertension and coronary artery disease, respiratory diseases, diabetes, osteoporosis, vision and hearing impairments, as well as dementia and related cognitive dysfunctions [10,13]. When multimorbidity overlaps with aging, it is referred to as the frailty syndrome [7,10,13]. Additionally, older adults may face functional limitations, cognitive impairments, communication difficulties, and limited social support [13].

A holistic approach to geriatric patients considers the assessment of cognitive abilities, fall risk, social circumstances, potential signs of neglect, and mental health status [6, 8, 10, 13].

### ELDERLY INDIVIDUALS IN THE CONTEXT OF COVID-19

The COVID-19 pandemic represented a true emergency for seniors. Over 90% of COVID-related deaths occurred in individuals over the age of 65 [6]. Advanced age, multiple comorbidities, and a weakened immune system significantly reduce the body's ability to effectively combat viral infections [7, 14]. As a result, geriatric patients are particularly vulnerable to severe disease progression, complications, and an increased risk of mortality in the context of the pandemic [14].

This weakening of immune system function is referred to as immunosenescence. This process encompasses dysfunctions in both innate and adaptive defense mechanisms [15]. Decreased T-cell activity, impaired macrophage function, and reduced cytokine production lead to a weakened response to SARS-CoV-2 infection [16]. Consequently, geriatric patients not only respond more slowly to infections but are also at an increased risk of developing severe complications such as acute respiratory failure, sepsis, or multiple organ failure syndrome [14, 16].

Another critical factor in the geriatric population is multimorbidity, or the coexistence of multiple chronic conditions, which is a significant risk factor for severe COVID-19 outcomes [14,16]. Undoubtedly, many elderly individuals were exposed to the risk of COVID-19 infection in the context of globalization and population aging, placing a significant burden on healthcare systems worldwide [16].

## THE AIM

The aim of this article is to analyze the challenges faced by emergency medical responders in caring for geriatric patients, the problems they currently encounter, and to consider the future of this field and the perspectives it offers.

## REVIEW AND DISCUSSION

### PERSISTENT ISSUES FOR EMERGENCY MEDICAL RESPONDERS IN CARING FOR ELDERLY PATIENTS

In recent years, even before the outbreak of the COVID-19 pandemic, emergency medical responders have

faced growing challenges in providing care for geriatric patients. Older individuals constitute an increasing proportion of society, and their complex health needs require not only specialized skills but also flexibility and empathy from responders [6, 10].

Among the key issues is the growing number of geriatric patients. In 2019, the global population aged 65 and older reached 703 million [17], and it is projected to increase to 1.6 billion by 2050 [18]. Studies indicate that elderly patients use emergency medical services significantly more often than younger individuals [8]. Additionally, the frequency of Emergency Department visits increases with age. For older patients, medical interventions by emergency responders more frequently result in hospital transport compared to younger patients [19].

Emergency medical responders also face communication challenges with geriatric patients, as many older individuals experience hearing, speech, and cognitive impairments. Stressful situations, changes in environment, and additional sensory stimuli often exacerbate these difficulties [20].

Conducting physical examinations outside the hospital can also be challenging, as geriatric patients often do not present typical or characteristic symptoms of illness [5, 6]. Multimorbidity is common among older adults, and as a result, these patients often take numerous medications, increasing the risk of potentially harmful drug interactions [5-7]. This has led to a rise in acute emergency interventions by medical teams [5, 7, 9].

A condition frequently observed in elderly individuals is frailty syndrome, characterized by reduced resilience to stressors and general physical weakness [6, 13, 20], which contributes to increased utilization of emergency medical services [5,7,9]. Emergency department staff may struggle to identify frailty syndrome due to a lack of time, resources, and standardized tools for its assessment [6, 13].

**Emergency Departments (EDS)**

During the COVID-19 pandemic, a significant decrease in the number of visits by elderly patients to Emergency Departments (EDs) was observed [21-23]. This phenomenon was driven by fear of infection, as geriatric patients are at higher risk of contracting the SARS-CoV-2 virus compared to younger individuals [21]. Consequently, many delayed seeking medical assistance until their health condition became critical [21, 23]. The decrease in the number of geriatric patients in EDs was also influenced by pandemic-related isolation and messaging from the media [21].

However, the pandemic also saw an increase in the number of repeat visits to EDs [22]. The process of admission to emergency departments changed, as patients suspected of SARS-CoV-2 infection were directed to isolation rooms [22].

The pandemic posed new challenges for EDs, which must adapt to the evolving needs of the geriatric population. New strategies should be implemented to improve the quality of care and ensure the safety of older individuals [21, 23].

The lack of adequate preparedness among medical personnel to work with geriatric patients during epidemic threats, such as the COVID-19 pandemic, exposed numerous deficiencies within the healthcare system. Facilities lacked sufficient resources and specialized knowledge, leading to difficulties in effectively managing the health of older adults, who are particularly vulnerable to complications associated with infectious diseases [24, 25].

Additionally, working conditions, including increased emotional burden, long working hours, and the necessity of using personal protective equipment, negatively impacted the ability of staff to provide holistic and empathetic care [25-27].

## THE FUTURE OF ELDERLY CARE IN THE CONTEXT OF EMERGENCY MEDICAL SERVICES

**The role of AI during COVID**

During the COVID-19 Pandemic, The Amiens Picardy University Hospital in France utilized artificial intelligence (AI) in its emergency department to aid in patient management by predicting the maximum and minimum number of beds required. AI was also utilized in triaging patients with and without suspected COVID-19 infections [28].

A study conducted by Chee and colleagues presented various AI applications that supported the diagnosis, monitoring, and treatment of COVID-19 patients. However, most of these applications carried a high risk of error and were therefore not ready for deployment in emergency departments. The authors emphasized the need for further research into the effectiveness and ethical implications of AI in medicine, highlighting the importance of integrating technology into clinical practice to maximize its potential in future health crises [29].

**Modern technologies**

Artificial intelligence is gaining prominence in emergency medical services, offering innovative solutions that can significantly improve the quality of care and the efficiency of emergency operations [25, 30-32]. Through advanced data analysis algorithms, AI enables rapid assessment of patient health, which is particularly critical in crisis situations where response time is vital [30, 31, 33].

Clinical decision support systems can monitor patient conditions, analyze symptoms, test results, and demographic data, allowing for more precise diagnoses and treatment decisions [25,30-33]. Additionally, AI can optimize emergency response team routes and predict hospital capacity demands, enhancing resource management and increasing patient survival rates [30,32].

In the face of growing demand for medical services, the use of AI in emergency medical care presents a promising perspective, and its development could bring significant benefits to the healthcare system [25, 30, 31, 33].

AN AGING SOCIETY: NEW GUIDELINES, PROTOCOLS, AND PERSPECTIVES FOR ELDERLY CARE

Given the forecasted increase in demand for specialized healthcare for seniors, the development of medical subspecialties dedicated to their needs has become imperative [34]. Currently, high-quality healthcare services are incorporated into Geriatric Emergency Medicine (GEM), introduced in the U.S. in 1996 [35, 36], which in Europe operates under the GEM section of the European Society for Emergency Medicine [37].

As geriatrics does not focus on a single specialty, a multidisciplinary team plays a critical role in elderly care, collectively planning and coordinating treatment while conducting comprehensive geriatric assessments [38]. Introducing training for staff in effective triage, equipment designed to meet the needs of elderly patients, and protocols tailored to geriatric patients could better prepare emergency departments [39], ultimately reducing the high healthcare costs associated with patients aged 65 and older [40].

## CONCLUSIONS

The COVID-19 pandemic highlighted the significant challenges involved in caring for geriatric patients within the emergency medical services system. With an aging society, a growing number of seniors, and their complex health needs, the responsibilities of emergency medical responders are becoming increasingly intricate. Older individuals, particularly those affected by multimorbidity, functional limitations, and cognitive impairments, require a personalized approach that addresses both physical and psychological aspects.

Many geriatric patients, fearing infection, delayed seeking medical attention or presented to hospitals only in critical conditions, which negatively impacted the quality and effectiveness of emergency interventions. Additionally, changing working conditions, such as the need to use personal protective equipment and the increased emotional burden on staff, posed challenges in providing adequate care.

The pandemic also underscored the importance of interdisciplinary education and the development of new protocols and guidelines that better address the needs of geriatric patients. Investment in modern technologies, such as artificial intelligence, will be crucial for supporting diagnostic processes and clinical decision-making, thereby enhancing the efficiency of emergency medical services.

In the future, it will be essential to continue developing specialized geriatric care, including emergency medicine tailored to the needs of older adults, and to train personnel in a holistic approach to these patients. Through collaboration among various specialists, improved coordination of actions, and the implementation of new tools, it will be possible to provide higher-quality care and better support for seniors within the emergency medical services system.

Given the growing number of older adults worldwide, adapting the healthcare system to meet the specific needs of this patient group will become a key priority in the years to come.

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**ADDRESS FOR CORRESPONDENCE**
Kinga Cogiel
Wielospecjalistyczny Szpital Powiatowy S.A. im. dr B. Hagera,
Tarnowskie Góry, Poland, Poland
e-mail: kinga.cogiel@gmail.com

**ORCID AND CONTRIBUTION**
Kinga Cogiel - 0009-0000-6456-2887 ABD
Małgorzata Osikowicz - 0009-0006-0305-8402 ABD
Magdalena Kronenberg - 0009-0009-5760-0019 ABD
Katarzyna Janik - 0000-0003-1596-071X ABD
Tomasz Męcik-Kronenberg - 0000-0002-0618-8265 ABDEF



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# Changes in the latest version of the Committee on Tactical Combat Casualty Care (CoTCCC) guidelines

Jakub Zachaj

DEPARTMENT OF EMERGENCY MEDICAL SERVICES, MEDICAL UNIVERSITY OF WARSAW, WARSAW, POLAND

**ABSTRACT**

This paper is based on the latest version of the Committee on Tactical Combat Casualty Care guidelines and the available literature relating to the changes proposed by CoTCCC. Changes in the latest version of the CoTCCC guidelines were implemented in the sections regarding airway management, assisting the casualty's breathing and the management of TBI. Clarification has been provided as regards the method of placing casualties in the recovery position, use of a nasopharyngeal airway, as well as the indications and method of performing a cricothyrotomy. Both the chapter on airway management and respiratory distress manaement in casualties indicate the parameters to be monitored during ventilation. A major change from the previous version of the guidelines is the definition of proper traumatic brain injury (TBI) management as early as at the TFC stage. In order to implement the changes introduced by the CoTCCC, it is necessary to properly prepare medical personnel through appropriate training, as well as to adjust the available equipment at their disposal. Changes should be introduced into training as soon as possible in view of changing doctrines for conducting military operations in future conflicts.

**KEY WORDS**

trauma, battlefield, tactical medicine, respiratory tract, ventilation, head injury

## INTRODUCTION

The Committee on Tactical Combat Casualty Care (CoTCCC) guidelines provide a set of recommendations for the management of casualties in battlefield conditions. The guidelines emphasize interventions to be performed on the casualty with the goal of rescuing as many people as possible with limited human, material, and equipment resources, as well as within a specific time regime in the tactical environment. The CoTCCC guidelines are perhaps the most frequently updated set of management guidelines for trauma patients. The latest update to the guidelines was introduced on 25 January 2024. Recent guidelines changes include ways to maintain airway patency, ventilation and the managing traumatic brain injury (TBI) [1].

## THE AIM

The purpose of this paper is to identify and discuss changes introduced in the latest version (25 January 2024) of the Committee on Tactical Combat Casualty Care guidelines.

## MATERIAL AND METHODS

This paper is based on the latest version of the Committee on Tactical Combat Casualty Care guidelines and the available literature relating to the changes proposed by CoTCCC.

## REVIEW AND DISCUSSION

The Committee on Tactical Combat Casualty Care (CoTCCC) is a unit within the U.S. Department of Defense dedicated to providing pre-hospital care to casualties on the battlefield. The goal of the CoTCCC is to develop the best possible guidelines for handling battlefield casualties and to reflect them in the training process and further their use in the US armed forces. CoTCCC consists of 42 voting members. The committee includes experts in the fields of trauma, battlefield medicine, tactical medicine, pre-hospital medicine with experience in real combat conditions. The working group developing the Tactical Combat Casualty Care (TCCC) guidelines consists of CoTCCC members and subject matter experts from a wide range of medical disciplines, liaisons from the Department of Defense and the U.S. government, as well as partner countries (mainly the North Atlantic Treaty Organization [NATO] member states).

The CoTCCC guidelines are the result of efforts that date back into the 1990s. Their goal was to create best-practice- and evidence-based guidelines. Drafting and implementing battlefield medicine guidelines was among the greatest achievements in the development history of the US military forces, which became apparent during the interventions in Iraq and Afghanistan (the survival rates were 90.2% in Iraq and 91.6% in Afghanistan, compared with 86.5% in Vietnam [2]). CoTCCC guidelines are based on the differences in management of casualties in the civilian vs. tactical environment, which result from the mechanism of injury, safety of the rescue operations performed, different environmental factors, as well as factors related to the tactics of the ongoing military operations. The work has resulted in the development of guidelines linking the

treatment of the casualty on the battlefield with the tactics of military operations.

The latest version of the CoTCCC guidelines was published on 25 January 2024. The proposed changes address the ways of establishing airway patency, ventilating the casualty and managing traumatic brain injury.

In the new version of the CoTCCC guidelines, the section on providing airway patency (4th Airway) has been revised to read as follows:

a. Assess for unobstructed airway;
b. If there is a traumatic airway obstruction or impending traumatic obstruction, prepare for possible direct airway intervention;
c. Allow a conscious casualty to assume any position that best protects the airway, to include sitting up and/or leaning forward;
d. Place unconscious casualty in the recovery position, head tilted back; chin away from chest;
e. Use suction if available and appropriate;
f. If the previous measures are unsuccessful, and the casualty's airway obstruction (e.g. facial fractures, direct airway injury, blood, deformation or burns) is unmanageable, perform a surgical cricothyroidotomy using one of the following:
    1. Bougie-aided open surgical technique using a flanged and cuffed airway cannula of less than 10 mm outer diameter, 6-7 mm internal diameter, and 5-8 cm of intratracheal length;
    2. Standard open surgical technique using a flanged and cuffed airway cannula of less than 10mm outer diameter, 6-7 mm internal diameter, and 5-8 cm of intra-tracheal length.
    3. Verify placement with continuous $EtCO_2$ capnography;
    4. Use lidocaine if the casualty is conscious;
g. Frequently reassess $SpO_2$, $EtCO_2$, and airway patency as airway status may change over time;
h. Cervical spine stabilization is not necessary for casualties who have sustained only penetrating trauma [3].

CoTCCC recommendations for the management of developing respiratory distress (5. Breathing/Respiration) are mainly concerned with ventilating the casualty in danger of respiratory distress. The guidelines also explicitly specify the proper way to monitor the adequate ventilation of the casualty:

- If the casualty has impaired ventilation and uncorrectable hypoxia with decreasing oxygen saturation below 90%, consider insertion of a properly sized Nasopharyngeal Airway, and ventilate using a 1000 ml resuscitator Bag-Valve-Mask [3];
- Frequently reassess $SpO_2$, $EtCO_2$, and airway patency as airway status may change over time.

The section dealing with management of the casualty with head trauma and suspected traumatic brain injury (TBI) (8. Moderate or Severe Traumatic Brain Injury) introduced the following guidelines:

a. Prevent hypoxemia (goal $SpO_2$ >90-95%);
    1. If basic airway maneuvers fail to maintain $SpO_2$ >90% or are not tactically feasible, ensure low oxygen saturations are not due to tension pneumothorax or hemorrhage;
    2. Consider definitive airway if unable to maintain $SpO_2$ >90%:
b. Prevent hypotension – maintain SBP 100-110 mmHg. Transfuse whole blood or plasma preferentially if casualty is in hemorrhagic shock. Otherwise use 1-2 L bolus of crystalloid if no evidence of hemorrhage or hemorrhagic shock.
c. Identify and treat herniation (declining neurologic status with asymmetric or fixed/dilated pupil(s), or posturing):

1. Interventions for signs of impending herniation should only be employed for up to 20 minutes, and if en route to surgical decompression.

- Administer 250 ml or 3% or 5% OR 30 ml of 23.4% hypertonic saline SLOW IV/IO push over 10 minutes followed by a saline flush. Repeat in 20 minutes if no response (max 2 doses).
- Monitor IV/IO site and discontinue if signs of extravasation.
- Elevate head 30 degrees if casualty not in shock and tactically feasible.
- Loosen cervical collar if present and keep head facing forward.
- Hyperventilate using continuous capnography (goal $EtCO_2$ 32-38 mmHg) [3].

The same guidelines apply when dealing with a casualty during casualty evacuation [3].

Changes in the latest version of the CoTCCC guidelines deal with ways to maintain airway patency, adequately ventilating the casualty with a bag-mask, monitoring respiratory capacity, and managing traumatic brain injury while still in the Tactical Field Care (TFC) phase.

The most recent version of the CoTCCC guidelines recommend placing the casualty in the recovery position with the head tilted back as the best management method. This method was mentioned in an earlier version of the guidelines, however without indicating the need to tilt the head backward. Maintaining airway patency using this method has been well-established and is reflected in the management guidelines for patients who are unconscious as a result of sudden illness, as well as those unconscious following anesthesia. Placing the casualty in the recovery position requires neither significant knowledge nor time for mastering this skill, which is of great benefit when preparing conscripted soldiers for participation in large scale combat operations. Authors of the guidelines emphasize the simplicity and effectiveness of the described technique, but also point out that it may not be suitable for casualties with extensive injuries, including mainly pelvic and spinal injuries. However, the final decision concerning placement in the recovery positioning should be reserved for personnel with medical training above the basic level. In the latest version of the CoTCCC guidelines, recommendations for the use of

a nasopharyngeal airway have been dropped. Authors of the guidelines note that despite the nasopharyngeal airway's significant potential for airway clearance, it may not be sufficient to effectively secure the airway in trauma casualties. The CoTCCC justifies its position by referring to the difficulty associated with proper sizing and the nasopharyngeal airway's lack of effectiveness in maintaining airway patency in cases of craniofacial trauma with potential fractures in the skull base, neck region with associated tracheal injury, and inhalation burns. However, the CoTCCC notes the potential benefits of using a nasopharyngeal airway in combination with bag-mask ventilation. This is justified by the presence of positive pressure during bag-mask ventilation. In their most recent version, the guidelines entirely drop epiglottal devices in managing airway. Similarly as in the case of the nasopharyngeal airway, the CoTCCC justifies their position by referring to the low effectiveness of this type of device in the tactical environment, lack of scientific evidence for increased survival rates in casualties with epiglottal devices and increased mortality in these casualties when adequate sedation was not provided. Surgical airway is the most advanced airway technique under tactical conditions. CoTCCC does not indicate any specific instrument for performing needle cricothyrotomy/cricothyrotomy that would offer any advantage over others in a tactical environment. The new version of the guidelines explicitly recommends a bougie-aided open surgical technique using an appropriately sized airway cannula. This is not a procedure that is taught to all levels of responders, but rather reserved to those who have more extensive training and experience. If the decision is made to support ventilation with a bag-mask, rescuers under tactical conditions should use bags with a capacity of no more than 1000 ml. Authors of the guidelines mention that the use of such a bag when conducting one-handed ventilation will correspond to the sufficient tidal volume recommended by AHA and ERC. The purpose of this recommendation is primarily to counteract the possibility of damaging the lungs by ventilating the casualty with excessive tidal volumes generated by larger volume bags. Capnometry should be used to monitor the effectiveness of ventilation, as well as airway clearance during mechanical ventilation. The CoTCCC notes the difficulty of performing this procedure, especially using colorimetry (low resistance to moisture, prolonged response time, potential for false results if the cannula is inserted into the esophagus), but points to the need to teach and incorporate this approach into the set of procedures in light of the still low success rates achieved with needle cricothyrotomy/cricothyrotomy performed in the tactical settings. A significant change against the previous version of the guidelines is the transfer of advanced care for patients with traumatic brain injury (TBI) to the Tactical Field Care phase. These recommendations do not deviate from the guidelines of internationally recognized organizations regarding management of trauma patients, emphasizing early prevention of hypovolemia and hypoxia. The CoTCCC guidelines also mention elevating the casualty's head above the heart level, hyperventilation controlled with capnometry and the use of 3% NaCl to reduce cerebral edema [4].

These changes were addressed by the Committee on Tactical Emergency Care (C-TECC). The C-TECC maintained its recommendations for the use of supraglottic devices to manage the airway. C-TECC justifies this decision primarily by referring to the unique characteristics of the environment in which assistance is provided to casualties (battlefield vs. civilian environment), the qualifications and experience of responders in maintaining airway patency, as well as the capacity of the emergency medical services. With the place of supraglottic devices in the TECC guidelines in mind, civilian responders deciding on their use must take into account the relevant indications and contraindications, as well as the responders' skills in using them. Other changes in the C-TECC guidelines refer to the range of rescue skills responders have in a tactical setting [5].

The CoTCCC's proposed changes are confirmed by the observations of the Medical Service of the International Legion of Ukrainian Armed Forces from the Ukrainian theater of operations.

## CONCLUSIONS

Changes in the latest version of the CoTCCC guidelines were implemented in the sections regarding airway management, assisting the casualty's breathing and the management of TBI. The first major change in these guidelines is the removal of supraglottic airway devices. Clarification has been provided as regards the method of placing casualties in the recovery position, use of a nasopharyngeal airway, as well as the indications and method of performing a cricothyrotomy. Both the chapter on airway management and respiratory distress management in casualties indicate the parameters to be monitored during ventilation. A major change from the previous version of the guidelines is the definition of proper traumatic brain injury (TBI) management as early as at the TFC stage. In order to implement the changes introduced by the CoTCCC, it is necessary to properly prepare medical personnel through appropriate training, as well as to adjust the available equipment at their disposal. Changes should be introduced into training as soon as possible in view of changing doctrines for conducting military operations in future conflicts.

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**ADDRESS FOR CORRESPONDENCE**

Zakład Ratownictwa Medycznego,
Warszawski Uniwersytet Medyczny,
Litewska 14/16, 00-575, Warszawa, Poland
e-mail: jzachaj@wum.edu.pl



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**ORCID AND CONTRIBUTION**

Jakub Zachaj – ORCID 0000-0001-7793-1653 ⒶⒷⒹⒺⒻ

Ⓐ – Work concept and design, Ⓑ – Data collection and analysis, Ⓒ – Responsibility for statistical analysis, Ⓓ – Writing the article, Ⓔ – Critical review, Ⓕ – Final approval

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