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TABLE OF CONTENTS

EDITORIAL

ORIGINAL ARTICLES

REVIEW ARTICLES

LETTERS TO THE EDITOR

VIA MEDICA

EDITORIAL

Disaster and Emergency Medicine Journal
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ETHICAL AND ORGANIZATIONAL DILEMMAS RELATED TO THE TREATMENT OF COVID-19 PATIENTS

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KEY WORDS: ethics, COVID-19, intensive care, public health

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The current COVID-19 epidemic and SARS-CoV-2 infections pose a huge challenge to health systems in many countries, even those with the most developed infrastructure, capacity, and equipment. For less developed countries, the COVID-19 epidemic represents a tragedy on an unprecedented scale, where inferior health systems and depressed economies mean that large parts of the population on the verge of poverty are deprived of adequate medical care [1]. Lack of work and diminished livelihoods compound the already uncontrolled development of the epidemic. While in developed countries, measures including quarantine, isolation, 'stay home' messaging and the use of masks by healthy people can reduce the number of cases, it is already clear that these health care systems are also on the verge of collapse [1].

The current situation, which is linked to the lack of availability of medical equipment, including ventilators and personal protective equipment (PPE), challenges cooperation between countries [2]. Italy's lack of sufficient support in its heroic fight against the pandemic is the best example of this. This problem may also affect hospitals in countries or regions that compete for medical equipment and personnel. Because small hospitals often have significantly smaller resources (both in staffing and supplies) compared to large hospitals, their inability to function normally will greatly affect local communities [3]. The current COVID-19 pandemic especially requires transparency of decision-making and engagement of stakeholders and its impact on the public perception of fairness.

The lack of availability of advanced life-saving methods, such as ventilation and intensive care makes it necessary to segregate patients who will be provided with high-quality medical assistance [4]. Such situations are usually single events limited in time. Each intensive care unit makes decisions related to ICU patient qualification in case of an imbalance between the number of patients and the availability of ICU beds. However, in the case of COVID-19, the problem of making choices over many weeks or even months arises. In addition, the health care system may have to make decisions about a serious reduction in the number of patients treated in the ICU.

One of the criteria used in some countries is the age of the patient. Otherwise, a 60-year-old patient with coexisting diseases would almost certainly have the possibility of ICU treatment, which is currently limited in many countries. It should be remembered that decisions about limitation are made not automatically by the healthcare or hospital systems or committees, but by individual persons - physicians, often after consultation with other specialists. This is a situation which we have not experienced before on such a scale. It raises a number of ethical and, in the long run, perhaps legal issues. Some physicians who have to make such decisions may also require psychological support and debriefing.

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A separate issue that is addressed is non-medical indications - the social usefulness suggested in some countries. This raises further ethical doubts as to the order in which assistance should be provided and which patients should be qualified for ICU treatment, whether the disabled have less right to life, whether their education or profession may be a criterion for qualification for intensive treatment. All these utilitarian (generally, social) criteria are intuitive, unjustified, and subjective. Therefore, this problem requires recourse to normative ethics, as medical science alone may be insufficient to justify such medical decisions [5, 6].

The application of the age and 'social usefulness' (e.g. occupation, proposed in some countries) criteria in the access to the ventilator in a situation of COVID-19 pandemic and overloaded health care system raise fundamental ethical concerns. These violate the principle of equity in access to medical services and place an enormous burden on the decision-makers' morals. Earlier attempts were made to formulate other criteria, taking into account the experience of the SARS pandemic, considering them fairer than the age criterion, e.g. physicians may employ a lottery process [7] or currently arguing for a limited time to use a ventilator for a patient with acute respiratory failure [8], giving everyone a chance to survive. The Swiss Society of Intensive Care Medicine (SSIM) and the Swiss Academy of Medical Sciences (SAMS) have developed guidelines that avoid the use of the age criterion, considering that such a criterion violates the prohibition of discrimination, and based on medical considerations as to which patients will benefit most from intensive care. Clear and, as far as possible, simple guidelines for decision-making are therefore needed, since the state of the pandemic and overburdened health systems provoke strong paternalism with the risk of arbitrary decisions by physicians and hospital management [6].

These are problems that require solutions. It should be remembered that after the end of the pandemic there will come a time to analyze the decisions that were made. It may turn out that the system of values on which the modern world is based will have to be updated, that the principle of equality does not always apply. However, it seems that a pandemic does not so much re-evaluate our system of values, but puts it to the test. Are we able, in a post-pandemic world, to accept behavior that refuses to care for the elderly or the very sick, which, contradicts what European culture has recognized as a moral obligation to others? What are the costs of the arbitrary justification of medical decisions concerning patients with coexisting diseases or elderly patients who have been refused life-saving assistance? Lack of trust in health services, physicians and nurses, seems to be the smallest problem.

At a time of universal shortages of personal protective equipment (PPE) for medical personnel in most countries, consideration should be given to whether the exposure of a physician, nurse, or paramedic is ethically acceptable. In the case of a procedure requiring an immediate attention, how much time should be spent donning and checking protective clothing? Is any delay that endangers the patient on one hand, and the staff on the other, ethically justified? Most often, codes of ethics and bioethical declarations do not mention the obligations of medical personnel in the event of a pandemic [9]. In the medical education system, there is no risk of practicing the profession by sacrificing one's own life for the benefit of the patient [4].

Another important aspect of the current epidemic is timely access to medical care. Some patients will deteriorate quickly or lose their lives due to obstacles in accessing the health care system - physical means of access (transportation), inadequate staffing, or even delays due to the fear of infection in a hospital [10]. Temporary restrictions on the activities of some health care units, including entire wards, or even the transformation of hospitals into infectious ones, may result in delays or complete prevention of care. There is no doubt the COVID-19 pandemic will increase medical needs, but after the pandemic, will we be able to finance the increase? What criteria for access to medical services must then be formulated in the event of a deficit of benefits and personnel caused by the pandemic?

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EDITORIAL

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SOCIAL DISTANCING DUE TO THE COVID-19 PANDEMIC: EFFECTS OF NON-URGENT EMERGENCY DEPARTMENT VISITS

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Abstract

INTRODUCTION: An outbreak of the novel coronavirus (COVID-19) that started in Wuhan, China, has spread quickly, with cases confirmed in 163 countries with broad impact on all health care systems. The previous 1918-19 H1N1 influenza pandemic was the last global emerging infectious disease at such scale to compare with no access to vaccines. In that pandemic as in the current, some communities responded with a variety of non-pharmaceutical interventions, especially social distancing. These types of intervention have a comprehensive effect on health care service consumption.

METHODOLOGY: This study describes and proposes possible explanations for the effects of non-pharmaceutical interventions on Emergency Department (ED) non-urgent visits.

RESULTS: Indirectly, the COVID-19 pandemic has led to a more informed emergency service use that allows ED's to fulfil their defined role, providing urgent service. Currently, this is of utmost importance given the rate of the virus spreading, and rise in the proportion of patients requiring intensive care in the ED. This is undoubtedly a by-product of an international disaster.

CONCLUSION: At the end of the pandemic, similar elements may be implemented to reduce unnecessary ED inquiries.

KEY WORDS: COVID-19, pandemic, emergency department, non-urgent visit

Disaster Emerg Med J 2020; 5(3): 124–126

INTRODUCTION

During 2019 a novel virus (COVID-19) emerged, composed of enveloped non-segmented positive sense ribonucleic acid virus belonging to the family coronaviridae [1]. Although most human coronavirus infections are mild, two recent pandemics of emerging betacoronavirus, severe acute respiratory syndrome (SARS-CoV) and the Middle East Respiratory Syndrome coronavirus (MERS-CoV), have caused approximately 440.000 cases including 19.700 deaths, with numbers rising exponentially.

Currently, the absence of a COVID-19 vaccine or any definitive medication has led to increased use of non-pharmaceutical interventions (NPIs), aimed at decreasing contact rates in the population and thereby distribution of the virus [2]. Two essential strategies are probable: a) mitigation (home isolation of suspect cases and social distancing), and b) suppression, which aims to restrain epidemic development, decrease case

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numbers to lower levels, and retain that condition indefinitely until treatment or vaccine become accessible.

On 11 March 2020, the World Health Organization (WHO) declared COVID-19 a pandemic. A subsequent literature review found that ideal mitigation strategies, combining mitigation and suppression, might decrease peak healthcare requirement by two-thirds and deaths by half [2].

In this clinical study and review of current information, we describe the effect of optimal mitigation policies on Emergency Department (ED) visits, especially the dramatic decrease in ED visit rate.

Impact of COVID-19 on ED visits at the start of the pandemic

It is important to note the beginning of the outbreak was characterized by a 'wait and see' mode of action in the ED's. As told by Dr Daniele Macchini, Intensive Care Unit physician in Bergamo, a city near Milan, there was a calm period characterized by medical staff uncertainty and slight indifference due to the lower ED arrival rates.

In the ED's, a respite with 50% occupancy was noted during this period.

Trends of the ED calm period during the initial stages of the COVID-19 pandemic has been observed in numerous countries. For example, during March 2020, Rambam Health Care Campus's ED (Haifa, Israel) experienced a smaller number (n∼30) of patient arrivals throughout the day, compared to hundreds during similar periods in previous years. This dramatic decrease was mostly due to a decline in non-urgent visits, as well as the low number of urgent patients. Furthermore, the Neurology Department was at 50% occupancy with a decrease in the number of patients presenting with stroke, and one neurological division closed for the sole treatment of COVID-19 patients with unchanged mortality rates.

Subsequently, a dramatic increase in visits by patients with COVID-19 was described by Robert Consentini, Head ED at Pope John XXIII Hospital in Bergamo, Italy [3] and others. With the outbreak flooding community services, 60–80 patients with COVID-19 arrived daily at the ED, many of whom required immediate respiratory care. As such, ED policy was forced to undergo major adjustments.

Relationship between ED visit patterns and Covid-19 pandemic

The initial abrupt decrease in ED visits for other causes in such a short period of time raises questions about the habitual visits of patient to the ED. Non-urgent ED visits are usually defined as 'visits for conditions for which a delay of several hours would not increase the likelihood of an adverse outcome' [3]. The estimated prevalence of non-urgent visits is 37% (range: 8–62%). Evidence indicates that younger age, greater accessibility of the ED compared to other ambulatory care options, referral to the ED by a healthcare provider, and negative experiences of non-ED care locations all play a role in decisions to seek care in the ED for non-urgent problems. Despite widespread interventions to discourage non-urgent ED visits, these kinds of visits have continued to rise [4].

There may be several explanations for the decreased ED visit rate during this pandemic. Firstly, due to state induced quarantine, patients are not allowed to exit their household for non-urgent causes, leading to reorganization in patients' medical priorities. Every year, thousands of people die from hospital acquired infections, yet non-emergency visits remain the same [5]. However, with the current pandemic threat, patients make considerable assessments for risk of infection with the virus and home symptomatic care took priority over ED visit.

Secondly, physiological aspects affect mind-body interactions. When one is in serious stress, as with the COVID-19 pandemic, we enter into a state of survival.

High dynamic environmental demands directly engage the body's stress responses through the stimulation of corticotrophin-releasing factor at the hypothalamus and sympathetic branch of the autonomic nervous system [6]. The previous leads to excretion of adrenocorticotrophic hormone from the pituitary gland, and subsequently to secretion of cortisol from the adrenals into the bloodstream. Further, there is a surge of peripheral catecholamines and activation/deactivation of body organs, according to their relevance in defending the organism. Additional reactions involve a stimulation of brain regions related to perceiving and reacting to threat, in which the brain's noradrenergic system has a pivotal role. All of these cause an increase in adrenaline levels, which then result in a decreased sense of pain and uncomfortable symptoms [6]. This masking effect lowers symptom severity temporarily, leading to lower ED visit rate.

Thirdly, the principle of continuity is maintained in dealing with a disaster at its various stages, as the management and therapeutic efforts aim at preserv-

ing the different continuities in the life of the individual, family, organization, and community, or to restore them: functional continuity, identity continuity, and interpersonal continuity [7]. The isolation strategy forced the closure of all educational centers for all age groups and, therefore, parents are constantly concerned with the wellbeing of their children and less for themselves. Maintaining balance within the home environment took priority over medical conditions as many found themselves in an unexpected new routine. Thus, leading to a decrease in ED visit rate.

Finally, social distancing keeps peoples at home. Consequently, the number of accident and trauma patients decreased automatically.

CONCLUSION

To conclude, indirectly the COVID-19 pandemic has led to a more informed emergency service use that allows the ED's to fulfil their defined role — urgent service. Currently, this is of utmost importance given the rate of virus spreading, and the rise in the proportion of patients requiring intensive care in the ED. This is undoubtedly a by-product of an international disaster. However, at the end of the pandemic, similar elements may be implemented to reduce unnecessary ED inquiries.

Research: The research has not been presented.

Conflict of interest

None of the authors has any conflicts of interest.

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ORIGINAL ARTICLE

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COMPARISON OF DIFFERENT CHEST COMPRESSION POSITIONS FOR USE WHILE WEARING CBRN-PPE: A RANDOMIZED CROSSOVER SIMULATION TRIAL

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ABSTRACT

INTRODUCTION: The prevailing COVID-19 pandemic forces paramedics to take medical rescue operations using personal protective equipment (PPE) for aerosol-generating procedures (AGP). The use of PPE-AGP may reduce the effectiveness of the procedures performed, including airway management, intravascular access, or chest compression.
The goal of the current study was to compare the quality by which a chest compression during simulated COVID-19 resuscitation while wearing PPE-AGP. A secondary goal was to assess provider preferences with standard versus OHD chest compression methods while wearing PPE-AGP.

METHODS: This is a randomized cross-over single-blinded study involving 37 paramedics performing 2-min continuous chest compression using two methods: the standard chest compression (CC) method during which the rescuer takes a position to the side of the victim (STD) and over-the-head position (OHD). During cardiopulmonary resuscitation, study participants wore Class C PPE-AGP. Both the order of study participants and compression methods were random. The results were blinded before statistical analysis. The compression rate per minute (CPM), CC depth as well as full chest recoil were measured. The analysis was undertaken using STATISTICA (V13.3EN).

RESULTS: Mean chest compression depth using distinct CC methods varied and amounted to 42 ± 2mm for STD vs. 46 ± 4mm for OHD ($p < 0.001$). Chest compressions based on the OHD method were associated with a lower frequency of chest compressions (107 ± 7CPM) compared with STD (114.5 ± 8; $p< 0.001$). A higher percentage of full chest recoil was observed in the case of STD (42 ± 6%) than in the case of OHD (34 ± 10%).

CONCLUSIONS: Based on the current simulation trial, it is impossible to clearly determine which method (STD vs. OHD) is more effective in resuscitation with PPE-AGP. Paramedics wearing PPE-AGP achieved better chest compression depth for OHD compared to the STD, however, OHD resuscitation causes a lower degree of full chest relaxation. A further well-designed clinical study looking at efficacy, safety, and outcomes is needed to confirm current results.

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KEY WORDS: chest compression, cardiopulmonary resuscitation, quality, position, personal protective equipment, CBRN, COVID-19, SARS-CoV-2, pandemic, medical simulation, manikin

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INTRODUCTION

The outbreak of coronavirus disease 2019 (COVID-19) has become a primary challenging public health issue [1]. On March 11, 2020, the World Health Organization declared that the pandemic of COVID-19 had become a public health emergency of global concern. As of September 2, 2020 COVID-19 has been reported with a total of 25.835.301 confirmed cases and over 858.661 deaths. New coronavirus SARS-CoV-2 is mainly transmitted through 1) Direct exposure with cough, sneeze, and droplet inhalation within a range of about 1.8 meters; and 2) Contact transmission through contact with oral, nasal, and eye mucous membranes [2, 3]. Current personal protective equipment (PPE) and infection control guidelines from the WHO is based on the assumption that the primary mechanism of transmission is direct and indirect droplet spread. In this situation, paramedics working in the pre-hospital setting should treat any patient as potentially infected with the SARS-CoV-2 virus [4, 5]. The WHO advises that airborne transmission can occur, but only when aerosol-generating procedures (AGP) are performed [6]. AGPs are those that have the potential to generate aerosols and droplets that can spread respiratory pathogens. In this context, cardiopulmonary resuscitation (CPR) is a complex procedure that is particularly dangerous for medical personnel. As the study by Borkowska et al. examining the effectiveness of cardiopulmonary resuscitation during the COVID-19 pandemic, the return of spontaneous circulation (ROSC) in prehospital setting was observed only in 9.4% of resuscitated patients [7]. In turn, Baldi et al. indicating the OHCA issues in Italy indicate that during the first 40 days of the COVID-19 outbreak (February 21 through March 31, 2020) with those that occurred during the same period in 2019 and indicate a 58% increase rate of OHCA in 2020 [8]. Low patient survival may be caused by both the negative consequences of SARS-CoV-2 infection, as well as the reduced effectiveness of the procedure performed by Emergency Medical Service personnel wearing PPE-AGP.

The goal of the current study was to compare the quality by which a chest compression during simulated COVID-19 resuscitation while wearing PPE-AGP. A secondary goal was to assess provider preferences with standard versus OHD chest compression methods while wearing PPE-AGP.

METHODS

Study Population and Setting

The study population consisted of paramedics participating in the training of Advanced Cardiovascular Life Support (ACLS) conducted according to the AHA guidelines [9]. Inclusion criteria were: a) consent to participate in the study, b) active paramedic status, c) minimum one year of experience in EMS teams. Exclusion criteria were: a) refusal to consent, b) presence of medical concerns precluding the ability to participate, including pregnancy or asthma, c) symptoms or suspicion of viral infection.

Study Design

A prospective, randomized, crossover single-blinded simulation trial was conducted. The protocol of this trial was approved by the Institutional Review Board of the Polish Society of Disaster Medicine (No. 22.01.20.IRB). The study was conducted according to the Consolidated Standards of Reporting Trials (CONSORT) statement (Suppl. 1).

Before beginning the simulation portion of the study, all participants were asked to complete a short questionnaire concerning previous experiences with clinical resuscitation as well as PPE-AGP using. Additionally, all participants participated in a 60-minute training session reminding the principles of cardiopulmonary resuscitation following the guidelines of the American Heart Association (AHA) [9], as well as the demonstration of the correct donning of the PPE-AGP suit and performing chest compression using the STD and OHD method (Fig. 1).

After the demonstration session, participants were randomized to STD or OHD while wearing a Tychem F Level-C (DuPont, Wilmington, USA) suit, airway protection N95 respirator (3M Poland, Kajetany, Poland), face shield (3M Poland, Kajetany, Poland) including double nitrile gloves (MedaSEPT®, Poznan, Poland).

The participants were then asked to perform a 2-minute cycle of continuous chest compression (CCC) using one method, then had a 30-minute

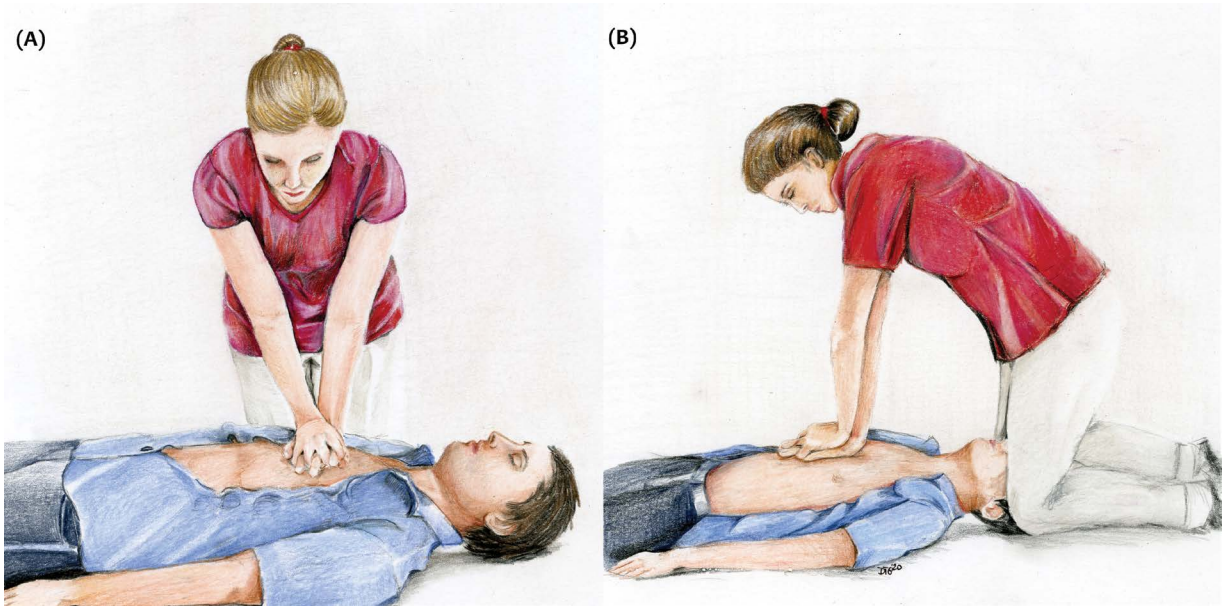

FIGURE 1. Chest compression methods used in the trial: (**A**) Standard position; (**B**) Over-the-head position

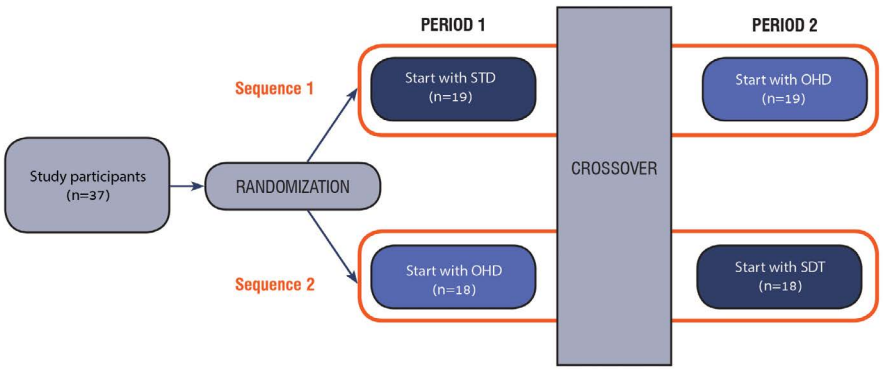

FIGURE 2. Randomization flow chart

break, and then performed chest compression using another method. The detailed procedure of trial randomization is presented in Figure 2.

All chest compressions were performed on a SimMan 3G (Laerdal Inc., Stavanger, Norway) adult simulator. The simulator was placed on a flat surface to simulate sudden cardiac arrest at home.

After performing chest compression both methods, each participant completed the post-intervention questionnaire regarding perceptions of ease of chest compression while wearing PPE-AGP.

Outcomes and Data Collection

The primary outcome measure was the quality of chest compression, which consisted of the following parameters: chest compression rate, chest compression depth as well as chest recoil. The values indicated in the AHA guidelines [9] were used as reference values. Accordance with those guidelines, chest compression rate should be between 100 and 120 compressions per minute (CPM), the depth of chest compressions should be 5 to 6 cm, and after each compression should be followed by full relaxation of the chest.

The chest compression quality data was recorded in real-time using the simulator control software — Laerdal Learning Application (LLEAP software, v.7.1.0; Laerdal Inc, Stavanger, Norway).

De-identified participants' data were entered into Macintosh Excel Database (Microsoft Excel for MAC 2020, v.16.40; Microsoft Inc., Redmond, WA, USA). Data were correlated with questionnaire response data by the use of pre-assigned participant numbers.

Table 1. Summary of study results

Compression parameter	STD	OHD	MD / OR (95%CI)	p-value
CC depth (mm)	42 (±2)	46 (±4)	MD = -4.00 (-5.44, -2.56)	< 0.001
CC rate (CPM)	114.5 (±8)	107 (±7)	MD = 7.50 (4.07, 10.93)	< 0.001
Chest recoil (%)	42(±6)	34 (±10)	MD = 8.00 (4.24, 11.76)	< 0.001
Correct hand placement (%)	96.5 (±2.5)	96 (±4)	MD = 0.50 (-1.02, 2.02)	0.52
Preferences (%)	16/37 (43.2%)	21/37 (56.8%)	OR = 0.58 (0.23, 1.46)	0.25

CC — Chest compression; CPM — Compressions per minute; STD — Standard position; OHD — Over-the-head position; MD — Mean difference; OR — Odds ratio; CI — Confidence interval

Statistical analysis and Sample Size Calculations

Sample size calculations were performed based on a two-sided paired t-test assuming 80% power and a significance level of 0.05. Assumptions for expected results were based upon the work of Malysz et al. [10]. Those calculations indicated that a sample size of 32 participants would be required to power the trial adequately to detect a difference of 5 millimeters between the two modalities. To ensure a safety margin, we recruited 37 participants in this study.

All calculations were done with the STATISTICA software package (v.13.3EN; Tibco Inc, Tulsa, OK, USA). For statistical analysis, the data was blinded. Continuous features were summarized with means and standard deviations. Categorical features were summarized with frequency counts and percentages. The Kolmogorov-Smirnov test was applied to test data for normality. Fisher Exact Tests were used to compare resident survey responses. We compared qualitative variables by Fisher exact test and Kruskal-Wallis test. Continuous data, including the time for the successful intravascular access, were analyzed using analysis of variance (ANOVA) testing. All tests were two-sided and p values less than 0.05 were considered statistically significant.

RESULTS

The study involved 37 paramedics whose mean age was 31 ± 7.5 years and mean work experience in EMS was 6.7 ± 4.5 years. All participants in the study declared their experience in the field of CPR in clinical settings. None of the study participants had experience with chest compression wearing PPE-AGP before study entry.

A detailed summary of the results of chest compression parameters is presented in Table 1. Mean chest compression depth using distinct CC methods varied and amounted to 42 ± 2 mm for STD vs. 46 ± 4mm for OHD ($p < 0.001$). Chest compressions based on the OHD method were associated with a lower frequency of chest compressions (107 ± 7CPM) compared with STD (114.5 ± 8; $p < 0.001$). A higher percentage of full chest recoil was observed in the case of STD (42 ± 6%) than in the case of OHD (34 ± 10%). This difference was statistically significant ($p < 0.001$). The differences incorrect hand placement between STD and OHD were not statistically significant.

Most people (58.8%) indicated OHD as the preferred method during true CPR. The remaining people indicated the STD method as the preferred method.

DISCUSSION

The aim of the study was to compare two techniques of chest compression (STD vs. OHD) performed by paramedics wearing PPE-AGP. The prevailing COVID-19 pandemic causes that in the case of OHCA paramedics should perform CPR in protective suits. To the authors' knowledge, this is the first STD vs. OHD under the conditions of use personal protective equipment against aerosol-generating procedures.

Performing medical procedures when healthcare workers are wearing PPE-AGP may reduce the effectiveness of the procedures performed by extending the duration of these procedures as well as reducing the effectiveness of individual attempts to perform the procedure. This applies to both obtaining intravascular access [11], advanced airway management [12], as well as the effectiveness of chest compression [13]. Chen et al. [14] indicated significant deterioration of CC performance in HCWs with the use of a level-C personal protective equipment, which may be a disadvantage for enhancing the survival of cardiac arrest. In turn, a study by Donoghue et al. shows that during a clinically appropriate 2-minute period, neither CC quality nor self-reported fatigue worsened to a significant degree in providers wearing PPE [15]. Donghue also indicates that that

Pediatric Basic Life Support recommendations for CC providers to switch every 2 minutes need not be altered with PPE use. The research of Malysz et al. [13] indicates that in the case of adult resuscitation, the use of PPE reduces the quality of chest compression, including a reduction in the depth of chest compressions and the correctness of chest relaxation with time. The differences between these two studies can be explained by the fact that resuscitation was carried out concerning the various simulators: an adult and a child. In the study by Malysz et al. an adult simulator was used, whose cardiopulmonary resuscitation requires much more effort than the resuscitation of a child. On the other hand, Donghue indicates that the depth of chest compression did not decrease significantly over time, however, according to the analysis of the data obtained by him, chest compression was performed based on too shallow chest compressions, which were on average 2.2 cm, while the guidelines of resuscitation for 5-years old child recommend that the CC depth be between 1/3 to 1/2 of the anteroposterior diameter of the chest, corresponding to a depth of at least 5cm [16]. Nerveless, it is clear that the returning of the spontaneous circulation (ROSC) in patients experiencing cardiac arrest is dependent on the quality of the CPR they receive. However, a number of investigations have demonstrated that rescuers develop immediate fatigue during CPR and the quality of CC declines rapidly after 1 to 3 min of CPR [17]. Abelairas-Gómez et al. showed that a simple strength training program has a significant impact on the quality of chest compressions and its maintenance over time [18]. The analysis of the performed examination showed a statistically significantly greater depth of chest compressions during compression performed by OHD. This may be due to the force applied to the chest being directed differently, thus exerting more pressure on the chest than is the case with an STD.

Another parameter, apart from the depth of chest compressions, influencing the quality of chest compression is the CC rate per minute. The chest compression rate was also associated with the return of spontaneous circulation [19, 20]. CPR guidelines performer by AHA as well as ERC recommends that the CPR be greater than 100CPM, but not greater than 120CPM [21, 22]. Despite the existence of differences in the rate of chest compression despite the STD and OHD groups, these rates were within the recommended range. Despite subsequent editions of the CPR guidelines, there is still no consensus among scientists regarding the optimal rate of chest compression. As indicated Solevåg et al. [23] and other authors, a higher CC rate (i.e. over 120/min) is also more fatiguing, which affects CC quality [24]. In turn, a study by Kilgannon et al. conducted in in-hospital cardiac arrest adult patients, a chest compression rate of 121-140CPM had the highest odds ratio of ROSC [25]. In the case of OHCA, Idris et al. indicated that compression rates between 100 and 120CPM were associated with the greatest survival to hospital discharge [19].

In this study, the continuous chest compression technique was selected. According to the ERC and AHA guidelines, efforts should be made to minimize interruptions in chest compressions. Moreover, as evidenced by Ewy et al. [26] research, CCC compared with 30:2 compressions-to-ventilations cardiopulmonary resuscitation improved neurological outcome. Wang et al. in a prospective, randomized animal study in the first 12 minutes of CPR, continuous compressions could maintain relatively better coronary perfusion pressure, PaO_2, and global ventilation/perfusion values than 30:2 cardiopulmonary resuscitation [27]. The above advantage of continuous chest compressions over 30:2 resuscitation was also confirmed in other studies [28-30]. However, as the study by Liu et al. shows, chest compression quality decreased significantly faster when performing CCC compared to 30:2 method [31]. Therefore, the person compressing the chest should be changed every two minutes or sooner.

Another parameter influencing the quality of chest compression is full chest recoil (FCR), which was independently associated with improved survival and favorable neurologic outcome at hospital discharge after adult OHCA [32]. In our study, the correctness of chest relaxation in both STD and OHD was insufficient, and in the case of OHD, a statistically significant reduction in the correctness of FCR was observed. This may be because paramedics tend to lean excessively on the patient's chest in over-the-head resuscitation.

The above-mentioned and described parameters of chest compression, such as the depth of chest compressions, the frequency of compression or the correctness of chest relaxation are extremely important and affect the quality of the compression and thus the effectiveness of the entire CPR, however, they should not be treated individually — but try to perform CPR based on all parameters of chest compression at the same time [33, 34].

Limitations and Strengths

Limitations of the medical simulation trials have been previously described [13]. In addition, only a group of paramedics participated in the study, however, it was a deliberate action dictated by the fact that paramedics are the first line of contact with OHCA patients and are relatively often forced to undertake resuscitation measures in pre-hospital conditions, and in the time of the prevailing COVID pandemic -19, these procedures should be performed in PPE-AGP.

The study also has strengths. To the authors' knowledge, this is the first study to evaluate STD vs. OHD chest compression methods by paramedics while wearing PPE-AGP. Another strong point of the study is its randomized cross-over nature and the fact that it was a single-blinded study.

CONCLUSIONS

Based on the current simulation trial, it is impossible to determine which method (STD vs. OHD) is more effective in resuscitation with PPE-AGP. Paramedics wearing PPE-AGP achieved better chest compression depth for OHD compared to the STD, however, OHD resuscitation causes a lower degree of full chest relaxation. A further well-designed clinical study looking at efficacy, safety, and outcomes is needed to confirm current results.

Supplement 1. CONSORT checklist

Supplementary material related to this article can be found, in the online version, at: https://journals.viamedica.pl/disaster_and_emergency_medicine/article/view/DEMJ.a2020.0034#supplementaryFiles

Conflict of Interest

All authors declare that they have no conflict of interest.

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VIESCOPE® LARYNGOSCOPE VERSUS MACINTOSH LARYNGOSCOPE DURING DIFFICULT INTUBATION PERFORMED BY PARAMEDICS: A RANDOMIZED CROSS-OVER MANIKIN TRIAL

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ABSTRACT

INTRODUCTION: The aim of this study was to evaluate intubation performance by paramedics using Macintosh laryngoscope and VieScope® laryngoscope under simulated difficult airway conditions.

METHODS: In a randomized, single-blinded, cross-over simulation trial, 42 paramedics performed endotracheal intubation using VieScope® and Macintosh (MAC) laryngoscopes in two difficult airway scenarios: (A) tongue edema, (B) manual cervical inline stabilization. The order of participants and intubation methods was random. Time to ventilation constituted the primary outcome, and the secondary outcomes were the success rate of first intubation attempt, overall intubation success rate, Cormack and Lehane grade, and ease of use.

RESULTS: In scenario A, the median overall intubation time was 55s (46–109) in the MAC group and 30.5s (26–35) in the VieScope® group ($p < 0.001$). The efficacy of the first intubation attempt with MAC and VieScope® varied and amounted to 64.3% vs. 95.2% ($p < 0.001$). During scenario B, VieScope® offered better intubation conditions than MAC ($p < 0.001$), including shorter intubation time, higher first attempt and overall intubation success rates, as well as better glottic view.

CONCLUSIONS: In this simulation trial, we found that VieScope® could be successfully used for intubation in difficult airways by paramedics with little simulation experience with this device. VieScope® was associated with shorter time and higher success rates of intubation attempt compared with MAC. Nevertheless, we recommend that the performance of VieScope® and MAC should be further evaluated in the clinical setting to confirm our results.

KEY WORDS: endotracheal intubation, difficult airway, VieScope® laryngoscope, channeled laryngoscope, medical simulation, paramedic

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INTRODUCTION

Endotracheal intubation is still considered the gold standard of airway protection in many clinical situations. It occupies a special place in emergency medicine in-hospital as well as pre-hospital conditions. In pre-hospital conditions, endotracheal intubation is associated with the risk of hypoxia, tracheal tube misplacement, esophageal intubation, hypotension, vomiting and aspiration, cardiac arrhythmia, dental injury, or bleeding [1]. Rapid, uncomplicated, and accurate placement of the tracheal tube is one quality indicator of good advanced airway management [2]. In accordance with many society guidelines, endotracheal intubation must be performed by the most experienced operator in the team [3].

Emergency intubation based on direct laryngoscopy arouses a high risk of failure. As many authors indicate, the effectiveness of the first intubation attempt with a Macintosh laryngoscope is 57.6% [4], 84.4% [5], 89.94% [6]. The issue concerns not only adults but also pediatric patients [7]. In pre-hospital situations, the effectiveness of intubation may be even lower owing to the conditions under which intubation is performed and the experience of medical staff. As Crewdson et al. [8] indicate in their meta-analysis, only 14,913 intubations out of the total of 19,178 (77.8%) were successful at the first attempt. Rognås et al. [9] report that following rapid sequence intubation, the incidence of first-pass success was 85.8% and the overall incidence of complications equaled 22.0%, with the incidence of hypotension of 7.3% and that of hypoxia of 5.3%. Therefore, it is reasonable to search for alternative methods of endotracheal intubation to direct laryngoscopy, which will allow for more efficient performance of the medical procedure by paramedics and other medical personnel.

The aim of this study was to evaluate intubation performance by paramedics using Macintosh laryngoscope and VieScope® laryngoscope under simulated difficult airway conditions. We hypothesized that the intubation time in the case of paramedics using VieScope® would be superior to that for Macintosh laryngoscope.

MATERIAL AND METHODS

Study design

We conducted a randomized, single-blinded, crossover simulation trial to evaluate intubation conditions when using VieScope® and Macintosh laryngoscopes in difficult airway scenarios. The study was performed between November 2019 and February 2020. The study protocol was approved by the Institutional Review Board of the Polish Society of Disaster Medicine (approval No.: 15.11.2019.IRB). The Consolidated Standards of Reporting Trials (CONSORT) statement was applied (see Supplementary Tab. 1) [10].

Participants

The study involved 42 paramedics who had no experience in endotracheal intubation with VieScope® but had experience in intubation with Macintosh laryngoscope. Voluntary written informed consent was obtained from each participant. All participants were active paramedics and worked in an Emergency Medical Services team in Poland.

Equipment and materials

Two types of laryngoscope were used in the study: a standard Macintosh laryngoscope with blade #3 (HEINE Optotechnik GmbH & Co. KG, Gilching, Germany) and a new VieScope® laryngoscope (Adroit Surgical, Oklahoma City, USA; see Fig. 1). VieScope® laryngoscope is a self-contained, battery-powered, disposable scope that takes advantage of a closed circular tube with a beveled end to visualize the vocal cords. The light is transmitted through the sidewall of the tube from end to end as well as within the lumen of the tube to give the user the best illumination of the target tissue with minimal chance of light obstruction by secretions or blood. Endotracheal intubation with VieScope® involved a two-step process. Firstly, the device was inserted orally to obtain visualization of glottis through the clear cylindrical lumen of the intubation channel. The second step involved a bougie

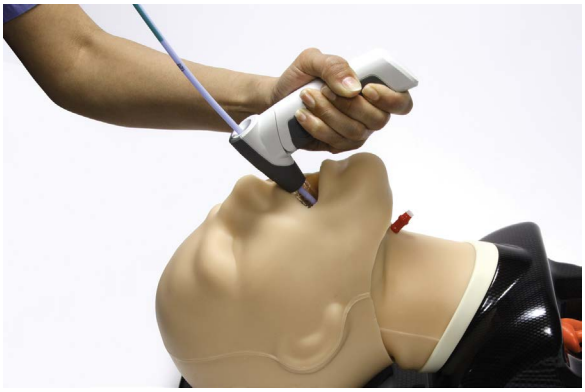

FIGURE 1. VieScope® laryngoscope

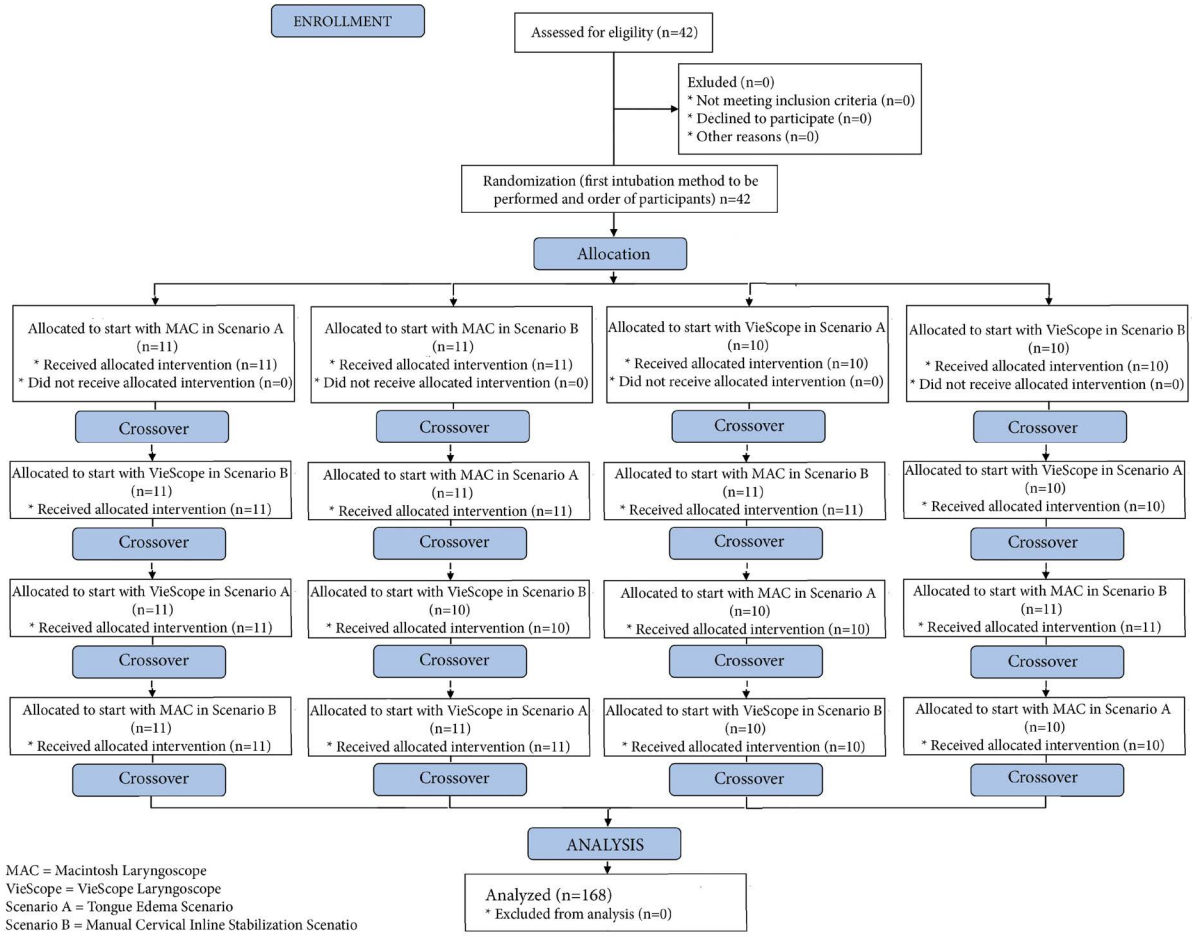

FIGURE 2. Randomization flow chart

guide insertion and removal of VieScope® followed by railroading the endotracheal tube over the bougie. The Voir Bougie guide size 15 Fr is dedicated to VieScope®. For intubation with Macintosh laryngoscope, a standard intubation stylet was used. In each case, the stylet, guide, and tube were covered with a lubricant dedicated for simulators.

Interventions

All participants listened to a 30-min lecture covering anatomical and physiological basics, as well as principles of endotracheal intubation with the particular devices. At the end of the theoretical part, the instructor demonstrated correct endotracheal intubation with VieScope® and Macintosh laryngoscopes. Afterwards, the paramedics had an opportunity to participate in a workshop session, during which they performed endotracheal intubation using the two types of investigated laryngoscopes under normal airway conditions. To this purpose, an AirSim Combo Bronchi X airway simulator (TrueCorp®, Ireland) was used.

One month later, the 42 paramedics participated in the proper evaluation. With the use of the Research Randomizer program (randomizer.org), they were randomized into individual groups. The order of both participants and intubation methods was random. The detailed randomization procedure is presented in Figure 2. An advanced SimMan 3G adult patient simulator (Laerdal, Stavanger, Norway) was used to simulate a patient requiring intubation. The simulator was placed on a flat floor in the neutral position. The paramedics were asked to perform endotracheal intubation using the VieScope® and Macintosh laryngoscopes in two separate difficult airway scenarios:

a) scenario A: tongue edema (simulated by inflating the tongue using the simulator software);
b) scenario B: manual cervical inline stabilization.

All participants performed a maximum of three intubation attempts with each device in the differ-

Table 1. Data from intubation in Scenario A: Tongue edema. Data are presented as median (IQR), or as number (percentage)

Parameter	Macintosh laryngoscope	VieScope®	p-value
Duration of intubation when one attempt needed, s	48.5 (44–58)	30 (23–39)	< 0.001
Overall intubation time, s	55 (46–109)	30.5 (26–35)	< 0.001
Overall success rate (%)	39 (92.9)	42 (100)	0.081
Number of intubation attempts (%) 1 2 3 Median (IQR)	 27 (64.3) 5 (11.9) 7 (16.7)	 40 (95.2) 2 (4.8) –	< 0.001
Cormack & Lehane grade 1 2 3 4	 – 10 (23.8) 30 (71.4) 2 (4.8)	 31 (73.8) 11 (26.2) – –	< 0.001
Ease of use (0–10; VAS score)	5 (3–7)	0 (0–3)	< 0.001

IQR — Interquartile Range

ent airway scenarios, with a 10-min break between the scenarios.

Outcomes

The primary outcome was time to first ventilation required by one intubation attempt, defined as the time from picking up the laryngoscope to the first visible ventilation of the lungs in the absence of gastric infiltration. Besides, overall intubation time was calculated, defined as the sum of times of individual intubation attempts where more than one intubation attempt was needed. The secondary outcomes were the success rate of first intubation attempt, overall intubation success rate, Cormack and Lehane grade, and ease of use [11]. Each airway scenario was limited to a maximum of 60 s, up to 3 intubation attempts. Between the airway scenarios, the paramedics had a break lasting 10 min. Following the completion of a scenario, the subjects were asked to grade each device for the ease of its technical use (0 — easy, 10 — difficult).

Statistical analysis

The results obtained for 10 paramedics in the preliminary study showed that the time required for successful intubation with VieScope® was approximately 27 ± 5 s. We estimated that 41 participants would be adequate for 2 independent groups with $\alpha = 0.05$ and $\beta = 0.2$.

All statistical analyses were performed with the use of the Statistica 13.3EN for Windows software (Tibco Inc.; Tulsa, USA). Qualitative variables are presented as absolute values and relative frequencies. Numerical variables are presented as means and standard deviations or medians and interquartile ranges. The relationship between categorical variables was analyzed with the Fisher exact test and the McNemar test. For numerical variables, the parametric and non-parametric tests applied were Student's *t*-test, the Wilcoxon test, and the Mann-Whitney test. A two-tailed p-value of 0.05 was considered significant.

RESULTS

Overall, 42 paramedics (15 women, 35 men; age: 32 (27–36) years; work experience: 6 (3–10) years participated in the trial. All participants had clinical experience in endotracheal intubation with Macintosh laryngoscope.

Tongue edema

The intubation time when only one intubation attempt was required equaled 48.5 s (44–58) for Macintosh laryngoscope vs. 30 s (23–39) for VieScope® ($p < 0.001$; Tab. 1). The total intubation time for Macintosh and Vie Scope® laryngoscopes varied and amounted to 55 s (46–109) vs. 30.5 s (26–35), respectively. The efficacy of the first intubation attempt with VieScope® was significantly higher than that for Macintosh laryngoscope (95.2% vs. 64.3%; $p < 0.001$). The total efficacy was comparable between the intubation methods and equaled 100% for Vie Scope® and 92.9% for Macintosh

Table 2. Data from intubation in Scenario B: Manual cervical inline stabilization. Data are presented as median (IQR), or as number (percentage)

Parameter	Macintosh laryngoscope	VieScope®	p-value
Duration of intubation when one attempt needed, s	49 (39–52)	30 (24–34)	< 0.001
Overall intubation time, s	88 (51–114)	30.5 (24–35)	< 0.001
Overall success rate (%)	41 (97.6)	42 (100)	0.328
Number of intubation attempts (%) 1 2 3	 16 (38.1) 7 (16.7) 18 (42.9)	 37 (88.1) 5 (11.9) –	< 0.001
Cormack & Lehane grade 1 2 3 4	 – 13 (30.9) 22 (52.4) 7 (16.7)	 29 (69.0) 11 (26.2) 2 (4.8) –	< 0.001
Ease of use (0–10; VAS score)	5 (4–7)	1 (0–3)	< 0.001

IQR — Interquartile Range; NS — not statistically significant

($p = 0.081$). Intubation with VieScope® compared with Macintosh laryngoscope involved better glottis visibility according to the Cormack and Lehane scale ($p < 0.001$); it also turned out easier ($p < 0.001$).

Manual cervical inline stabilization

In the manual cervical inline stabilization scenario, the duration of intubation when one attempt was needed equaled 30 s (24–34) when using VieScope® and 49 s (39–52) with Macintosh laryngoscope; the difference was statistically significant ($p < 0.001$; Tab. 2). The overall intubation time needed for successful intubation with VieScope® and Macintosh laryngoscope varied and amounted to 30.5 s (24–35) vs. 88 s (51–114) ($p < 0.001$). The success rate of first intubation attempt was 88.1% with VieScope® and 38.1% with Macintosh ($p < 0.001$). In turn, the total efficacy of intubation was close to 100% vs. 97.6% ($p = 0.328$). Intubation with VieScope® was characterized by statistically significantly better intubation parameters compared with Macintosh laryngoscope ($p < 0.001$) in terms of both glottis visibility and ease of the procedure.

DISCUSSION

The aim of the study was to evaluate difficult intubation performance among paramedics using standard Macintosh laryngoscope and VieScope® laryngoscope. To our knowledge, this is the first comparison of VieScope® laryngoscope with a direct laryngoscope in adult difficult airway conditions.

As the scientific literature lacks reports on the VieScope® laryngoscope, which would enable discussion of the results, the authors decided to relate the obtained data to articles on channeled laryngoscopes, which include VieScope®.

In the conducted simulation study, intubation with the new VieScope® laryngoscope was associated with higher efficiency of the first intubation attempt and shorter procedure duration for both tongue edema and manual cervical inline stabilization. Rognås et al. [9] showed that multiple endotracheal intubation attempts were associated with an increased overall incidence of complications, such as bleeding or pharyngeal edema, and might lead to a situation referred to as "cannot intubate, cannot ventilate" [12, 13].

As indicated by Driver et al. [14], the effectiveness of emergency intubation among difficult airway patients is insufficient and equals only 82% when an endotracheal stylet is used. Moreover, hypoxemia was observed in 14% of patients during intubation. In a tongue edema simulation study, Szarpak et al. [15] reported a 63.6% effectiveness of first intubation attempt with Macintosh laryngoscope.

Research indicates that alternative types of laryngoscopes, including channeled laryngoscopes, can be used instead of direct laryngoscopes, as they guarantee better glottis visibility in difficult airways. The above thesis has also been confirmed by the results obtained in the present study, where the efficacy of the first VieScope® endotracheal intubation attempt for tongue edema was 95.2% and turned out statistically significantly higher than that for Macintosh

laryngoscope (64.3%; $p < 0.001$). Szalast et al. [16] also emphasize the advantage of channeled laryngoscopes over direct laryngoscopes in difficult airways intubation: the efficacy of the first attempt intubation equaled 70.4% for Airtraq and 14.8% for Macintosh laryngoscope. The lower efficacy of intubation with both devices compared with our outcomes may result from the fact that in the Szalast et al. study, intubation was performed by a nurse and our study involved paramedics, who learn how to protect the airways with, among others, Macintosh or Miller laryngoscopes. In turn, Al-Ghamdi [17] indicate that Airtraq requires longer intubation times but less frequently causes sore throat compared with Macintosh when used by anesthesiologists with limited experience in patients with normal airways.

Endotracheal intubation under trauma conditions or suspicion of cervical spine injury in pre-hospital settings requires cervical spine stabilization with at least manual cervical inline stabilization. Numerous studies have shown that direct laryngoscopic intubation under such conditions is ineffective and prolonged in time compared with normal airway intubation [17–19]. In patients undergoing endotracheal intubation with cervical immobilization, Hosalli et al. [20] showed that channeled laryngoscopes were superior to Macintosh laryngoscopes, with greater ease of intubation and lower impact on hemodynamic variables. In turn, as reported by Çolak et al. [21], a minimal cervical motion was obtained during tracheal intubation with the use of Airtraq types of laryngoscope compared with the Macintosh laryngoscope. The advantage of channeled laryngoscopes over Macintosh devices in terms of less movement of the cervical spine was also indicated by Hirabayashi et al. [22]. A meta-analysis conducted by Suppan et al. [23] relating to cervical spine immobilization intubation revealed that the Airtraq device reduced the risk of intubation failure when compared with Macintosh laryngoscope.

Another important aspect, besides the efficacy of intubation itself, is the duration of the procedure, directly related to the risk of hypoxia and thus of hypoxia-induced changes in the central nervous system. In the tongue edema and manual cervical inline stabilization scenarios, Vie Scope® intubation was significantly shorter than the procedure with Macintosh laryngoscope (30.5 s vs. 55 s and 30.5 s vs. 88 s, respectively). In pre-hospital conditions, the long duration of intubation also poses additional problems, i.e. limited strength during rescue procedures; the intubating paramedic is excluded for more than 1 min from performing other procedures. In this case, it is necessary to make specific therapeutic choices. In a Szalast et al. study [16], intubation with Airtraq was significantly shorter than that with Macintosh (26 vs. 53 s, respectively). Rendeki et al. [24] indicated that Airtraq was superior to the Macintosh laryngoscope in difficult airway intubation performed by novice users. This finding is in line with studies by other researchers [25, 26].

Limitations and strengths

Owing to its specificity, the study has its strengths and weaknesses. The limitations may include, first of all, the conditions of medical simulation; however, this procedure was deliberate and dictated by the randomized, cross-over study design. Medical simulation is now a rapidly growing branch of medical science and allows for full standardization of the conditions of procedures without potential damage to a patient's health [27, 28]. Another limitation is the inclusion of paramedics; nevertheless, this professional group, acting under pre-hospital conditions, relatively often has to protect the patient's airways and can only count on their knowledge and skills [29]. Therefore, it is justified to search for intubation methods which will increase the effectiveness of this procedure when performed by paramedics under pre-hospital conditions. Currently, studies are planned to extend the research group to other medical professions.

The strengths of the study include its randomized, cross-over character, which was intended to minimize the learning curve effect. Also, we used the most modern simulators of an adult patient, as well as performed the first evaluation of a new type of laryngoscope. Another strong point of the study is the blinding of results at the stage of statistical analysis.

CONCLUSIONS

In this simulation trial, we found that VieScope® could be successfully used for intubation in difficult airways by paramedics with little simulation experience with this device. VieScope® was associated with shorter time and higher success rates of intubation attempt compared with Macintosh. The presented study is the first to report that VieScope® shows promise for further clinical evaluation.

Conflict of interest

The authors declare no conflict of interest.

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NON-INVASIVE ASSESSMENT OF HAEMODYNAMIC PARAMETERS IN AN EMERGENCY DEPARTMENT

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Abstract

INTRODUCTION: Hospital Emergency Departments are places where fractions of a second decide about human life and every possibility of quickly and reliably obtaining additional information about the patient's condition is extremely important. Therefore, an attempt was made to determine the usefulness of non-invasive assessment of haemodynamic parameters in patients in Emergency Departments.

MATERIAL AND METHODS: The research was conducted in June and July 2019 in the Emergency Room of the Bielański Hospital, Jerzy Popiełuszko in Warsaw. Non-invasive measurement of haemodynamic parameters was performed with the ICON (Osypka Medical, GmbH) Heart Rate Monitor. The study was conducted among patients of the green part of the Emergency Department. $P < 0.05$ was adopted as the significance level.

RESULTS: One-way non-parametric ANOVA confirmed the existence of statistically significant differences (all p for trend < 0.05) between BMI ($p < 0.001$), HR ($p = 0.040$), ICON ($p = 0.048$), and CO ($p = 0.006$) and for the four groups according to the reason for reporting to the Emergency Department (orthopaedic injuries, surgical intervention, internal medicine, other medical fields). One-way non parametric ANOVA confirmed the lack of statistically significant differences (all p for trend > 0.05) between age ($p = 0.418$), SV ($p = 0.161$), TFC ($p = 0.142$), and STR ($p = 0.094$) and for the four groups according to the reason for reporting to the Emergency Department.
In simple linear regression analysis (Spearman), BMI was negatively correlated with CO, ICON, SV, and TFC (all p for trend < 0.05). Age was negatively correlated with CO, ICON, and SV.

CONCLUSIONS: Due to the diversity of patients and their conditions, non-invasive assessment of haemodynamic parameters can become an invaluable help during the diagnosis and subsequent treatment of Emergency Department patients.

KEY WORDS: Emergency Department, cardiac output, thoracic fluid content, non-invasive monitoring

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INTRODUCTION

Haemodynamics of the heart is one of the basic functions of the circulatory system that allows the proper functioning of the body, and hence it is extremely important to have a continuous and reliable reading of the parameters that prove the efficiency of the heart, especially in a state of danger to life and health. Therefore, an attempt was made to determine the characteristics of haemodynamic parameters among patients of the Hospital Emergency Department.

For many years, doctors around the world have been able to determine haemodynamic parameters by invasive methods, but these are time-consuming, expensive, risky methods requiring extensive

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knowledge and high skills of the personnel obtaining them, and they are burdened with a high risk of complications and require appropriate sterile conditions. Non-invasive methods have proven to be a real breakthrough in medicine, allowing not only minimisation of costs, but also rapid, if not instant, results and significant simplification of the entire procedure leading to their receipt. They can be carried out in almost any conditions, the results are given in real time, and obtaining them, including connecting the patient to the equipment, does not take more than five minutes.

Assessment of haemodynamic parameters could be an important element of diagnostics in departments such as Hospital Accident and Emergency Department, Operating Theatres, Intensive Care Units (ICUs), and Cardiology Departments and their quick and non-invasive acquisition with the gold standard, because traditional measurement of blood pressure, pulse, or saturation provides too little information. The comprehensive picture of haemodynamic parameters allows for better quality patient care, earlier response in life-threatening situations, and thus in many situations the avoidance of complications.

The aim of the study was to make a non-invasive measurement of haemodynamic parameters in patients of a Hospital Accident and Emergency Department and to determine the degree of utility of this type of care in Emergency Departments.

MATERIAL AND METHODS

The measurements of haemodynamic parameters were carried out in June and July 2019 in the Emergency Room located at the Bielański Hospital, Fr. Jerzy Popiełuszko in Warsaw, while complying with the principles of the Declaration of Helsinki and after obtaining permission to conduct the study from the Head of the Hospital Emergency Department.

The research was conducted on the green part, where patients report to the Emergency Room by themselves and their health condition allows them to wait for a medical doctor for 60 to 360 minutes, which is determined by a paramedic or a properly trained nurse, based on a preliminary interview and physical examination. Patients imported by the Medical Emergency Teams and remaining on the red side due to their critical health were excluded from the study.

The inclusion criteria of the research sample were the possibility of expressing in writing fully informed consent to participate in the conducted research and the age of participants being above 18 years. Patients who met these requirements were verbally instructed on the purpose of the tests and on the method and course of measuring haemodynamic parameters. The study did not include patients under 18 years of age, who could not give written, informed consent, including people under the influence of alcohol or other psychoactive substances.

A total of 132 patients were asked to participate in the study, of whom 42 patients gave written, informed consent to take measurements. The youngest participant was 25 years old and the oldest was 88 years old. The research group consisted of 20 women aged 28 to 88 and 22 men aged 25 to 88 years.

The sample was divided into four groups according to their reason for reporting to the Emergency Department. The first group consisted of patients after orthopaedic injuries — eight persons, among whom torsional limb injuries predominated. The second group included patients requiring surgical intervention — four persons, mainly with upper limb wounds qualified for sewing. The third patient group was admitted by a specialist in internal medicine — 24 persons — the most diverse group, comprising people after drug intoxication, cardiac incidents, fainting, and with chest pain. The fourth patient group comprosed those requiring consultation by specialists from other medical fields, mainly neurologists and laryngologists — six persons.

Non-invasive measurement of haemodynamic parameters was performed with the index of contractility (ICON) Osypka Madical, GmbH Heart Rate Monitor (Fig. 1). The tests were conducted during the patients' stay in the Hospital Emergency Department by placing four electrodes on the left side of the patient's body — two on the neck and two on the side of the chest (Fig. 2, 3). The device emits a low-amplitude, high-frequency current, and based on resistance measurements haemodynamic parameters are measured. The study was performed on patients remaining lying down during its duration, as well as previously collecting data such as age, height, and weight.

The following parameters were analysed: HR, (ICON), stroke volume (SV), cardiac output (CO), thoracic fluid content (TFC), and systolic time ratio (STR).

Statistical analysis

Results concerning quantitative variables were presented as average values ± standard deviation. Qualitative variables (age, sex) were presented as quan-

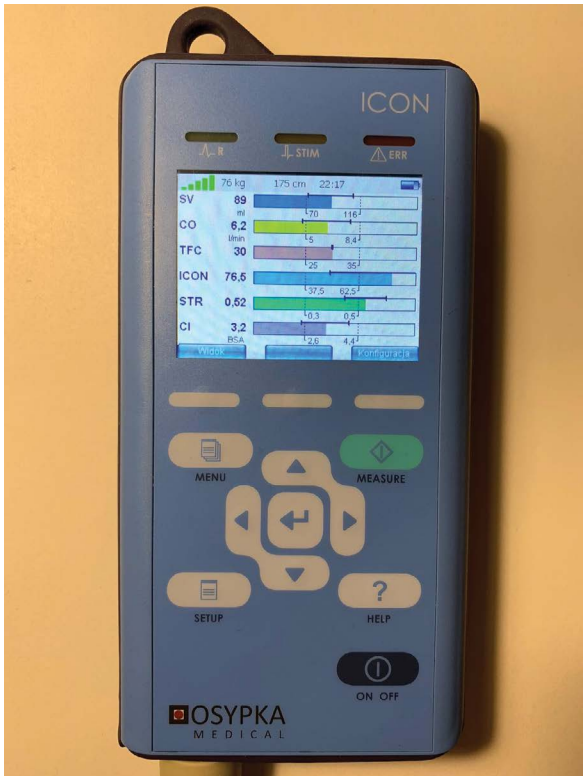

FIGURE 1. ICON Osypka Madical, GmbH Heart Rate Monitor; ICON — index of contractility

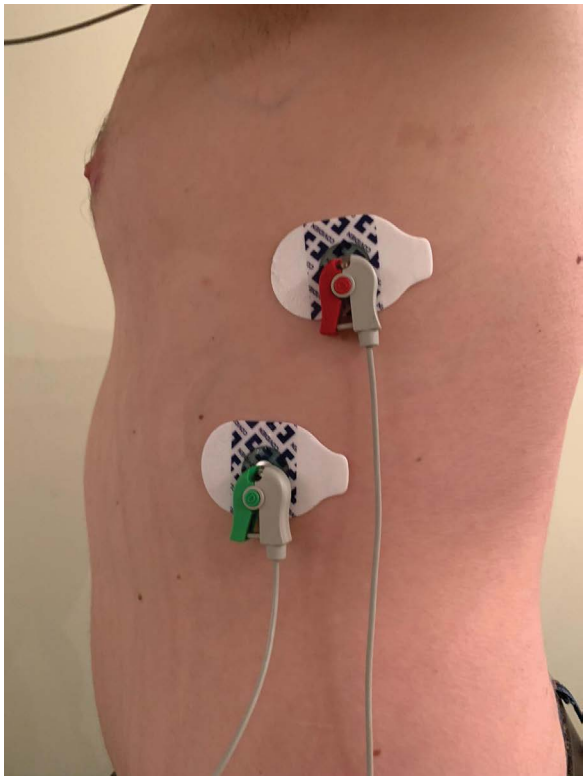

FIGURE 2. Localisation of 2 electrodes on the neck

tity (n) and percentage values of the whole group (%). The one-way ANOVA on ranks was applied to compare the different times and to determine the statistical difference for each group (post-hoc). In the comparative analysis of BMI, age, and haemodynamic parameters simple linear regression analysis (Spearman) was applied to detect and describe the strength and direction of correlations of clinical data. Statistica 13.3 software (Tibco Inc., Tulsa, USA) was used in the statistical analysis. $P < 0.05$ was adopted as the significance level.

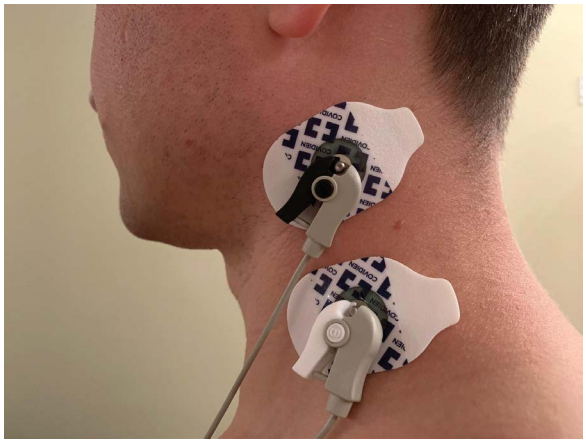

FIGURE 3. Localisation of 2 electrodes on the side of the chest

RESULTS

Among the examined Emergency Department patients, the average results of haemodynamic parameter measurements were within the generally accepted standards — only TFCs were recorded outside the lower limit, on average it was 23.08 1/kΩ. However, if one considers the sex of the respondents, there is a significant discrepancy in results. The surveyed women have a lower average TFC score of 20.80 1/kΩ compared to the norm — Table 1.

In the group of patients after orthopaedic injuries, a decrease in CO to 4.23 l/min on average and TFC to 22.50 1/kΩ on average dominated. Women presented a decrease in parameters such as ICON average to 29.70, SV to 53.00 ml, CO to 3.35 l/min and TFC to 16.50 1/kΩ. The characteristics of the haemodynamic parameters of the group of patients after orthopaedic injuries are presented in Table 2.

In the group of patients requiring the intervention of a surgeon, the results of haemodynamic parameters were not collected from any women, so the group analysis was carried out only among men. They were characterised by increased pulse — on

Table 1. General characteristics of the study group

		Woman (n = 20)		Man (n = 22)		Altogether (n = 42)	
		Average	SD	Average	SD	Average	SD
Age (years)		55	21	57	24	56	23
BMI (kg/m^2)		26.20	4.76	26.27	2.9	26.24	3.85
Haemodynamic parameters	HR (bpm)	71	8	82	18	77	15
	ICON	55.94	45.89	45.41	20.46	50.42	35.78
	SV (ml)	64.30	24.65	74.91	11.54	69.86	19.93
	CO (l/min)	5.46	3.94	6.17	2.28	5.83	3.23
	TFC (1/kOhm)	20.80	8.59	25.36	5.52	23.19	7.58
	STR	0.42	0.14	0.45	0.07	0.43	0.11

CO — cardiac output; HR — heart rate; ICON — index of contractility; n — number of people surveyed; TFC — thoracic fluid content; SD — standard deviation; STR — systolic time ratio; SV — stroke volume

Table 2. Clinical characteristics of the group of patients after orthopaedic injuries

		Woman (n = 4)		Man (n = 4)		Altogether (n = 8)	
		Average	SD	Average	SD	Average	SD
Age (years)		65	9	27	2	46	20
BMI (kg/m^2)		30.28	5.24	24.80	2.07	27.54	4.78
Haemodynamic parameters	HR (bpm)	73	3	69	4	71	4
	ICON	29.70	2.20	51.60	0.40	40.65	11.11
	SV (ml)	53.00	7.00	76.50	3.50	64.75	12.99
	CO (l/min)	3.35	0.05	5.50	0.20	4.46	1.12
	TFC (1/kOhm)	16.50	1.50	28.50	4.50	22.50	6.84
	STR	0.31	0.04	0.38	0.07	0.34	0.07

CO — cardiac output; HR — heart rate; ICON — index of contractility; n — number of people surveyed; TFC — thoracic fluid content; SD — standard deviation; STR — systolic time ratio; SV — stroke volume

average up to 95 bpm, reduced ICON parameter — on average to 31.60, and slightly reduced TFC — on average to 24.00 1/kΩ. Table 3. presents the characteristics of the haemodynamic parameters of the group of patients requiring surgical intervention.

Among the patients admitted by the internist, the most common changes were ICON — the mean of this parameter was 61.34 and the TFC average was 24.67 1/kΩ. An increase in HR to 86 bpm was characteristic for men, while the rest of the haemodynamic parameters were mostly normal. In women, an increase in ICON to 73.08 on average and a decrease in TFC to 23.83 1/kΩ on average dominated. The characteristics of the haemodynamic parameters of the group of patients admitted by the internist are presented in Table 4.

Patients consulted by other specialists constituted a very diverse group, in which changes of such parameters as ICON (to 33.13 on average), CO (to 3.78 l/min on average), and TFC (to 18.50 1/kΩ) on average were noticeable. In addition, in this group,

Table 3. Clinical characteristics of the group of patients requiring surgical intervention

		Man (n = 4)	
		Average	SD
Age (years)		51	19
BMI (kg/m^2)		30.13	0.99
Haemodynamic parameters	HR (bpm)	95	5
	ICON	31.63	2.33
	SV (ml)	70.50	6.03
	CO (l/min)	6.45	0.21
	TFC (1/kOhm)	24.00	0.71
	STR	0.47	0.03

CO — cardiac output; HR — heart rate; ICON — index of contractility; n — number of people surveyed; TFC — thoracic fluid content; SD — standard deviation; STR — systolic time ratio; SV — stroke volume

Table 4. Clinical characteristics of the group of patients admitted by the internist

		Woman (n = 12)		Man (n = 12)		Altogether (n = 24)	
		Average	SD	Average	SD	Average	SD
Age (years)		51	25	68	23	59	25
BMI (kg/m^2)		23.48	2.37	25.23	2.50	24.36	2.59
Haemodynamic parameters	HR (bpm)	70	10	86	19	78	17
	ICON	73.08	52.39	49.60	25.59	61.34	42.87
	SV (ml)	72.50	28.62	76.33	14.81	74.42	22.86
	CO (l/min)	6.83	4.60	6.65	2.89	6.74	3.84
	TFC (1/kOhm)	23.83	9.94	25.50	6.45	24.67	8.42
	STR	0.43	0.16	0.46	0.07	0.45	0.12

CO — cardiac output; HR — heart rate; ICON — index of contractility; n — number of people surveyed; TFC — thoracic fluid content; SD — standard deviation; STR — systolic time ratio; SV — stroke volume

Table 5. Clinical characteristics of the group of patients consulted by other specialists

		Woman (n = 4)		Man (n = 2)		Altogether (n = 6)	
		Average	SD	Average	SD	Average	SD
Age (years)		61	6	66	0	62	5
BMI (kg/m^2)		30.46	2.84	27.77	0.01	29.12	2.60
Haemodynamic parameters	HR (bpm)	73	3	65	5	69	6
	ICON	30.75	9.25	35.75	0.25	33.25	7.01
	SV (ml)	51.00	5.00	72.00	1.00	61.50	11.10
	CO (l/min)	3.45	0.15	4.10	0.10	3.78	0.35
	TFC (1/kOhm)	16.00	1.00	21.00	1.00	18.50	2.69
	STR	0.51	0.09	0.42	0.00	0.47	0.08

CO — cardiac output; HR — heart rate; ICON — index of contractility; n — number of people surveyed; TFC — thoracic fluid content; SD — standard deviation; STR — systolic time ratio; SV — stroke volume

SV women had an average reduction of 51.00 ml. Table 5. presents the characteristics of the haemodynamic parameters of the group of patients consulted by other specialists.

The one-way non-parametric ANOVA confirmed the existence of statistically significant differences (all p for trends < 0.05) between BMI ($p < 0.001$), HR ($p = 0.040$), ICON ($p = 0.048$), CO ($p = 0.006$) and the four groups according to the reason for reporting to the Emergency Department (orthopaedic injuries, surgical intervention, internal medicine, other medical fields). The one-way non parametric ANOVA confirmed the lack of statistically significant differences (all p for trends > 0.05) between age ($p = 0.418$), SV ($p = 0.161$), TFC ($p = 0.142$), STR ($p = 0.094$) and thefour4 groups according to the reason for reporting to the Emergency Department.

Table 6. Results of simple regression analyses between BMI, age, and haemodynamic parameters

	BMI		Age	
	R	P	R	P
CO	-0.426	0.005	-0.419	0.006
HR	-0.075	0.638	-0.053	0.736
ICON	-0.738	< 0.001	-0.408	0.007
SV	-0.552	< 0.001	-0.568	< 0.001
TFC	-0.474	0.002	-0.032	0.839
STR	0.058	0.713	0.031	0.847

CO — cardiac output; HR — heart rate; ICON — index of contractility; TFC — thoracic fluid content; STR — systolic time ratio; SV — stroke volume

In simple linear regression analysis (Spearman), BMI was negatively correlated with CO, ICON, SV, and TFC (all p for trends < 0.05). Age was negatively correlated with CO, ICON, and SV (Tab. 6) (Fig. 4, 5).

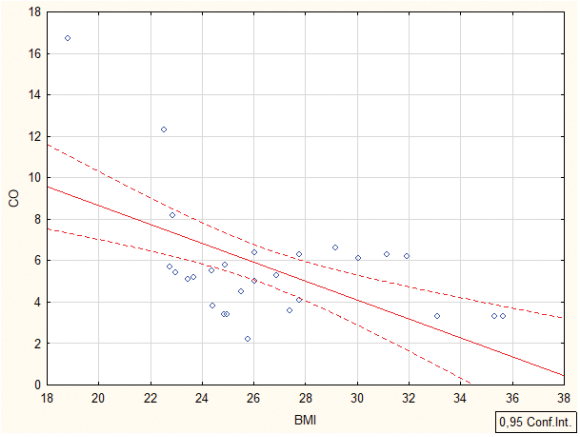

FIGURE 4. Simple linear regression analysis (Spearman) of CO and BMI; CO — cardiac output

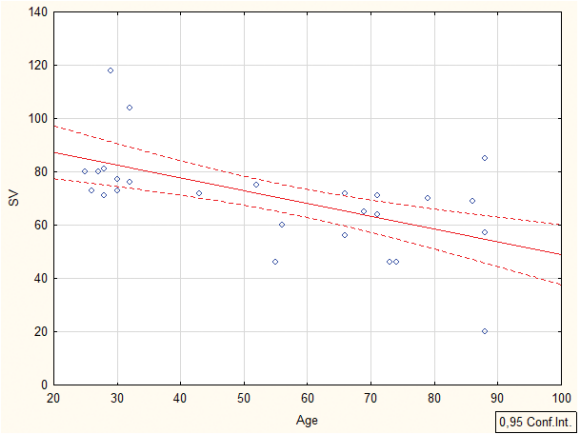

FIGURE 5. Simple linear regression analysis (Spearman) of SV and age; SV — stroke volume

DISCUSSION

Currently, many valuable clinical studies are being prepared regarding non-invasive measurement of haemodynamic parameters. They show that in many respects this type of measurement is characterised by versatile usefulness in many fields of medicine, ranging from determining the appropriate antihypertensive treatment, through monitoring during dialysis, to high mountain climbing.

P. Krzesiński et al. [1] showed the usefulness of non-invasive monitoring of haemodynamic parameters among participants of high-altitude climbing and the possibility of using this method even in extreme conditions. The study involved 13 participants of two spring expeditions in the Himalayas. A comprehensive examination of the expedition members was carried out before departure and again at an altitude between 4300 and 5700 m a.s.l. considering the symptoms of acute mountain sickness. Studies have shown that despite very individual responses to altitude, non-invasive measurement of haemodynamic parameters can be a useful tool for monitoring at high altitudes, especially when it comes to breathing disorders.

The study of Trzeciak et al. [2] showed that with the help of non-invasive measurement of haemodynamic parameters it can be easily determined whether hypertension is well controlled in patients. The study involved 199 patients treated for hypertension by primary care physicians. The patients were divided into two groups: the first consisted of those whose blood pressure was well controlled (< 140/90 mmHg), and the second consisted of patients with poorly controlled hypertension. The study showed that haemodynamic parameters differentiate these two groups of patients. In the group with poorly controlled arterial pressure, such parameters as HR, TFC, or stroke volume index (SI) increase, while in the group with well-controlled hypertension these values are within normal limits.

In an article published in the Family Medicine Forum, Siebert et al. [3] mention impedance cardiography as one of the possible methods for extending stroke monitoring. They point to numerous cardiovascular complications occurring in connection with damage to important brain structures, as well as the frequent occurrence of hypertension, which is a risk factor for re-stroke. With the help of non-invasive measurement of haemodynamic parameters, it is possible to monitor the patient's condition in real time without requiring intervention that predisposes to further complications, while providing accurate and reliable data that allows for adequate correction of the treatment process.

Further evidence confirming the comprehensive possibilities of impedance cardiography is the study of the impact of obesity on the haemodynamic profile of men with coronary artery disease conducted by Krzesiński et al. [4]. Fifty-two men who were in the second stage of rehabilitation in 87% after acute coronary syndrome participated in the study. During measurements, obese men had significantly lower cardiac impedance indices of cardiac function as a pump relative to non-obese participants. In addition, impedance cardiography enabled early detection of the presence of left ventricular systolic dysfunction, and thus the implementation of actions aimed at improving the quality of patients' functioning and eliminating further complications.

In an article on the importance of research on haemodynamic changes in patients with chronic

kidney disease by Siebert et al. [5] the topic of monitoring haemodynamic parameters of dialysed patients was discussed. The incidence of dialysis complications such as hypotension, which affects up to half of patients on dialysis, muscle cramps, cardiovascular incidents, headaches, and itching of the skin, as well as nausea and vomiting, are underlined. Attention was drawn to a variety of complications, including stroke, acute ischaemia, sudden cardiac arrest, or sepsis, and to the rare occurrence of prodromal symptoms, which greatly hinder early and adequate medical response to the patient's condition. High efficiency of continuous haemodynamic parameters has been shown to reduce adverse events in dialysis patients. It allows early detection of changes that herald dialysis complications and implementation of appropriate medical procedures aimed at stabilising the patient's condition.

A large research group can boast of non-invasive monitoring of patients with suspected heart failure, sepsis, and stroke conducted by Nowak et al. [6], in which 510 patients were examined — 185 with suspected heart failure, 194 with sepsis, and 131 with stroke. Each patient was subjected to a non-invasive study of haemodynamic parameters of the beat-to-beat type, which allowed the authors to state that all these groups were characterised by different deviations of haemodynamic parameter measurements. Consequently, the study led to the conclusion that an early non-invasive examination of haemodynamic parameters could in the future allow for initial diagnosis of patients, individual adjustment of therapy based on the readings obtained, and estimation of mortality within 30 days. At the same time, scientists warn against hasty enthusiasm and recommend further scientific research aimed at expanding the study group and specifying more precisely the standards of conduct.

Another study emphasising the utility of measuring haemodynamic parameters is the study by Karpiarz et al. [7] in which 31 patients requiring intervention of an Emergency Medical Team participated. As the authors emphasised, measurements made by impedance cardiography showed significant discrepancies in the parameters between trauma/poisoning patients, patients with suspected cardiovascular disease, and patients with other suspected disease entities. Based on the results obtained, the authors concluded that impedance cardiography can be a useful tool especially for use in patients with haemorrhagic shock or circulatory failure, where the possibility of additional measurements can determine the fate of the patient.

In the article published in the pages of Anestezjologia i Ratownictwo T. Trafidło, T. Gaszyński, and W. Gaszyński [8] familiarise the reader with the laws that allow the reading of haemodynamic parameters, present principles that can help in the selection of methods for monitoring haemodynamic parameters, and indicate the main differences between the various measurement methods. They emphasise the usefulness of such monitoring and draw attention to how rapidly all methods of monitoring cardiac output are developing.

Noteworthy is the work of B. Żuchowski and P. Guzik [9], which transparently explains the principles of non-invasive measurement of haemodynamic parameters and compares non-invasive measurement of haemodynamic parameters to more traditional methods of assessing the cardiovascular system. Electric bioimpedance of the chest, despite its many advantages such as accuracy and speed of measurement, non-invasiveness, and wide application possibilities, also has some limitations, which the authors of the article mention. For the results of this method to be reliable, the patient must remain still. Conditions such as atrial fibrillation, severe arrhythmia, and frequent extrasystoles interfere with interpretation of the record. In addition, non-standard dimensions of the patient's body also affect the reliability of the bioimpedance curve recording.

This study has some limitations. Firstly, compared to the other studies, our sample was quite small. Secondly, the fate of the patients was evaluated only in the Emergency Department.

CONCLUSIONS

1. Non-invasive measurement of haemodynamic parameters should be the gold standard for Emergency Departments due to the complexity of the problems that patients report and the relatively short time required to service the patient. Haemodynamic parameters allow for an accurate assessment of the condition and, acquired quickly and non-invasively with the help of the Heart Rate Monitor, can be a valuable source of information enabling the introduction of adequate treatment, consequently preventing many complications. It should be empha-

sised that the method is cheap and allows for significant reduction of costs in the future, even in terms of treatment of complications that can be avoided.

2. Research on non-invasive measurement of haemodynamic parameters of Emergency Department patients should be conducted again by expanding the green group of patients, and similar studies should be initiated among Emergency Department patients admitted on the red side.

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Conflict of interest

The authors declare that they have no conflicts of interest. None of the authors involved in this study have any financial relationship.

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VIA MEDICA

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POINT-OF-CARE EMERGENCY ULTRASONOGRAPHY IN NON-TRAUMATIC CARDIAC ARREST AND NEAR-ARREST EMERGENCY PATIENTS; A PILOT TRIAL

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Abstract

INTRODUCTION: In this study, we evaluated the applicability and interpretation of point- of- care emergency ultrasound (POCEUS) performed by an emergency physician (EP) in non-traumatic adult cardiac arrest and near-arrest patients at presentation to the Emergency Department (ED).

METHODS: POCEUS was performed in 5 steps on 73 adults to assess; 1. Qualitative global cardiac function, cardiac chambers and presence of pericardial effusion; 2. Presence of pleural sliding, B-lines, A-lines or consolidation on anterior-superior; 3. Presence of an abdominal aorta aneurysm and pelvic free fluid; 4. Presence of pleural effusion, consolidation, free fluid on lateral-inferior; 5. Qualitative width and collapsibility of the inferior vena cava. A fulfilled checklist and real-time images of ultrasonography were sent by WhatsApp to the head of the study to generate the evidence and collect the data.
The process of patient care, in-hospital diagnosis and survival were retrieved from digital hospital records. This prospective multicenter sample study was conducted from November 16, 2015, to January 5, 2016.

RESULTS: The most common findings of POCEUS were performed and interpreted to have a first prediction of patients' acute clinic problem by EPs were compatible with global systolic dysfunction (n = 16, 22.9%), pulmonary edema (n = 17, 23.3%), pulmonary embolus (n = 6, 8.2%), distributive/hypovolemic shock (n = 12, 16.4%), cardiac tamponade or pericardial effusion (n = 5, 6.8%), and pneumonia (n = 31, 42.5%) at presentation.
The kappa correlation coefficient value of the POCEUS at presentation versus the final, traditional clinical diagnosis of the admitted ward, was 0.773 (95% CI, 0.747–0.892; p = 0.064, McNemar).

CONCLUSIONS: POCEUS performed by an EP at presentation had a good agreement between in qualitative prediction of the first differential diagnosis in life-threatened patients and the last diagnosis obtained during hospitalization. Furthermore, this study showed the requirement of evidence in comparison of measurements to the qualitative manner and new descriptive processes in POCEUS for unexplained situations and questions.

KEY WORDS: cardiopulmonary arrest, near-arrest, emergency patient, point-of-care emergency ultrasound

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INTRODUCTION

The history of ultrasonography literature for the emergency patient had been started by Kristensen et al in 1971 including splenic haematoma in trauma [1]. Since then it has been a core application still growing as an independent method performed by emergency medicine in the world [2].

At the present time, emergency ultrasound imaging criteria compendium involves the aorta, cardiac, kidney and bladder, lung and pleura, ocular, pelvic, right upper quadrant, soft tissue/musculoskeletal, trauma, ultrasound-guided procedures and venous thrombosis. For each one primary and extended indications, contraindications, limitations and pitfalls were released and updated by American College of Emergency Physicians [3].

More than, there are many valuable researchers identified the ultrasonographic findings by explaining the relations in algorithms of systems in acute and critical patients [4, 5].

Point of care emergency ultrasound (POCEUS) is generally superior to traditional physical examination alone in the emergency department (ED) and can therefore be highly valuable.

It allows rapid assessment of differential diagnosis of a life-threatening and is performed by emergency physicians (EPs) [6–9].

Evidence-based on real-time ultrasound imaging performed in limited time on cardiac, lungs, abdomen, and inferior vena cava (IVC) is essential to solve the emergency problems on patients in ED. Various protocols for a point-of-care ultrasound with cardiac arrest, shock, and respiratory failure have been reported and improved patient care at the ED [4, 10–12]. Moreover, in stable patients with a new complaint, the ultrasound can also be used to enlighten and prevent the progress of the problem.

In the present study, we aimed to evaluate the applicability and interpretation of POCEUS based on only visual estimation performed by EP on patients with cardiac arrest and near-arrest at presentation to the ED.

We also evaluated the relation predictions obtained by POCEUS and the last diagnosis on hospitalization.

METHODS

This seven-center of EDs (Baskent University Adana Dr. Turgut Noyan Training and Research Center, Ufuk University, Ege University, Akdeniz University, Gaziantep University, Baskent University Ankara Hospital, and Eskisehir Osmangazi University) prospective random-sample study was performed between November 16, 2015 and January 5, 2016.

The study was carried out in a period where all the centers had at least one working ultrasound in ED continuous and simultaneously at the same time. As the presence of ultrasound machine has not been a formal rule in all EDs in Turkey, yet, as in many developing countries. The study protocol was approved by Baskent University Institutional Review Board (no. KA15/214).

There was only one volunteer researcher in each ED contributed in the study who performed emergency ultrasonography on study cases.

The cases were involved in shifts of volunteer researchers'.

Emergency ultrasonography was performed at once on initial of the presentation of the patient to the ED.

Inclusion criteria were included the age of > 18 years, non-traumatic cardiac arrest or acute, life-threatening, near-arrest cases. Near-arrest cases had at least one of them; Acute; Hypotension/ /hypertension + tachycardia or hypoxia or clinical deterioration at presentation with poor looking with the presence of a significant, intolerable, and unexplained reason to clarify this situation, requiring immediate treatment and management in ED [13].

Performance of POCEUS upon arrival to the ED was realized prior to any blood tests, another imaging methods or any consultation, without any inhibition of advanced life support or emergency treatment/management if required. Real-time ultrasonographic images were recorded by another witnessed healthcare staff member's smartphone and a checklist of ultrasonographic findings in the study with predicted differential diagnosis interpreted was filled by EP who performed POCEUS, sent all via WhatsApp Messenger to the first author of the study to make evidence and collect the data in a file. The findings of the POCEUS were not shared with consultants in order not to affect their final diagnosis for the patient in hospitalization by their traditional way except the emergency staff.

Exclusion criteria included trauma cases, ST-elevation myocardial infarction, gastrointestinal or external hemorrhage, cerebral events and intoxication.

POCEUS was a tool, provided only a prediction in preliminary differential diagnosis on patients by answering the presence or absence of some ultra-

Table 1. The checklist study form

1. Cardiac	
Ventricle contraction	Left/right: Normal/ /Hypokinetic/Hyperkinetic/ None
Chambers	Left/Right: Enlarged/Normal/ /Small
Pericardial effusion	-/+/Tamponade
2. Bilateral anterosuperior lungs	
Pleural sliding	+/-/Decreased
B-lines	< 3/≥ 3/≥ 5
A-lines	+/-
Consolidation	+/-
3. Abdomen	
Abdominal medial aortic aneurysm ± rupture	+/-
Suprapubic free fluid	+/-
4. Inferiolateral lungs and physiological lateral fossas	
Pleural sliding	+/-/Decreased
B-lines	<3 /≥ 3/≥ 5
A-lines	+/-
Consolidation	+/-
Bilateral pleural/hepatorenal/ /splenorenal fluid	+/-
5. IVC	
Width and Collapsibility	Narrow/Normal/Enlarged and 50%/< 50%/> 50%
+ If qualitative right ventricle dilatation is present, on 3-point DVT examination: Compressible/Uncompressible	

sonographic signs in a few minutes. In this sample, it was an independent and the first method performed, prior to the physical examination, advanced examinations, patient care management and plan.

All EPs were emergency medicine fellowship-trained physicians, including at least 2 years experience of emergency ultrasound.

2D-ultrasound with three probes were used. Patients in cardiac arrest were placed in supine, and all other patients were placed in the semi-sitting position.

The parameters were;

1. Qualitative global cardiac function, cardiac chambers, and the presence of pericardial effusion 2. Presence of pleural sliding, B-lines, A-lines, or consolidation in 1 intercostal area (ica) of each side on anterosuperior lungs. 3. Presence of a middle abdominal aorta aneurysm and suprapubic free fluid 4. Pleural sliding, B-lines, A-lines, consolidation, or effusion in 1 ica of each side on inferolateral lungs and free fluid in the physiological lateral abdominal fossas. 5. Qualitative width as narrow, normal, enlarged and IVC collapsibility as $<$, $>$, $\sim$ 50%. The checklist used in the study is shown in Table 1.

Cardiac and leg vein (if indicated) comprised at first the four-chamber cardiac evaluation that was preferably performed in the apical or parasternal view.

If these views could not be obtained, a subcostal view was done with a phased array or convex probe. Contraction and dilatation of the left and right ventricles and the presence of pericardial effusion were qualitatively evaluated [8, 9].

If there was suspicion of pulmonary thromboembolism (PTE) with a dilated right ventricle, D-shaped left ventricle, or McConnell's sign on the cardiac view, a probe was used to perform the three-point compression technique for evaluation of DVT to determine the presence of uncompressible or limitedly compressible veins [8, 9, 14, 15]. Although, evaluation of D-shaped left ventricle or McConnell's sign were difficult and not considered in emergencies.

For lung views, the anterosuperior and inferolateral areas of the lungs were evaluated with a convex ultrasound probe. Pleural sliding was defined as the movement of the pleural line in an ica with each respiration.

The diffuse interstitial syndrome was defined as 3 or more B-lines, at least in 2 icas in each lung. Focal interstitial parenchymal pathology was considered to be present when 3 or more B-lines were seen in 1 ica on each lung or only in one side. Pneumothorax was predicted as the first probability in differential diagnosis in an acute deteriorated unintubated case while the absence of pleural sliding and B-lines. Lung point is the confirmation, lung pulse is the exclution of pneumothorax, they were not used in this study.

Consolidation was defined as an irregular hypoechoic or tissue-like subpleural area in the parenchyma [5, 12, 16].

In IVC views, IVC collapsibility was qualitatively defined as a diameter change between expansion during expiration and narrowing on the inspiration of approximately 50% within normal conditions are.

If the IVC collapsibility $<$ 50% on inspiration or the diameter of 2.5 cm is measured define that there is sufficient intravascular volume for septic patients in a report [17].

Table 2. The demographic data and presenting complaint/condition of patients

Demographic characteristics	
Age in years	70 ± 13 (29–94)
Female sex	43% (n = 32)
The first presenting complaint or condition	
Dyspnea	50.7% (n = 37)
Cardiac arrest	9.6% (n = 7)
Chest pain	9.6% (n = 7)
Palpitation	6.8% (n = 5)
General impairment	5.5% (n = 4)
Abdominal pain	4.1% (n = 3)
Emesis	4.1% (n = 3)
Dizziness	2.7% (n = 2)
Syncope	2.7% (n = 2)
Unconsciousness	2.7% (n = 2)
General pain	1.4% (n = 1)
Total	100% (n = 73)

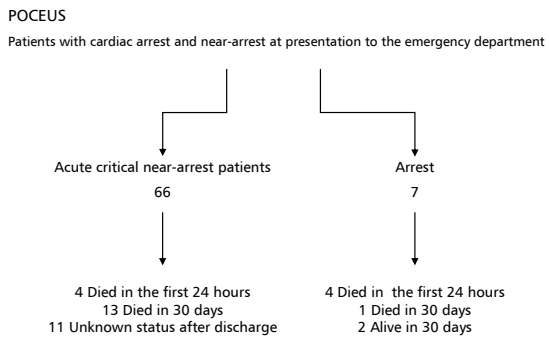


FIGURE 1. The patient flow

Increased collapsibility was defined as a volume deficiency or an increased volume requirement. However, decreased collapsibility was defined as increased preload in volume overload, or indicating cardiac malfunction, tamponade, pulmonary thromboembolism, or acute respiratory distress syndrome (ARDS) [8, 9].

In this study, IVC width and collapsibility was estimated visually as normal or abnormal in a qualitative manner and was not measured. It was a limitation and lack in this study according to the limited time and situations, need further studies in relialibility.

For abdominal aorta aneurysm (AAA) and suprapubic view, abdominal aorta was scanned on the superior umbilical line in the transverse plane. AAA is defined when the diameter greater than 3 cm in literature [18, 19]. In this study, scanning was performed to find a significant visual one.

Suprapubic free fluid was evaluated by examining the medial pelvis in the perpendicular axis using a convex probe [19].

POCEUS on arrest patient was performed only while < 10 seconds of rythm-control intervals not to inhibit or retard the advanced life support guidelines by interrupting chest compressions. This was a protocol ruled for the study.

The last diagnosis in hospitalization is formed a combination of whole traditional reported results of all examinations including of X-ray, echocardiography, computed tomography, and other examinations, planned by other physicians, consultants. Only the decision in diagnosis of them who hospitalized the patient were studied prospectively from the records of patients.

Statistical analyses were performed with SPSS 17.0 statistical analysis software (SPSS Inc., Chicago, IL, USA). Categorical data are presented as number and percentage, and continuous data are presented as mean and standard deviation. Relations were evaluated with the inter-rater correlation method, and statistical differences were tested with the McNemar test. Good agreement between the POCEUS and the clinical diagnosis was defined as a p value of < 0.05 using the McNemar test and a kappa correlation coefficient of > 0.70.

RESULTS

In total, 73 patients were evaluated.

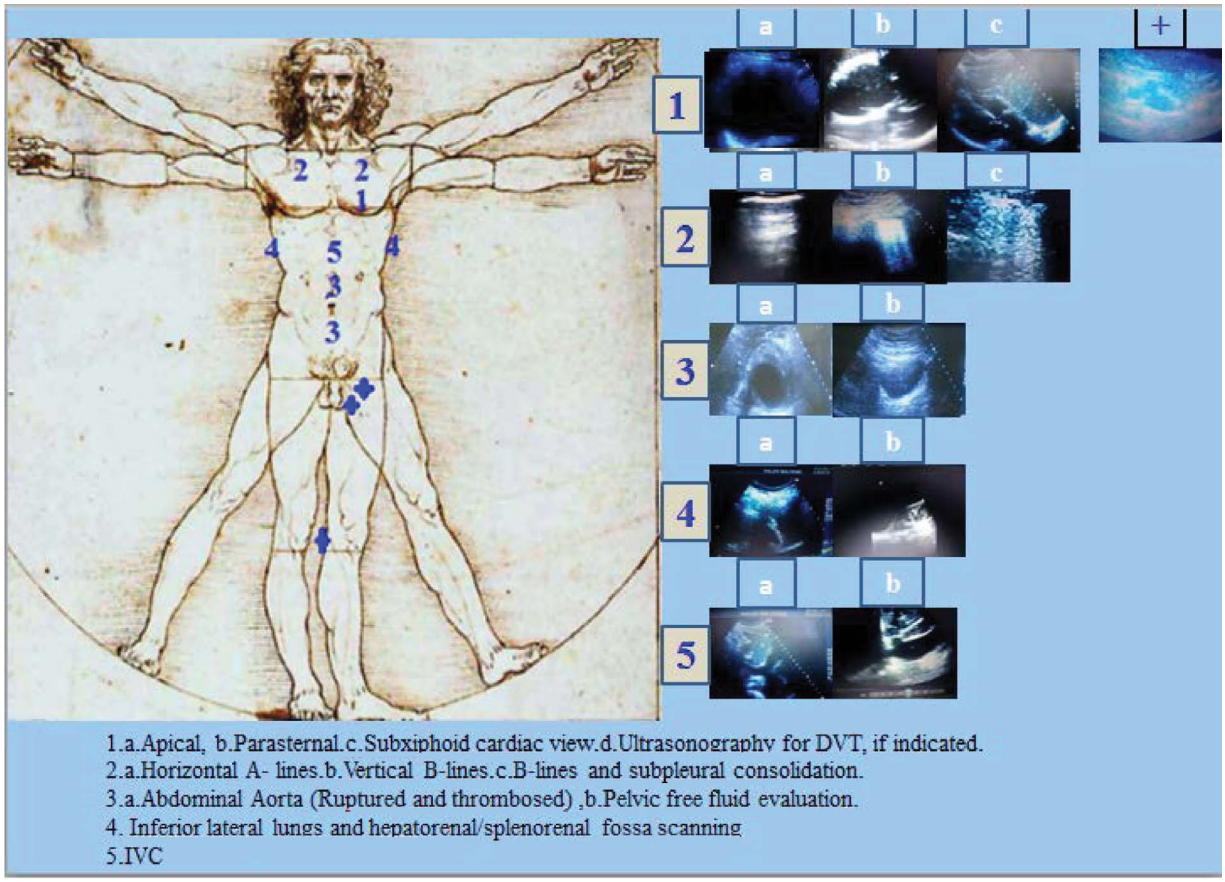
Four patients were excluded according to the exclusion criteria (Gastrointestinal hemorrhage began after the first evaluation at ED in 1 patient, a cerebral event was confirmed without any lateralization at presentation in one patient, and incomplete data forms were obtained for two patients.

The patients' demographic data (age and sex) and presenting complaint/condition are shown in Table 2.

Figure 1 shows the patient flow.

Figure 2 demonstrates the places of a probe used in the study and the sample of the ultrasound views.

Comparison of the emergency ultrasound interpretation versus blind traditional clinical diagnoses during hospitalization revealed a kappa correlation coefficient of 0.773 (95% CI, 0.747–0.892; p = 0.064, McNemar test) (Tab. 3).



Respectfully to Leonardo Da Vinci for science and art in Vitrivius

FIGURE 2. Demonstrates the places of a probe used in the study and the sample of the ultrasound views

Figure 3 compared the prediction of differential diagnosis by POCEUS at presentation to the last diagnosis on hospitalization on a chart.

DISCUSSION

Differential diagnosis in emergency patients presenting to the ED with cardiac arrest or near-arrest is a complex problem to be solved within limited time. Physical examination alone ensures neither an accurate preliminary prediction of the clinical problem nor optimal treatment of the patient's condition. X-ray examination is generally insufficient in the interpretation of findings and cannot demonstrate additive systematic clues [16]. Computed tomography is not the first diagnostic option in the management of these patients, just suitable after the patient's vital signs have been stabilized and thus controlled.

POCEUS is used by EPs only to answer the essential questions and prioritizing the treatment. Algorithms manage this process in a shorter time and provide real-time findings based on confirmation or exclusion [7–9].

Clattenburg reported a CPR pauses with POCUS performed lasted a mean 19.3 s with versus a mean 14.2 s without it. It was longer of 6.1 s by the same physician both active in resuscitation and POCUS. While there was not any association between ROSC, the number of CPR pauses or POCUS duration [20]. Ideally, it should be performed by another EP independently, unfortunately, there was not a time counter used alone in our study. This could be controlled and prevented by another commissioned staff in CPR.

Some studies have described algorithms for arrest, shock, and respiratory failure [4, 5, 10–12, 16, 21–22]. The Fluid Administration Limited by Lung Sonography (FALLS) protocol has been used to identify circulatory collapse, using cardiac and lung ultrasonography [4]. In addition to the FALLS protocol, fluid management is essential in patient care. In the SESAME protocol, 1. Anterior lungs for pneumothorax, 2. DVT for pulmonary embolus, or 3. Abdomen for hypovolemia were evaluated.

Table 3. Comparison of POCEUS diagnosis at presentation with last clinical diagnosis during hospitalization

Diagnosis	POCEUS prediction/ The last diagnosis in hospitalization (n/n)	Kappa coefficient (95% CI), p
Systolic heart failure Depressed global cardiac contraction	16/15	0.877 (95% CI, 0.812–0.921), 1
Pulmonary edema 1) Systolic heart failure and pulmonary edema Depressed cardiac contractiliy + ≥ 3 common B-lines + IVC collapsibility of < 50%, qualitative diameter normal or dilated 2) Non-cardiac pulmonary edema Normal/hyperkinetic cardiac contractiliy + ≥ 3 common B lines + IVC collapsibility of < 50% or ≥ 50% , qualitative diameter narrow, normal or dilated	5/8	0.748 (95% CI, 0.637–0.839), 0.25
	12/10	0.893 (95% CI, 0.839–0.933), 0.50
Pulmonary thrombus Dilated right ventricle, D-shaped left ventricle, McConnell's sign, ± DVT	6/5	0.706 (95% CI, 0.569–0.805), 1
Distributive/septic/ hypovolemic shock Hyperkinetic/normal cardiac function ± small left ventricle + IVC collapsibility of > 50%	12/13	0.759 (95% CI, 0.642–0.842), 1
Tamponade or pericardial effusion Incomplete right ventricle diastole + pericardial effusion	4/5	0.786 (95% CI, 0.678–0.860), 1
Pneumonia Consolidation/local, ≥ 3 one-sided B-lines/pleural effusion	31/22	0.682 (95% CI, 0.564–0.802), 0.012
Pneumothorax No pleural sliding, no B-lines	2/2	0.486 (95% CI, 0.289–0.643), 1
Chronic lung diseases Common A-pattern Normal cardiac contractility and IVC collapsibility	7/10	0.537 (95% CI, 0.356–0.684), 0.453

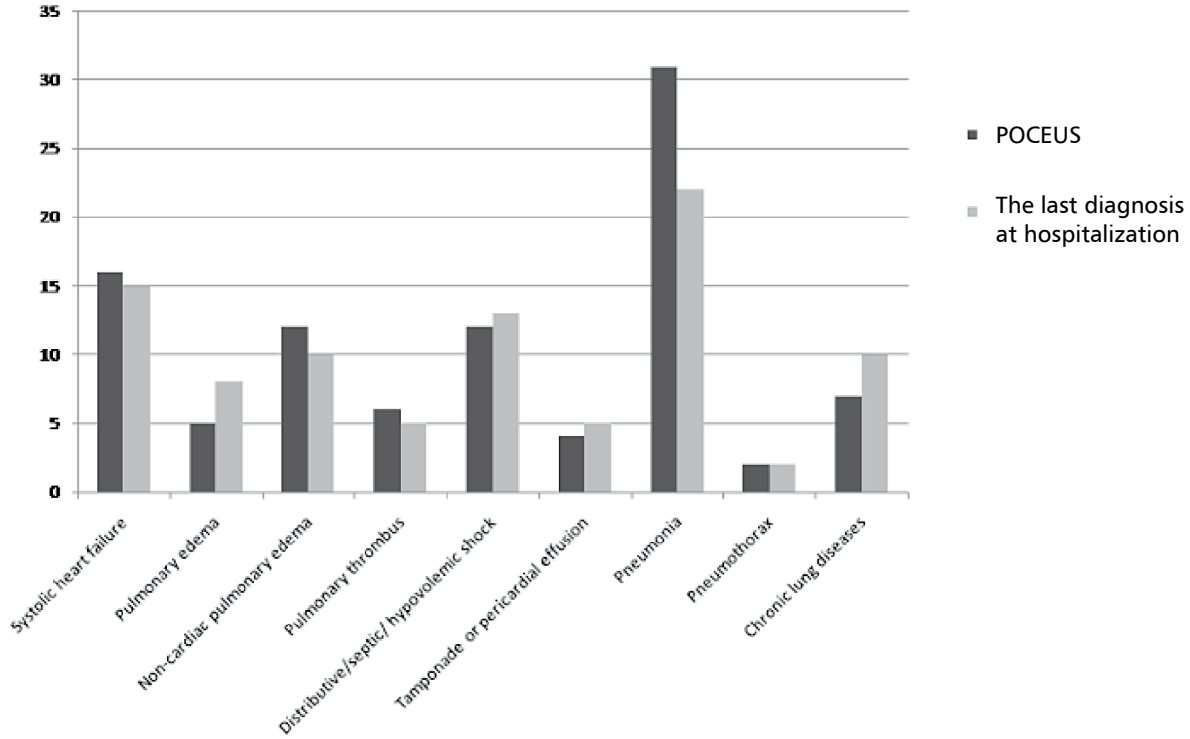


FIGURE 3. Compared the prediction of differential diagnosis by POCEUS at presentation to the last diagnosis on hospitalization on a chart

If a B-profile is present, differentiation between ARDS and a cardiac etiology is required. The cardiac view for pericard is suggested in the last step [11]. However, the cardiac view was the first step in our study in accordance with life support guidelines [22, 23].

In the study of Volpicelli et al., incorporation of a lung examination in multiorgan ultrasonographic protocol was decisive for a definite diagnosis in 24 cases (22%) in undifferentiated hypotension patients in ED. An ultrasound definite diagnosis was reached in the majority of patients, excluding only 7 patients out of 108 enrolled [5].

In another study included patients with cardiac arrest and undifferentiated hypotension, as well as cardiac contraction, valvular, pericardial, IVC, pleural, and abdominal abnormalities were identified with POCUS [21] Only for 2 patients of cardiac arrest cases were not obtained any initial specific ultrasonographic clue by POCEUS. Aortic dissection, aortic aneurysm rupture, and ileus were the other diagnoses obtained by POCEUS and were compatible with the findings in the literature [24, 26].

The BLUE protocol was created as a diagnostic protocol for critically ill patients with acute respiratory failure by Lichtenstein, finalized to diagnose all the main causes, that are, cardiogenic edema, pneumonia, pulmonary embolism, exacerbation of COPD/asthma, pneumothorax [4, 11, 12]. Another study revealed that multiple B-lines on at least two scans per side were present in patients with a diffuse interstitial syndrome called the 'B pattern' by Volpicelli. This condition was explained with relation to cardiogenic pulmonary congestion or ARDS but was also present in pulmonary fibrosis, interstitial or multiple bilateral pneumonia, and tuberculosis miliarisis [16]. In a study, the sensitivity and specificity of lung ultrasound for pneumonia were 0.985 and 0.649, respectively [27]. In the present study, 31 patients were interpreted (42.5%) as pneumonia by POCEUS; As EPs were interpreted consolidation or local B-pattern as only pneumonia for the first possibility without considering other reasons. Only 22 (71%) of these had a diagnosis of pneumonia in the patients' final clinical records at hospitalization. However, not all patients had undergone computed tomography for confirmation or exclusion. In another one detected pulmonary consolidation by lung ultrasonography in 30 patients, 18 patients also showed air bronchograms [5], while it was not studied in our cases.

Six patients were interpreted as pulmonary embolism, however, five were confirmed to have pulmonary embolism based on pulmonary angiography computed tomography (PACT). One of 5 patients had an uncompressible main femoral vein with a thrombus image. The misdiagnosed one had interstitial lung disease, reported on PACT.

As another POCEUS algorithm indicator, the IVC is used to estimate the patient's volume status and preload by only the qualitative estimation of collapsibility because of the limited time. In patients with pericardial tamponade, massive pulmonary embolus, and cardiac failure, the IVC collapsibility decreases and the expiration diameter increases along with an increased preload pressure and duration without intubation [16]. On the other hand, pulmonary embolism (PE) with a pulmonary A pattern and without IVC congestion has been reported [5].

In our study, 2 cases were unexplained in non-arrest group, they were finalized as acute renal failure and diastolic failure.

Limitations were that the diameter of IVC was not measured. Qualitative manner needs to be proven in further studies for reliability. The diameter of right ventricle on suspected of dilatation was not measured. The abdominal aorta was not measured. There was not a plan to identify bronchograms. There were no video recordings studied in all along with the patient management. There was only one performer in each center participated voluntarily in this study.

Near-arrest was a clinical situation intuitive decided with inspection foresight of the patient by physician.

Three or more B-lines in two zones of each lung with normal cardiac contraction could be present in both pulmonary edema caused in diastolic failure and other etiologies besides ARDS. Diastolic failure parameters were not studied.

CONCLUSION

POCEUS is an applicable method performed in ED. The first interpretation of findings at presentation had a relation within the last diagnosis obtained during hospitalization. Development of evidence-based algorithms including unexplained cases would enlighten and contribute in the first emergency differential diagnosis and ensure the survival of patients.

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Statement of competing interests

There are no competing interests including financial or others that may have affected the research or the conclusions drawn from the study.

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RETROSPECTIVE ANALYSIS OF THORACIC TRAUMA AND EVALUATION OF THE FACTORS AFFECTING THE DURATION OF STAY IN THE HOSPITAL

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ABSTRACT

INTRODUCTION: The aim of this study is to evaluate the epidemiological and demographic features, treatment types of patients with thoracic trauma, as well as the duration of hospital stay and the factors affecting mortality.

MATERIAL AND METHODS: This retrospective cross-sectional study included patients who applied to the emergency room in a tertiary care hospital, between 2017–2019 and having thoracic trauma. Patients; age, gender, date of application, type of injury (blunt or penetran), arrival saturation, use of anticoagulants, type of injury, side of injury (right, left, bilateral) additional injury, hospitalization and mortality status were recorded. $P < 0.05$ was considered as statistically significant.

RESULTS: Total of 113 people were included in the study. The average age was 52.15 ± 20.3. The most common reason of applying to the hospital was falling with 50 patients. A negative weak correlation was found between saturation and age and hospital stay. In terms of pathology and gender, there was no statistically significant difference in mortality.

CONCLUSION: As a result, in this study, thoracic trauma occurs mostly in men and due to falls and motor vehicle accidents, and the majority of injuries due to thoracic trauma can heal without follow- up or tube thoracostomy.

KEY WORDS: thoracic trauma, duration of hospital stay, mortality

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INTRODUCTION

Trauma has been and continues to be an important health problem both in Turkey and in the world. 10–15% of the patients exposed to trauma have life-threatening injuries [1]. And the thorax traumas are the most often ones after abdominal and head traumas. They are indicated as the reason for death [2, 3]. In both blunt and penetran thoracic injuries, serious injuries can be observed such as rib fracture, pneumothorax, hemothorax, contusion, tracheal or bronchial injuries, major artery injuries and air embolism [3]. Blunt thorax

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traumas generally occur together with other system injuries.

There is no consensus in the approach to thorax trauma in the clinic of trauma patients, due to differences in mortality and morbidity rates in a wide range of studies, which may vary depending on the occurrence of the event, and isolated thoracic trauma, especially in blunt trauma patients.

The aim of this study is to evaluate the epidemiological and demographic features, treatment types of patients with thoracic trauma, as well as the duration of hospital stay and the factors affecting mortality.

MATERIAL AND METHODS

This retrospective cross-sectional study included patients who applied to the emergency room in Ataturk Education and Research Hospital, a third level public hospital between the dates of 2017 and 2019 and having thoracic trauma.

Prior to the study, the Ankara City Hospital ethics committee approved the study (with a number of E1-20-363 and a date of 27.02.2020). The data were obtained by scanning the hospital data system and patient files after obtaining permission from the hospital management.

Patients who were admitted to the emergency department with thoracic trauma or multi- trauma between the dates of 01.01.2017–01.01.2019 were included in the study. Patients with ongoing forensic investigations, with missing data in the file, referred to another center, or leaving the hospital refusing treatment, who had been ex following the resuscitation in the emergency service, and absolute fatal trauma were excluded from the study. A total of 113 patients were included in the study since of 146 patients who met the criteria, 14 were under on-going forensic investigations, 7 were ex in the emergency room and 12 were sent to another center or they went to their request and were excluded from the study. Patient's age, gender, date of application, type of injury (blunt or penetran), arrival saturation, use of anticoagulants, type of injury, side of injury (right, left, bilateral) additional injury, hospitalization and mortality status were recorded.

STATISTICAL ANALYSIS

Data were evaluated using Statistical Package for the Social Sciences 23.0 (SPSS), IBM, USA. Data are presented in mean ± Standard Deviation (SD) or n (%), where appropriate. Comparison of the categorical data between groups was used chi-square test. Analysis of variance (ANOVA) was used for comparing normally distributed continuous data of more than two groups. Correlations between continuous variables were tested using Spearman's rho. $P < 0.05$ was considered as statistically significant.

RESULTS

Total of 113 people were included in the study. The average age was 52.15 ± 20.3. 29 (25.7%) of the patients included in the study were women and 84 (74.3%) of them were men. The most common reason of applying to the hospital was falling with 50 patients. It was followed by motor vehicles accidents (n = 47). 4 patients applied to the hospital due to pounding; 1 patient applied due to firearm injuries and 11 patients applied to the hospital sue to various reasons such as occupational accidents, being kicked by an animal.

55 (48.7%) patients had the injuries on the left side, while 45 (39.8%) had it on the left and 6 (5.3%) had bilaterally. Pathologically, 15 (13.3%) patients had hemothorax, 17 (15.0%) had pneumothorax, 7 (6.2%) haemopneumothorax, 79 (69.9%) rib fracture and 22 (19.5%) contusion. Injury-wise, 105 (92.9%) were impacted by obtuse injury, 4 (3.5%) penetran injury, 4 (3.5%) had a spontaneous pneumothorax. There was anticoagulant use in 23 patients (20.4%).

While 51 of the patients (45.1%) are monitored without a procedure, 62 (54.9%) of the patients received the surgical procedure. Oxygen saturations of the patients monitored without procedure were statistically significantly higher than those of patients who underwent surgery ($p = 0.007$). There was no statistically significant difference between the groups in terms of age ($p = 0.115$) (Tab. 1).

When the duration of hospital stay was analyzed, there were 100 patients hospitalized. 72 of them were male and 28 were female. Duration of hospital stay ranged from 1–15 days.

While there was no gender difference in terms of hospitalization, there was a statistically significant difference between the groups according to the existing pathology ($p < 0.001$) (Tab. 2). When the correlation of the duration of the hospital stay with age and oxygen saturation was analyzed, a negative weak correlation was found between saturation

Table 1. Effect of age and oxygen saturation level on hospital stay

		Age	SO2	Stay	
Age	Pearson Correlation	1	-0.210*	0.180	
Stay	Sig. (2-tailed)		0.028	0.073	-0.366**1–-0.21 0*Pearson CorrelationSO2100110113N
	Sig. (2-tailed)	0.028		0.000	
	N	110	110	100	
	Pearson Correlation	0.180	-0.366**	1	100100100N.000.073Sig. (2-tailed)

*Correlation is significant at the 0.05 level (2-tailed). **Correlation is significant at the 0.01 level (2-tailed)

Table 2. Duration of the stay in hospital by the existing thorax pathology

Pathology	Min-max (day)	Mean ± SD
Pneumothorax	1–9	4.63 ± 2.11
Hemothorax	2–10	5 ± 2.569
Hemopneumotorax	3–9	5.28 ± 2.058
Contusion	1–15	3.47 ± 3.059
Other pathologies (Costa fracture etc.)	0–8	2.22 ± 1.776

SD — Standard Deviation

Table 3. Comparison of pathology groups by the length of hospital stay

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	137.918	4	34.479	6.856	0.000
Within Groups	477.792	95	5.029		
Total	615.710	99			

and age and hospital stay ($r = -0.210$, $p = 0.028$; $r = -0.366$, $p < 0.001$ respectively) (Tab. 3).

Considering the prognosis of the patients, 6 (5.3%) died. One of the patients was female and there was no statistically significant difference in mortality in terms of gender ($p = 0.515$). Regarding the existing pathologies of patients who died, hemopneumothorax was found in 1 patient and pneumothorax in 3 patients. In terms of pathology, there was no statistically significant difference in mortality ($p = 0.133$). There was anticoagulant use in only 1 of the patients who died, which was statistically insignificant ($p = 0.646$).

DISCUSSION

In this study, in which thorax traumas were included, the most common reason for hospital application was fall and motor vehicle accidents which is consistent with the literature. Blunt thoracic traumas generally occur due to motor vehicle accidents, falls, pounding and accidents caused by animals [4]. Both blunt and penetrant thoracic traumas are more common in the male gender in the literature, as the reason for this is shown to be the number of men working in dangerous jobs as well as the excess of male sex in traffic [5, 6]. In this study, 74.3% of the patients were male, consistent with the literature.

Rib fracture is seen in 35–50% of the patients exposed to thoracic trauma [7–9]. Isolated rib fractures should be followed conservatively [10]. At this stage, atelectasis is the major component of pain control to prevent blood gas abnormalities and hypoventilation-related pneumonia [9]. In addition, it should be kept in mind that additional complications such as contusion, pneumothorax or hemothorax may develop if the patient becomes worse during monitoring, and the patient should be evaluated again [11]. In this study, the rate of rib fracture is high (69.9%) compared to the literature. However, in a study by Segen et al, rib fracture was reported to be 71%, which is consistent with this study [12]. This may be due to the inclusion of not only the patients with rib fractures but also with additional complications to rib fracture such as hemothorax and pneumothorax.

The fractures in the sternum and the first 3 clavicles should be stimulating due to high-energy trauma. 8% of all blunt thoracic traumas are seen in the sternum fracture, and sternum fractures are managed conservatively with pain control, such as elevation fractures [13]. Rarely, surgery may be considered in the presence of lung herniation, anterior chest wall defect, or non-boiling sternum for more than 6 weeks [14]. The clinician should be in alert in the presence of a sternum fracture is whether there is a cardiac injury. Because the cardiac injury is reported in 18–64% of sternum fractures [15]. EKG and troponin should be followed. Patients who do not have any sign of cardiac injury can be monitored in the service

and no intensive care monitoring is required. In this study, 5 patients (4.3%) had sternum fractures, and all patients were monitored with analgesics and no surgical treatment was performed. However, no heart injury was found in any patient in this study.

Similarly, scapula fractures are indicative of high energy trauma. In a study by Thompson et al., scapula fractures were reported to be observed together with 53.6% rib fracture, 53.6% pulmonary contusion, 26.8% clavicle fracture, 12.5% brachial plexus injury and 10.7% subclavian, brachial or axillary artery injuries [16]. In this study, 2 patients had scapula fracture and thoracotomy was performed in both patients. There was no major vascular injury in this study. In some other studies conducted in Turkey, no major vascular injuries were reported [17, 18]. This may be due to the absolute mortality of major vascular injuries due to thoracic trauma and the loss of life at the scene before coming to the emergency room.

Pneumothorax, hemothorax and hemopneumothorax are among the most common injuries in thorax trauma [5, 6]. In Turkey, the incidence of pneumothorax is reported as %25, hemopneumothorax as %16–20 and haemothorax as approximately %20 [19]. In 2007, Altunkaya et. al. reported the rate of pneumothorax as 33%. In this study, the rate of pneumothorax was 15%, hemothorax 13.3% and hemopneumothorax 6.2%. These rates, which are lower than the literature, may be due to the exclusion of the patients with absolute fatal additional system injuries, patients who died either in the emergency service or at the scene, where thoracic trauma was not at the forefront.

These rates, which are lower than the literature, may be due to the inclusion of patients with an absolute fatal additional system injury, in which the thoracic trauma was not in the foreground, who died in the emergency service or on the scene. The rate of lung contusion seen in almost 1/3 of trauma patients has been reported in a wide range of 11 to 30% in different sources, and lung contusion is known to have a major impact on mortality [4–6, 20]. In this study, this rate was found to be 19.5% in accordance with the literature. Many cases with thoracic trauma can be treated without requiring surgical treatment. The rate of injury requiring thoracotomy in thoracic trauma has been reported between 3–14% [5, 21, 22]. In this study, the number of patients who underwent thoracotomy was 2. This rate is quite low compared to the literature. The proportion of patients who were applied tube was 45%. Tube thoracostomy rate appears to be higher than 29% reported in the literature [23].

Like the morbidity of patients with thorax trauma, the length of hospital stay can vary in a wide range. No publication was found in the literature regarding the length of hospital stay. There are many factors that affect the length of hospital stay, especially in patients with additional injury. Besides the patients factors, many factors such as injury type, complication, intensive care or being treated in the service may affect this period. In this study, a negative weak relationship was found with age and oxygen saturation. In other words, as the oxygen saturation decreases, the length of hospital stay increases. This means that the patient with more severe thoracic trauma stays longer, which is not unreasonable. But it does not seem possible to say the same thing for age. As a result of the age of hospitalization decreases with increasing age, elderly patients should not mean as if they recover more quickly. This situation may not be interpreted correctly due to the limited number of patients, and the earlier death of older patients may have caused a shorter hospital stay.

In this study, the mortality rate was 5.3%. This rate has been reported in the literature as between 9% and 20% [24]. The low mortality rate, which is the result of this study, may be due to inclusion criteria. Already, high mortality conditions such as major vascular injury in thoracic trauma are lost at the scene in the first minutes. Since the patients with absolute fatal trauma outside the thorax and those who died in the emergency service were also excluded from the study, the mortality among the remaining patients may have been low compared to the literature. The hypothesis of this study that 'the use of anticoagulants may increase mortality by making it difficult to stop bleeding or stop spontaneously' is not supported by this study results. This situation may vary depending on the patients International Normalized Ratio (INR) value at the time. In addition, the fact that only one patient uses anticoagulant drugs among the patients who died makes it difficult to say whether there is a relationship between mortality or not.

CONCLUSION

As a result, in this study, thoracic trauma occurs mostly in men and due to falls and motor vehicle accidents

and the majority of injuries due to thoracic trauma can heal without follow-up or tube thoracostomy.

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LEGAL AND ORGANIZATIONAL ASPECTS OF ORGAN DONATION AFTER IRREVERSIBLE CARDIAC ARREST

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ABSTRACT

Sudden cardiac arrest is a challenge for medical personnel. Donation after circulatory death (DCD) has opened new perspectives and could be a valuable option to expand the brain-dead donors. The purpose of this review is to provide an overview of current legal and organizational aspects of organ donation after irreversible cardiac arrest. The article presents basic issues related to the epidemiology of sudden cardiac arrest, criteria for the diagnosis of irreversible cardiac arrest. It also discusses special situations related to cardiac arrest and determining irreversible cardiac arrest in practice. Much attention has been paid to donor organ transplantation after irreversible cardiac arrest in the context of scientific research. This article aimed to present the Polish statutory and administrative regulations concerning donation after circulatory death. Following the 2010 Minister of Health's Notice on Criteria and Methods of Determining Irreversible Cardiac arrest, it should be stated that it legally allows for all types of donation included in the Mastricht classification.

KEY WORDS: irreversible cardiac arrest, transplantation, organ conditioning, legal act, cardiopulmonary resuscitation

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In Poland, the organ donation after cardiac arrest became legally permitted with the introduction in 2009 of a provision in the Act on Donation, Storage and Transplantation of Cells, Tissues and Organs (hereinafter: 'Transplantation Act') [1]. Over the years, legislative provisions on transplantology have developed further [2, 3].

According to the main rule of transplantology, the 'dead donor rule', it is unacceptable to donate vital organs for life before the natural death of the donor [5]. Therefore, most of the organs taken for transplantation come from the deceased [6]. In the United States, as in other countries, most organs transplanted are procured after determination of death by neurological criteria (BDD, brain dead donors) or planned withdrawal of life-sustaining therapy and donation after circulatory determination of death (DCD).

In the context of the DCD which is the subject of this article, there are two types of donation — controlled (cDCD) and uncontrolled (uDCD) DCD. The first category may include unexpected casualties and sudden cardiac arrest (SCA), and cardiopulmonary resuscitation (CPR) has been ineffective. The controlled donation, on the other hand, refers to the removal of organs from patients who have suffered cardiac arrest as a result of the planned withdrawal of life-support therapy. In addition to the general classification above, several more detailed distinctions can be made. Another example of the division

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Table 1. The Modified Maastricht Classification of Donation after Circulatory Death

Type of cardiac arrest	Donor category	Place of event	Definition
Uncontrolled cardiac arrest	Type I	Unwitnessed cardiac arrest: IA — out of hospital IB — in hospital	Sudden, unexpected cardiac arrest without attempted resuscitation by the medical team
	Type II	Witnessed cardiac arrest: IIA — out of hospital IIB — in hospital	Sudden, unexpected and irreversible cardiac arrest, with ineffective resuscitation by the medical team
Controlled cardiac arrest	Type III	Expecting a cardiac arrest	Planned expected cardiac arrest after disconnection from the respirator
	Type IV	Cardiac arrest in a donor with brain death. Controlled or uncontrolled	Sudden or expected cardiac arrest during diagnosis or after brain death

of DCD is based on the classification of donors after cardiac arrest, established at the Maastricht conference in 1995, which adopted the term 'Donation after Circulatory Death'. This term was originally intended to cover the term Non-Heart-Beating Donor (NHBD) which was used previously in Europe. In turn, in Paris in 2013, there was the 6th International Conference on Organ Donation after Circulatory Death, which clarified the Maastricht classification and definitions in the field of deceased organ donation particularly to DCD [7]. The categorisation of donors was adopted in 2013 (Tab. 1).

EPIDEMIOLOGY OF SUDDEN CARDIAC ARREST

Out-of-hospital cardiac arrest (OHCA) is worldwide quite a common disease and in Europe, about 350.000 persons are affected [8]. The World Health Organization (WHO) indicated that death from cardiovascular and respiratory diseases accounts for more than 20 million deaths [9].

In the United States, over 100.000 patients annually survive to hospital care after resuscitation from in- or out-of-hospital cardiac arrest, of which approximately 65% do not survive to discharge. Elmer et al. [10] indicated that each year approximately 167.000 OHCA patients are treated by the emergency medical services in the USA. Of these, 41.750 (25%) are successfully resuscitated and admitted to an Intensive Care Unit.

CRITERIA FOR THE DIAGNOSIS OF IRREVERSIBLE CARDIAC ARREST

The criteria for establishing irreversible cardiac arrest were included in the Minister of Health's notice of 9 August 2010 [11], published based on the Act of 1 July 2005 on Donation, Storage and Transplantation of Cells, Tissues and Organs [12]. The present Notice contains indications on how irreversible cardiac arrest, including for organ transplantation, should be found.

While Article 9a, paragraph 3 of the Act on Collection, Storage and Transplantation of Cells, Tissues and Organs, which constitutes the basis for issuing the notice in question, was repealed as of 27 April 2017 by the Act of 24 February 2017 on amending the Act on the Professions of a Physician and a Dentist and the Act on the Collection, Storage and Transplantation of Cells, Tissues and Organs (Journal of Laws, item 767), under which the legal basis for issuing the notice in this matter was added in Article 43a(3)(2) of the Act on the Professions of a Physician and a Dentist; however, to this day the notice in question is a valid act. According to Article 3 of the Act of 2017, until the manner and criteria for establishing irreversible cardiac arrest before the donation of organs based on the Act on Professions of a Physician and a Dentist are announced, the criteria and manner announced under Article 9a(3) of the Act on Collection, Storage and Transplantation of Cells, Tissues and Organs apply. To date, the Minister of Health has not issued a new notice on this matter.

According to the above notice, irreversible cardiac arrest can be diagnosed concerning different clinical situations. The first of them is when during advanced CPR procedures, carried out according to the current knowledge and thus guidelines for cardiopulmonary resuscitation, asystole or pulseless electrical activity was observed for at least the last 20 minutes. Due to physiological differences in paediatric patients, the time should be longer and at least 45 minutes in children under two

years. According to the guidelines for cardiopulmonary resuscitation, the patient's vital functions should be assessed every two minutes, which in the case of medical personnel comes down to the assessment of electrocardiographic rhythm and pulse presence on large arteries, including the carotid or femoral artery. According to the law, during the above-mentioned period of at least 20 minutes in the case of older children and adults and over 45 minutes in the case of children under two years, no pulse should be felt during the palpation test. At this point, it should be mentioned that the legislator had in mind the occurrence of a spontaneous pulse, which cannot be confused with a pulse wave caused by chest compressions during CPR procedures; hence, the pulse is assessed in the absence of chest compressions.

The second situation refers to asystole or PEA in the absence of a spontaneous pulse in the carotid or femoral arteries persisting continuously for at least 5 minutes after the end of ineffective cardiopulmonary resuscitation performed following the current guidelines for cardiopulmonary resuscitation.

If during the periods referred to in the preceding paragraphs, ventricular fibrillation or ventricular tachycardia or the return of a palpable spontaneous pulse on the carotid or femoral arteries occurs, the period of cardiopulmonary resuscitation and the subsequent observation of asystole or PEA is counted again from the beginning. During the described situation the stem reflexes are also assessed. The following are assessed: pupil response to light, corneal reflexes, vestibulo-ocular reflexes, any motor response to a pain stimulus applied to cranial nerve innervation, as well as a motor response in the face to pain stimuli applied to the spinal nerve area. Respiratory function is also assessed. The above procedures have been described in detail in the Minister of Health's notice of 4 December 2019 [13]. Besides, where an absence of stem reflexes cannot be established, the irreversible cardiac arrest shall be established based on the conditions described in the first situation [11]. Thanks to the development of medical technologies over the last decades and the increasing availability of modern devices in both pre-hospital and in-hospital settings, there are techniques for determining the quality of resuscitation [14, 15] and the return of spontaneous circulation [16]. Current guidelines for cardiopulmonary resuscitation published by the European Resuscitation Council [17, 18] and the American Heart Association [19, 20] recommend that capnography should be used during CPR as a method to assess the correctness of airway management and ventilation. However, capnography — provided that the patient is properly ventilated — thanks to its sensitivity allows for rapid detection of the return of spontaneous circulation which is reflected by a rapid rise in the capnographic curve to values close to physiological ones [16, 21].

The third situation of irreversible cardiac arrest refers to the situation when sudden cardiac arrest occurs and the attending physician determines that according to current medical knowledge cardiopulmonary resuscitation will not result in survival. Then the five-minute countdown mentioned in the previous paragraph can be started, or chest compressions and ventilation can be started for organizational preparation for vascular catheterization and organ perfusion, and after the end of chest compressions and ventilation, the five-minute countdown can be started. The second option is more desirable from a medical point of view, as it allows minimal maintenance of organ perfusion and the exchange of metabolites, which improves the condition of the organs intended for potential transplantation. Besides, it is in line with Article 34 of the Code of Medical Ethics which states that: 'The physician, on the discovery of brain death, should maintain the functioning of cells, tissues and organs if they are to be transplanted' [22].

SPECIAL SITUATIONS

As in all recommendations related to the medical procedure, we can also list special situations — this is also the case here. The Minister of Health's notice lists four special situations in which the process of establishing irreversible cardiac arrest is systematized.

The first special situation indicated in the Notice is when we have to deal with a patient in hypothermia. In this case, the central body temperature of the patient should be brought to 35° C, while providing cardiopulmonary resuscitation, and only then does the period of ineffective cardiopulmonary resuscitation count from this point on [23]. Of the recommended temperature test sites, the most accurate measurements are obtained on the eardrum or in the oesophagus.

In the case of patients with cardiac arrest, the time required to establish an irreversible arrest may

be extended for organisational arrangements for vascular catheterization and organ perfusion, and at its completion, the observation referred to in the third paragraph of the second chapter may begin.

Another situation described refers to cardiac arrest, which occurred when brain death was diagnosed: however, before the necessary instrumental and clinical examinations were performed. In such cases, cardiopulmonary resuscitation should be undertaken and, if circulation is restored, the brain death recognition procedure should be restarted. If cardiopulmonary resuscitation is ineffective, it should be performed as in the case of diagnosing irreversible cardiac arrest. On the other hand, if cardiac arrest occurred after an instrumental test confirming brain death is performed, the procedure provided in Part II of the Minister of Health Health's Notice of 4 December 2019 on the method and criteria for determining irreversible brain death should be initiated.

DETERMINING IRREVERSIBLE CARDIAC ARREST IN PRACTICE

To establish an irreversible cardiac arrest, the physician should use the above-described recommendations included in the Ministerial Notice [11]. According to this Notice, a physician establishing irreversible cardiac arrest for organ donation is obliged to consult two physicians selected from among specialists in the following fields of medicine: anaesthesiology and intensive care, emergency medicine, cardiology, paediatric cardiology or internal diseases. The opinion is based on the signature of the protocol of irreversible cardiac arrest. (Suppl. 1). In a situation where a physician establishing irreversible cardiac arrest has a specialization in the medical fields listed above, he or she can use only one opinion from another specialist in the above-mentioned fields of medicine. The above provisions apply to in-hospital settings; however, in the case of actions taken by ambulances, the only possible solution is the use of mechanical chest compression systems, which enable high-quality chest compressions to be performed during patient transport to the hospital. The next step is to connect the patient to ExtraCorporeal Membrane Oxygenation (ECMO). ECMO is an extracorporeal system containing a pump and an oxygenator that allows the lungs and/or heart to be replaced for some time by extracorporeal oxygenation of the blood and elimination of carbon dioxide. Such actions increase the chance that the organ will be suitable for transplantation and that it will function properly [24, 25].

DONOR ORGAN TRANSPLANTATION AFTER IRREVERSIBLE CARDIAC ARREST IN THE CONTEXT OF SCIENTIFIC RESEARCH

Approximately 120.000 organ transplants are performed each year; therefore, the WHO estimates that this number of transplants only resolves 10% of the annual worldwide transplant need [9]. As shown in the previous sections of the article on the epidemiology of cardiac arrest, according to WHO 20 million deaths caused by cardiovascular and respiratory diseases theoretically could be used for DCD.

Many organ types such as kidney, liver, pancreas, lung and, recently, heart donation are eligible for controlled DCD, although this varies by country [26]. In the uncontrolled DCD (uDCD), kidneys, livers and lungs have successfully been transplanted; an example of such actions can be the 'ECMO for Wielkopolska' programme introduced in Wielkopolska (Poland) under which the first uDCD transplants have already been performed [27, 28]. In the world, DCD is becoming increasingly important as an alternative to brain death donors. A good example is the United Kingdom, where DCD-transplanted organs accounted for 19% in 2007 and increased to 43% of all transplants in 2016 [29].

DCD can be used in the case of irreversible cardiac arrest and thus ineffective cardiopulmonary resuscitation, moreover, as already mentioned; it can be used after the cessation of futile therapy as a controlled version of DCD. In countries where it is legal, such as Belgium and in the Netherlands, DCD has been performed after euthanasia [30].

It is worth noting that Polish regulations, and in particular the regulation contained in the Act of 1 July 2005 on the Collection, Storage and Transplantation of Cells, Tissues and Organs, do not differentiate the prerequisites to be met for the collection of human cells, tissues and organs from corpses, based on the criterion of the cause of death. In particular, according to Article 4 of this Act, cells, tissue and organs may be collected from human corpses for, inter alia, therapeutic purposes after death has been established in the manner laid down in the Act on the professions of physician and dentist. However, the provisions of this Act provide for the declaration of death either in the case of permanent irreversible cessation of brain function

PROTOCOL FOR DIAGNOSIS OF IRREVERSIBLE CARDIAC ARREST

1. Name of the person diagnosed with irreversible cardiac arrest .....
2. PESEL number.....
3. Cause of irreversible cardiac arrest.....
4. Time (hour and minute) to start CPR.....
5. Time (hour and minute) from which the period during which no ventricular fibrillation or spontaneous pulse wave was found during CPR was counted .....
6. Time (hour and minute) to start the 5-minute observation period after CPR is completed .....
7. Time (hour and minute) of the end of the 5-minute observation period after the end of CPR.....
8. The period of ineffective CPR was at least 20 minutes in adults or at least 45 minutes in children under 2 years of age* .....
9. No pupil response to light was found * .....
10. No corneal reflex was found * .....
11. No vestibulo-ocular reflexes were found *.....
12. No response to painful stimuli was found * .....
13. No respiratory function was found * .....
14. At least 5-minute observation period after the end of CPR has passed * .....
15. The central body temperature exceeded 35° C* .....

The physician giving the opinion stated irreversible cardiac arrest in the manner consistent with the announcement of the Minister of Health of 9 August 2010 on the criteria and manner of stating the irreversible cardiac arrest

..... on..... at the hour.....
(physician stamp and signature)

The physician giving the opinion stated irreversible cardiac arrest in the manner consistent with the announcement of the Minister of Health of 9 August 2010 on the criteria and manner of stating the irreversible cardiac arrest

..... on..... at the hour.....
(physician stamp and signature)

Death due to irreversible cardiac arrest was confirmed by a physician confirming the irreversible cardiac arrest

..... on..... at the hour.....
(physician stamp and signature)

* Indicate: yes, no or no investigation (with reason).

SUPPLEMENT 1. Protocol for diagnosis of irreversible cardiac arrest

(brain death) or irreversible cardiac arrest preceding the removal of organs. In both cases, the removal of cells, tissues and organs is possible under the conditions specified in Chapter 2 of the 2005 Act.

SUMMARY

This article aimed to present the Polish statutory and administrative regulations concerning donation after circulatory death. Following the 2010 Minister of Health's Notice on Criteria and Methods of Determining Irreversible Cardiac arrest, it should be stated that it legally allows for all types of donation included in the Mastricht classification [10].

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Conflicts of interest

There are no conflicts of interest.

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LETTER TO THE EDITOR

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USE SIMULATION TO IMPROVE THE EFFECTIVENESS OF PPE IN COVID-19

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Medical simulation is the most dynamically developing field of medical education to prepare medical personnel to work with the patients [1]. Its main advantage is the possibility for learners to make mistakes, draw conclusions, and learn without fear about patient safety [2, 3]. Medical simulation is a tool using simulators — from simple trainers, through advanced mannequins, so-called patient simulators, and standardized patients (actors) to the virtual training centers. The simulator is a device that allows us to reproduce clinical cases in safe conditions. Learning from experience requires the use of clinical scenarios and appropriate preparation of an environment in which the staff will be obliged to practice and validate procedures [3–5].

Proper use of personal protective equipment (PPE) by health and social care workers, in the context of the current COVID-19 pandemic, is very important to stop the infection spreading process [6, 7]. On May 1, there were 3 323 935 confirmed cases with 1 051 651 recovered patients and, unfortunately, 234 471 deaths. In Poland, which has more than 38 million inhabitants confirmed 13 105 cases (+228 last day), 3 491 (+255 last day), and 651 (+7) death. Since the beginning of the Pandemic in Poland used 354 628 test (16 600 was made last 24 h) [8–10].

Use simulation to improve the effectiveness of PPE in COVID-19 we should think about a few areas, such as:

IN SITU SIMULATION

The biggest role in times of pandemic medical simulation fulfilled and continues to fulfill when creating in situ training. This type of simulation is a training that takes place in a patient care environment often using providers and staff who are currently on shift [11]. This allows achieving a high level of fidelity and realism, which is particularly important when training teams and/or individuals in a given unit. They are often used in case of emergency or so-called 'never event'. Many studies have shown that technical knowledge and skills are essential for patient care. However, non-technical skills related to crisis management, medical team leadership, patient to staff communication, and medical staff communication also have an impact on the outcome of treatment quality improvement and are improved during in situ simulation [12–14].

The European Center for Disease Prevention and Control (ECDC) guidelines themselves provide training for employees on all procedures for using PPE, with particular emphasis on its removal. Employees of health care units and medical institutions

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must demonstrate appropriate competence during training and practical exercises before they take up the care of patients. Trained observers (supervisors) should be used to monitor the proper use of PPE, including the safe donning and removal of available personal protective equipment.

Besides, observers should supervise (including issue instructions). Each stage in the use of PPE should be based on the use of checklists. In situ simulation helping to identify systems issues and latent patient safety threats [13–15]. To analyze the situation, it is helpful to record the entire process, which should include a record of all data occurring at the same time. Then it is very important to conduct a debriefing process (discussion of the event), which helps to conclude the simulation [12, 14, 15].

MODEL OF DEBRIEFING

Debriefing is a situation analysis that allows participants to reflect on their experience and give it meaning. This specially conducted session to discuss the scenario immediately after it is completed is a common tool in medical simulation because an independent experience can be unsystematic or inappropriate. It is a very important part that allows recreating and discussing it. The teacher who conducts the simulation scenario can record and later reconstruct the exercise session. There is no 'gold standard' to discuss the course of the simulation in situ. Most of the debriefing after the in situ session is done through a simplified discussion (55%) and a simplified summary with feedback combined with a review of the recorded simulation session (31%) [13]. It is also important to allow a large part of the participants to make a self-assessment, which allows more topics to be covered in a limited period [16]. The minimum time spent on debriefing is equal to the length of the scenario itself [17].

VIDEO RECORDINGS

The use of University Medical Simulation Centres around the world has allowed the recording of numerous procedures related to the insertion and take-off of PPE. This is of great importance in the process of educating a wider group of people, especially during remote education in times of social isolation. Any training that is provided is intended to assure conditions in which medical personnel can apply the latest guidelines and proceed in a rational, safe manner based on scientific reports [18]. COVID-19 personal protective equipment training courses include a combination of video instructions and interactive attitudes that allow the participant to reproduce the material repeatedly to master the techniques correctly (COVID-19 I SIM Program Trains for Proper and Efficient Use of PPE) [18]. It is important to critically address any areas of PPE use that may lead to contamination and disruption of security levels during the training.

RESEARCH ON THE USE OF SIMULATION IN WORKING WITH PPE IN OTHER DISEASES

Infectious diseases with a high risk of mortality require special training to master the required competence and to prevent the transmission of infection. It is not clear which type of equipment best protects in a given situation and which equipment should be removed as safely as possible after use. It is also unclear what is the best way to train workers to follow the guidelines for this equipment. In the context of COVID-19, previous experience with PPE such as Ebola or SARS can be supported [19, 20]. Most studies have shown the effectiveness of training based on simulation. Studies are showing that active training in the use of personal protective equipment reduces non-compliance with procedures during insertion and removal of more than passive training.

In conclusion, it should be noted that using simulation in situ to improve the effectiveness of PPE in COVID-19 can improve teamwork and the work of individual team members. During the PPE training, we can freely verify the activities undertaken by each individual. This allows us to draw conclusions and improve the attitude of a particular person. The basis for a successful simulation is to discuss the quality of the activities undertaken.

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INTERFERON LAMBDA WITH REMDESIVIR AS A POTENTIAL TREATMENT OPTION IN COVID-19

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KEY WORDS: remdesivir, interferon lambda, COVID-19, SARS-CoV-2, treatment

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Dear Editor,

we read the article by Grein et al. [1] published in New England Journal of Medicine with interest. The new SARS-like coronavirus (now named SARS-CoV-2) that emerged in December 2019 has been shown to be closest related (~88%) to two bat-derived SARS-like CoVs (bat-SL-CoVZC45 and bat-SL-CoVZXC21), with ~79% overall sequence identity to SARS-CoV and ~50% to MERS-CoV [2]. Remdesivir is well known in antiviral treatment of coronaviruses (SARS, MERS) [3], hence its consideration for SARS-CoV-2 therapy. However, we must remember that the coronavirus induces the endogenous expression of IFN-λ and/or blocks IFN-λ, affecting inflammatory responses and mechanisms of tissue damage and repair. The main function of IFN-λ is to prevent viral infection by establishing an antiviral state and, if infected, to slow down viral replication and dissemination. IFN-λ acted as a unique immunomodulatory agent by modifying transcriptional and non-translational neutrophil responses, which might permit a controlled development of the inflammatory process [4]. In vitro, treatment with IFN-λ showed potency against a variety of viruses, including SARS-CoV-1 and MERS-CoV [5], and currently pegylated IFN-λ1 (peg-IFN-λ1) is the only IFN-λ currently available as a therapeutic agent.

In summary, to increase the therapeutic effect, it is therefore worth considering combined treatment of COVID-19 patients by using interferon lambda with Remdesivir.

Conflict of interest

The authors declare no conflict of interest.

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