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# Knowledge and skills toward capnometry and capnography among Emergency Medical Service providers

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## Abstract

Capnometry is an increasingly used element of patient monitoring in emergency medicine, also in pre-hospital area. The increasing availability of compact devices for measuring the end-expiratory concentration of carbon dioxide ($EtCO_2$) offers great opportunities to improve the quality of treatments, as well as giving rescuers feedback on the effectiveness of life-saving procedures. However, the capnometer is just another device and without the proper substantive preparation of the person who uses it, its usefulness will be negligible.

Aim of this study, is to assess paramedics knowledge about capnometry and capnography.

The study group consisted of 102 paramedics who are actively working in ambulance service, aged 30.5 ± 5.7 years including 7% of women and 93% of men. Results were collected with the author's questionnaire.

Most of participants (91%) confirmed that in their ambulance was available device to measure end-expiratory carbon dioxide ($EtCO_2$). The most commonly available device was capnometry (72%), followed by the capnography (19%). Moreover, the analysis shows that the rescuers who declared participation in the training of monitoring and analysis end-expiratory value of carbon dioxide concentration in the last 12 months obtained significantly higher correct answers than the staff who did not have such training (6.5 ± 2.0 vs. 5.4 ± 1.7). However, only 35% of participants took part in such training in last year.

**S**tudy shown a lack of knowledge and experience in use of devices to measure end-expiratory carbon dioxide concentration ($EtCO_2$) by Emergency Medical Service providers.

**Key words:** resuscitation, paramedic, capnography, capnometry,

## Introduction

Monitoring basic vital parameters is one of the most important elements in care of patient in critical condition and it is regarding to pre-hospital such as hospital conditions. Characteristics of rescue operations in pre-hospital medicine is associated with need to use methods that in short time will give medical staff reliable and credible information about patient clinical condition.

Apart from monitoring of basic vital parameters like for example: peripheral oxygen saturation ($SpO_2$), non-invasive blood pressure monitoring (NiBP), electrocardiography monitoring (ECG), Emergency Medical Service (EMS) providers at the accident scene more often has a possibility of non-invasive monitoring of end-expiratory carbon dioxide concentration ($EtCO_2$). Thanks to capnometry and capnography apart from access into vital important physiological processes of the patient's body, medical staff in real time gets feedback about effectiveness and correctness of their medical procedures [1]. With reference to the above, it seems important that in the age of huge medical technology development, every Emergency Medical Service provider could effectively use capnography or capnometry and could react to changing parameters of end-expiratory carbon dioxide concentration in a situation of patient in life-threatening condition.

Global organizations such as the European Resuscitation Council (ERC) and the American Heart Association (AHA) in their latest guidelines for the management of patients in a state of sudden cardiac arrest (SCA) emphasize the importance of using equipment that allows continuous monitoring the end-expiratory carbon dioxide concentration (EtCO2) [2-4]. This is due to the fact that thanks to the capnography curve it is possible to: monitor the quality of chest compressions, continuously control the frequency of ventilation and avoid hyperventilation, confirm correct position of intubation tube, recognize the return of spontaneous circulation of the patient during resuscitation (ROSC) [2,4]. Thanks to so much information that a EMS provider can get from such an easy to use device, it is reasonable for medical personnel to quickly and accurately read the parameters, analyze them and respond effectively by improving their activities.

## Purpose of work

Aim of this study, is to assess Emergency Medical Service providers knowledge about capnometry and capnography.

## Material and methods

Examined group constituted of 102 Emergency Medical Service (EMS) providers in Poland. The examination was conducted at using the author's, anonymous questionnaire form. The questionnaire consisted of 21 questions, which main purpose was to check the current medical staff knowledge level of capnometry and capnography. The first section contained some questions concerning demographic data: gender, age, level of medical education, type of the ambulance, in which EMS provider usually performs medical rescue activities as well as whether is serving it as the team manager, what work experience he has. The next section of the survey form concerned specialist medical knowledge, which included: knowledge of correct $EtCO_2$ values, acquaintance of differences between capnometry and capnography, ability of analyze capnography curves charts.

The questionnaire was distributed mainly through social media, as the electronic template Google Docs (www.docs.google.com). The examination was led by 2 months since

January to February 2018. The written invitation described the goals and aims of the study and assured the EMS providers that all data was confidential and collected anonymously. Due to voluntary participation in this study, formal written consent was waived. The possibility of sending the questionnaire was connected with a need to answer all asked questions. Data from the questionnaires was collected in Microsoft Excel. We used simple descriptive statistics to report participants demographics and clinical experience in using of capnometry and capnography. All analyses were performed using Statistica 13.1 EN statistics software (StatSoft, Tulsa, OK, USA).

**Results**

102 Emergency Medical Service providers completed the survey (95 [93.2%] male and 7 [6.9%] female). The median age of participants was 29 [IQR: 26-34] years while median experience in EMS was 5 [IQR: 2-10] years. Considering the education of study participants, it can be seen that majority of them (82%) completed 3-year high school education, while only 18% completed the 2-year post-secondary school.

Most of paramedics (82%) participating in survey declare that they perform their medical activities on board of ambulance with "P" standard, which in Polish Emergency Medicine System means that it is without physician. Only 18% of them work on board an "S" type ambulance – with an emergency medicine doctor.

What is more, 93 participants of the study (91%) confirmed that in their ambulance was available device to measure end-expiratory carbon dioxide concentration ($EtCO_2$). The most commonly available device was capnometry in 72%, followed by the capnography in 19%.

Question regarding the frequency of $EtCO_2$ device use in situation of patient in a critical condition shows that paramedics declare their frequent use. Research shows that more than half of them use capnometry or capnography either always or very often in such a situation. What's more, only 35% of them took part in training or course on this subject in the last 12 months. 93 participants declared that devices to measure end-expiratory carbon dioxide concentration ($EtCO_2$) are very necessary. However, about 8% of paramedics believe that these devices are only gadgets that are unnecessary and unusefull in pre-hospital emergency medicine.

In the second part of the questionnaire, which concerned specialist medical knowledge in the field of $EtCO_2$ value analysis and capnography chart curve assessment for providing the correct answer, each medical rescuer had one point. Therefore, the maximum result of correct answers was 9 points.

Question about use of $EtCO_2$ measurement to assess the quality of advanced resuscitation procedures in a patient in cardiac arrest turned out to be the easiest one. 96% of participants declared that it is a good tool to assess the quality of resuscitation. However, as one of the following questions unfortunately shows, only 36% of respondents can correctly determine the $EtCO_2$ values, which will be indicative of the high quality of the patient's chest compressions. In addition, it is worth noting that only half of the study participants correctly analyzed the graph illustrating the dynamic increase in end-expiratory concentration of the carbon dioxide in the patient during resuscitation as a probable state of return of spontaneous circulation.

**Table 1.** All questions about specialist medical knowledge about end-expiratory concentration of carbon dioxide ($EtCO_2$).

| | Question | Correct answer | Correct answers in the study group n (%) |
|---|---|---|---|
| 1. | The normal end-expiratory range of carbon dioxide ($etCO_2$) in a healthy patient is within: | 4,7 - 6,0 kPa (35 - 45 mmHg) | 89 (85%) |
| 2. | Can the quality of advanced life support for a patient in a state of cardiac arrest be assessed on the $EtCO_2$ values and the capnography chart? | Yes, it is a good tool to assess the quality of resuscitation. | 98 (96%) |
| 3. | What is the main difference between a capnograph and a capnometer? | Capnograph shows the dynamics of changes in the $EtCO_2$ value as a graph, while the capnometer shows only the current value of the measurement. | 77 (76%) |
| 4. | When analyzing the graph of the $CO_2$ concentration curve, the selected point (A) corresponds to: | The beginning of the expiratory/ the end of the inhale | 68 (67%) |
| 5. | Analyzing the graph of the $CO_2$ concentration curve, which points correspond to the $EtCO_2$ value: | Point D | 78 (77%) |
| 6. | The following chart for monitoring a patient who is correctly intubated and mechanically ventilated may indicate: | Probably the ventilation system was disconnected | 46 (45%) |
| 7. | During cardiopulmonary resuscitation in a patient correctly intubated you notice on monitor the course of the graph. It may indicate: | Return of spontaneous circulation (ROSC) | 51 (50%) |
| 8. | High-quality compressions of the patient's chest during resuscitation typically result in $EtCO_2$ values in the range of: | 2,0 - 2,5 kPa (15 - 19 mmHg) | 31 (36%) |
| 9. | You carry out advanced resuscitation procedures in a patient with cardiac arrest. At the moment your colleague leads chest compressions, you fan the properly intubated patient. The graph below shows the current status of patient monitoring. On its basis, it can be concluded that: | High quality of cardiopulmonary resuscitation | 47 (46%) |

*(Source: Own study)*

The average result in the general study group was 5.8 ± 1.9 points. With a breakdown due to the completed school level for a 3-year high school, the average score was 5.75 ± 1.9 points, while for a 2-year post-secondary school was 5.89 ± 1.9 points. In addition, there was made a comparison of medical knowledge test results with the division according to

the type of ambulance in which the paramedics work. This analysis shows that EMT providers working on teams in which the supervisor is a doctor obtained average results higher than rescuers from "P" type teams (6.1 ± 1.6 vs. 5.7 ± 2.0). Moreover, the analysis shows that the rescuers who declared participation in the training of monitoring and analysis end-expiratory value of carbon dioxide concentration in the last 12 months obtained significantly higher correct answers than the staff who did not have such training (6.5 ± 2.0 vs. 5.4 ± 1.7).

**Table 2.** The average of correct answers considering the type of completed school.

| | Whole study group (mean ± standard deviation) | Graduate of a 3-year university (mean ± standard deviation) | Graduate of a 2-year post-secondary school (mean ± standard deviation) |
|---|---|---|---|
| Score | 5.8 ± 1.9 | 5.75 ± 1.9 | **5.89 ± 1.9** |

*(Source: Own study)*

**Table 3.** Average of correct answers, taking into account the type of ambulance in which the participant works.

| | Whole study group (mean ± standard deviation) | Medical rescuer working in a basic team ambulance (P) (mean ± standard deviation) | Medical rescuer working in a specialist team ambulance (S) (mean ± standard deviation) |
|---|---|---|---|
| Score | 5.8 ± 1.9 | 5.7 ± 2.0 | **6.1 ± 1.6** |

*(Source: Own study)*

**Table 4.** Average of correct answers considering the fact of completing training in the field of monitoring and analysis end-expiratory value of carbon dioxide concentration in the last 12 months.

| | Whole study group (mean ± standard deviation) | Medical rescuers who have completed medical training in the field of monitoring and analysis end-expiratory value of carbon dioxide concentration in the last 12 months. (mean ± standard deviation) | Medical rescuers who do not have completed medical training in the field of monitoring and analysis end-expiratory value of carbon dioxide concentration in the last 12 months. (mean ± standard deviation) |
|---|---|---|---|
| Score | 5.8 ± 1.9 | **6.5 ± 2.0** | 5.4 ± 1.7 |

*(Source: Own study)*

**Discussion**

Our study indicates lack of sufficient knowledge about use of devices to non-invasive monitoring of end-expiratory carbon dioxide concentration ($EtCO_2$) in resuscitation procedure in study group of EMS providers. Capnometry and capnography are more and more frequently mentioned by world organizations as an ideal tool both to assess the correctness of performed procedures such as: airway clearance as well as to assess the quality of cardiopulmonary resuscitation [5]. By using such techniques, it is possible to increase the patient's safety against, for example, incorrect intubation, too much ventilation, too low chest

compressions, etc. Avoiding such errors can significantly improve the prognosis of the patient in life-threatening condition and should therefore be regularly used in pre-hospital medicine [6,7]. Capnography has been long used in the operating room, intensive care unit and is widespread both in adult patients and in children [8,9,10]. Therefore, such devices should be an inseparable element of each ambulance's equipment.

Our research shows that devices for measuring end-expiratory carbon dioxide concentration in the patient's air are available in approximately 9 out of 10 ambulances (91%), with the capnometry being the most commonly available device. An additional conclusion coming from our study is the fact that over half of the participants of the study almost always uses such a device in a patient with cardiac arrest. Moreover, only 35% of participating medical rescuers declare their participation in the last year in training workshops, which included principles for monitoring concentrations and analysis of the end-expiratory diagram of carbon dioxide concentration ($EtCO_2$). This discovery shows a significant problem of the lack of systematic refresher training.

A sudden and significant increase of end-expiratory carbon dioxide concentration in the patient during cardiopulmonary resuscitation is associated with the probable return of spontaneous circulation (ROSC) [11]. Only half of our EMS providers indicated the correct answer in the question regarding precisely the aspect of return of spontaneous circulation. In addition, only 36% of respondents are aware of the importance of maintaining the correct high $EtCO_2$ values in a patient in cardiac arrest and know their good values. Unfortunately, only 45% of EMS providers correctly analyzed the graph showing the disconnection of the ventilation system. These incorrect answers, again, point need for high-quality training with continuous education of medical personnel.

Despite the fact that the general results are average, the research pays special attention to the fact that regular and high-quality training with professional medical staff is particularly important in the development of medical staff. EMS providers due to the specific type of work and exposure to extreme stress should have master medical knowledge because only with that they will be able to avoid the errors and improve their care about patient in a critical condition.

## Conclusions

In conclusion, our study had shown a lack of knowledge, experience and education in use of devices to measure end-expiratory carbon dioxide concentration ($EtCO_2$) by Emergency Medical Service providers. More detailed and practical training is undoubtedly indicated. Critical review of training and education curricula is therefore recommended**.**

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