ORIGINAL ARTICLE

Developments in Health Sciences 1(2), pp. 33–38 (2018)
DOI: 10.1556/2066.2.2018.12
First published online July 20, 2018

Does level of training predetermine the success rate of prehospital sepsis assessment? A prospective survey on early recognition

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(Received: September 19, 2017; revised manuscript received: January 10, 2018; accepted: January 17, 2018)

Introduction: Sepsis is a challenge for health professionals. The increasing number of cases emphasizes the importance of early recognition resulting in better survival. *Materials and methods:* Questionnaires were spread focusing on the prehospital recognition, treatment, and care pathway of septic patients. After presenting an initial scenario, other sepsis-like diseases were given as diagnosis of choice and the answers were registered. After redefining the situation, the same potential diagnoses were given and the difference in correct answers was detected. *Results:* The number of responders was 120. Among them, 33% of responders chose hypovolaemia, 10% allergic reaction, 2.5% endocrine disease, 30.8% systemic inflammatory response syndrome/sepsis, 0.83% internal bleeding, 0.83% drug effect, 2.5% pulmonary embolism, and 19.17% metabolic disorder as primary diagnosis with a significantly higher number of trained paramedics highlighting the correct answer. After redefining the scenario, 63% changed the diagnosis, while 37% did not change ($p < .001$). Further management was correctly chosen by the majority of responders. *Discussion:* The small number of correct answers from non-paramedics highlights the need for more education in identifying the pitfalls of early recognition and therapy of those who attend patients first. *Conclusion:* Trained paramedics recognize the sepsis better than other representatives, necessitating the introduction of new guidelines.

Keywords: prehospital care, emergency care, recognition, sepsis, infection, scores, biomarkers

INTRODUCTION

Sepsis is an ever increasing problem and a challenge for people who are suffering with it and also for those who are fighting against it. Despite elaborated details on the pathophysiology and structural changes of sepsis, there are certainly many questions that need to be answered, but it is quite clear that early recognition and early treatment are associated with better survival [1, 2]. But, how can a pathophysiological process provoking organ failure and shock with unclear details be recognized accurately and in a timely manner as well as treated in a simple way? It is clear that there is not a single symptom or sign, nor a single biomarker available to prove the presence or the development of the septic process, although there are some cornerstones that mark the pathophysiology route of sepsis.

The initial concept of "severity order", i.e., bacteraemia, then infection, sepsis, followed by severe sepsis, septic shock, and ultimately multiple organ dysfunction [3], lived long enough to get used to this linearity, but it has been quite clear that this concept is rather oversimplifying the otherwise intricate processes.

To initiate early therapy, the Surviving Sepsis Campaign came up with the idea of using "bundles of care" that encompassed early recognition and early treatment. The diagnosis was based on the use of general variables (fever, hypothermia, tachycardia, tachypnea, hyperglycaemia, and peripheral oedema), inflammatory variables (leukocytosis, leukopenia, normal white-cell count with >10% immature forms, elevated plasma C-reactive protein, and elevated plasma procalcitonin), haemodynamic variables (arterial hypotension or decrease in systolic pressure of >40 mm Hg in adults, elevated mixed venous oxygen saturation, and elevated cardiac index), organ-dysfunction variables (arterial hypoxemia, acute oliguria, increased creatinine levels, coagulation abnormalities, paralytic ileus, thrombocytopenia, and hyperbilirubinemia), and tissue-perfusion variables (hyperlactataemia and decreased capillary refill or mottling) [2]. Inevitably, diagnostic tools, such as laboratory facilities, in the ambulance are limited if any; therefore, one should focus only on variables such as vital signs that can be observed and assessed on the scene or in the ambulance. In the emergency departments, our diagnostic capabilities are widened by being able to measure some laboratory parameters, i.e., full blood count,

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ISSN 2630-936X © 2018 The Author(s)

biomarkers, and performing blood gas analysis, but these activities are often time-consuming.

We can quickly recognize that even this long list of signs, symptoms, and markers could not determine with a high accuracy of whether the patient was in sepsis, severe sepsis, or septic shock; moreover, the nature of sepsis (i.e., infectious agent, the state of the host organs, and individual factors, such as intercurrent diseases) was not considered. In addition, some atypical presentation might result in establishing a diagnosis of haemorrhage, pulmonary embolism, myocardial infarction, pancreatitis, and diabetic ketoacidosis (abdominal crisis) [4].

With the advent of the Sepsis-3 task force [5], a paradigm shift is observed in the recognition of sepsis. The nomenclature that was used earlier has changed and left us with only the terms sepsis and septic shock, while leaving out the rest of the "linearity", and even the term severe sepsis was also eliminated.

The introduction of the quick Sequential Organ Failure Assessment (quick SOFA) score resulted in an easier approach to the signs and symptoms of sepsis (Table 1).

Using parameters of altered mental state with a new onset, a respiratory rate (RR) higher than 22/min and a systolic blood pressure lower than 100 mm Hg conclude that if the patients score two or more points, the suspicion of sepsis is confirmed. Further elaboration is assisted by the use of SOFA score based on PaO_2/FiO_2 ratio, mean arterial pressure (MAP), urine output or creatinine levels, serum levels of bilirubin, the Glasgow Coma Scale (GCS), platelet count, and the need of vasoactive support.

The systematic Sepsis Six approach, i.e., giving oxygen and crystalloid infusion, measuring lactate and hourly urine output, obtaining cultures and administering wide spectrum antibiotics within the first hour, is an acceptable tool in the emergency department but not feasible in the ambulance. Out of the six steps, only administration of oxygen and intravenous fluids can be completed in the prehospital settings, but in the case of meningococcal meningitis, Hungarian ambulances are equipped with ceftriaxone that can be given as soon as the suspicion is raised.

This simplified approach, along with maintaining the high suspicion of sepsis based on the predisposition to the disease, the presence of infection, the response to the pathological process, and the presence of organ failure, i.e., the PIRO concept [6], either the prehospital or the intrahospital process of sepsis recognition may become more simple and more coherent.

The aim of this study was to assess the extent to which sepsis is recognized as an emergent process in the prehospital care among caretakers of different levels of training by comparing physician skills with paramedic and paramedic assistant skills and also to look into the treatment and disposition of patients with different severities of sepsis by different providers.

Table 1. The quick SOFA score

Parameter	Value
Systolic blood pressure	<100 mm Hg
Respiratory rate	>22/min
Level of consciousness	<GCS of 15

METHODS

The prehospital survey was initiated after acquiring permissions from the relevant bodies of the Hungarian National Ambulance Service.

An Internet-based, anonymous questionnaire was created comprising 16 questions, subdivided to four groups focusing on diagnosis, treatment, follow-up, and personal issues. Answers to personal questions were not analysed in this survey.

The responders were stratified according to their level of training and competences, i.e., inexperienced paramedic assistants, trained paramedic assistants I and II, nurses, BSc nurses, paramedics, general physicians, emergency physicians (EP), and other unspecified caretakers.

The first question was based on a case presentation: "*In a springtime running competition a 35 year old runner is attended. His vital parameters are a respiratory rate of 23/min, an oxygen saturation of 97%, blood pressure of 100/60 mm Hg, temperature of 38.5 °C. His blood sugar is 4.6 mM/L, and a serum lactate was measured resulting in 3.6 mM/L. He is slightly disoriented (A on AVPU) but only partly cooperative, he keeps telling that he is feeling unwell. Apart from pollen allergy there is no relevant medical history.*"

Based on the given details, the correct answer of sepsis/SIRS could be misdiagnosed most likely as hypovolaemia and allergic reaction, less likely as epilepsy, some kind of endocrine disease, and internal bleeding, and least likely as drug effect, pulmonary embolism, and metabolic disorder.

After the primary situation, additional information was given to the responders: "*You realize that the right arm of the patient is swollen, oedematous, and there is a two centimetre infected wound that is oozing*". Based on the extended information, we wanted to see whether the responder is going to change his primary diagnosis or not.

A third question focused on the knowledge of quick SOFA scores articulated as: "*Have you ever heard about quick SOFA?*"

The fourth question emphasized the runner's deteriorating condition and targeted the subclassification of the disease process, which this time in most cases seemed to be SIRS/sepsis: "*The runner's respiratory rate is 24/min, SpO_2: 97%, pulse: 115/min, BP: 75/45 mm Hg, temperature: 39.0 °C, blood sugar: 4.6 mM/l, serum lactate: 4.1 mM/L, there was no urine output in the last hour. What would describe the patient's condition best?*"

Possible answers were SIRS, sepsis, severe sepsis, septic shock, or multiple organ dysfunction syndrome (MODS).

The fifth question focused on planning additional treatment for this patient by giving five opportunities to the responders:

"*Please choose one of the treatment plans:*

1. *Administration of wide spectrum antibiotics, then obtaining haemoculture, followed by adequate fluid replacement.*

2. *Administration of wide spectrum antibiotics, then adequate fluid replacement, followed by obtaining haemoculture.*
3. *Obtaining haemoculture, then administration of wide spectrum antibiotics, followed by adequate fluid therapy.*
4. *Obtaining haemoculture, then adequate fluid therapy, followed by administration of wide spectrum antibiotics.*
5. *Adequate fluid therapy, administration of wide spectrum antibiotics, followed by obtaining haemoculture.*
6. *Adequate fluid therapy, then obtaining haemoculture, followed by administration of wide spectrum antibiotics.*"

Data collection was over a period of 6 months.

Anonymous data were stored on a secure server and statistical analysis was carried out using Kolmogorov–Smirnov and Shapiro–Wilk tests to assess normality, and the intragroup deviance was tested by Levene's test. According to the results of pretests, parametric data were examined by χ^2 test.

RESULTS

In the prehospital settings, 120 responders answered the questionnaire and the stratification resulted in the percentage of responders as 4.2% of inexperienced paramedic assistant, 10.8% and 5.0% of trained paramedic assistants I and II, respectively, 11.7% nurse, 4.2% BSc nurse, 32.5% paramedic, 17.5% general physician, 8.3% EP, and 5.8% other (unspecified) (Figure 1).

Out of these possibilities, 40 responders (33.3%) chose hypovolaemia, 12 (10.0%) allergic reaction, 3 (2.5%) endocrine disease, 37 (30.8%) SIRS/sepsis, 1 (0.8%) internal bleeding, 1 (0.8%) drug effect, 3 (2.5%) pulmonary embolism, and 23 (19.2%) metabolic disorder as the primary diagnosis (Figure 2).

Further analysis focused on the experience and training of the responders and resulted in choosing hypovolaemia by 1 inexperienced paramedic assistant, 4 trained paramedic assistants I, 1 trained paramedic assistant II, 1 general nurse, 1 BSc nurse, 10 paramedics, 14 general physicians, 6 EPs, and 2 other responders.

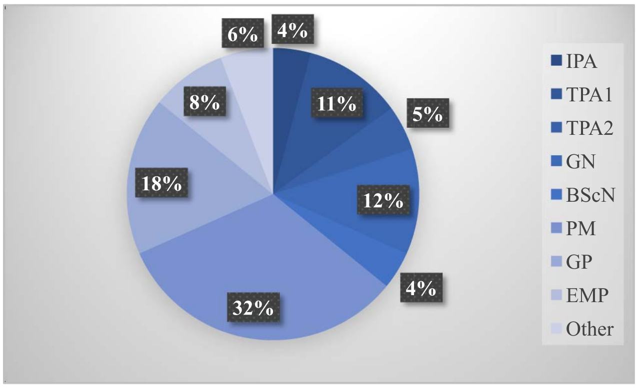

Figure 1. Knowledge on quick SOFA of the different responders. IPA: inexperienced paramedic assistant; TPA1: trained paramedic assistant I; TPA2: trained paramedic assistant II; GN: general nurse; BScN: BSc nurse; PM: paramedic; GP: general physician; EMP: emergency medicine specialist; Other: other responder

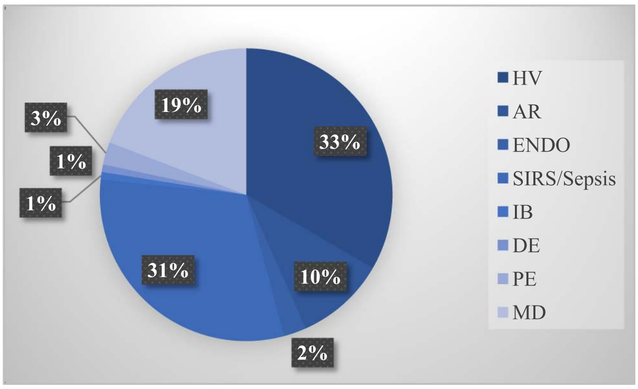

Figure 2. Responders' answers to the question focusing on the initial problem after answering the question with additional information. HV1-HV2: hypovolaemia initially and after; AR1-AR2: allergic reaction; ENDO1-ENDO2: endocrine disorder; SIRS1-SIRS2: SIRS/Sepsis; IB1-IB2: internal bleeding; DE1-DE2: drug effect; PE1-PE2: pulmonary embolism; MD1-MD2: metabolic disorder

Allergic reaction was chosen by 1 inexperienced paramedic assistant, 3 trained paramedic assistants I, 3 trained paramedic assistants II, 1 general nurse, 1 BSc nurse, 3 paramedics, general physicians, EP, and other responders and they did not find it as the cause of deterioration. Epilepsy as primary diagnosis was not chosen by any subgroup of responders. Endocrine disease as the cause of deterioration was marked by 2 trained paramedic assistants I and 1 other responder, no one else chose it as a potential problem. SIRS/sepsis was selected as a primary diagnosis by 3 trained paramedic assistants I, 1 trained paramedic assistant II, 7 general nurses, 3 BSc nurses, 15 paramedics, 2 general physicians, 2 EPs, and 3 other responders. Only one other responder marked internal bleeding. Drug effect as the cause of the symptoms was chosen by only 1 general physician, whereas pulmonary embolism was considered to be the problem by 2 paramedics and 1 general physician. Three untrained paramedic assistants considered that metabolic disorder was responsible for the symptoms along with 1 trained paramedic assistant I, 1 trained paramedic assistant II, 5 general nurses, 9 paramedics, 1 general physician, and 1 EP.

After answering the second question referring to the wound on the patient's arm, 75 (63.0%) of the responders changed their diagnosis, whereas 45 (37.0%) did not change. The answer was "yes" in 5 inexperienced paramedic assistants, 8 trained paramedic assistants I, 5 trained paramedic assistants II, 5 general nurses, 2 BSc nurses, 23 paramedics, 16 general physicians, 7 EPs, and 4 other responders. Those who answered "yes" to the question whether the diagnosis has changed gave the below answers.

Answering question two, only 1 trained paramedic assistant I chose hypovolaemia as an alternative diagnosis, 1 inexperienced paramedic assistant voted for allergic reaction along with 4 trained paramedic assistants I and 1 nurse. None has chosen epilepsy or endocrine disorder as an alternative diagnosis, while SIRS/sepsis was considered to be the cause in 4 inexperienced paramedic assistants, 8 trained paramedic assistants I, 6 trained paramedic assistants II, 10 general nurses, 5 BSc nurses, 38 paramedics, 19 general physicians, 9 EPs, and 7 other responders. No one thought of internal bleeding or drug effect as the second diagnosis, while only 1 EP believed that pulmonary embolism is the main problem and only 2 general nurses believed that metabolic disorder is responsible for the patient's condition (Figure 3).

Regarding hypovolaemia, SIRS/sepsis, and metabolic disorder, the difference proved to be significant when comparing the two answers. From the inexperienced paramedic assistants, 1 responder answered "yes" for the third question about quick SOFA, along with 1 trained paramedic assistant I, 1 trained paramedic assistant II, 2 general nurses, 1 BSc nurse, 13 paramedics, 8 general physicians, 4 emergency specialists, and 2 other responders. The rest has not heard about quick SOFA. Answering the fourth question regarding subclassification for severity of the infection, 8 responders chose SIRS, 3 voted for sepsis, 21 for severe sepsis 71 for septic shock, and 17 for MODS. The majority of the responders categorized the patient as being in septic shock (Figure 4).

Responses for the fifth question on planning further management of the patients resulted in three persons

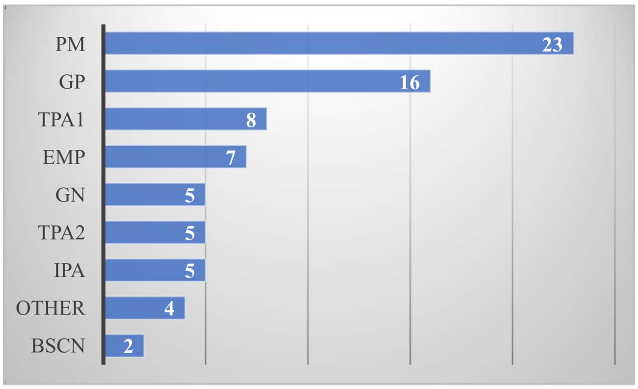

Figure 3. Responders changing their primary diagnosis. PM: paramedic; GP: general physician; TPA1: trained paramedic assistant I; EMP: emergency medicine specialist; GN: general nurse; TPA2: trained paramedic assistant II; IPA: inexperienced paramedic assistant; Other: other responder; BScN: BSc nurse

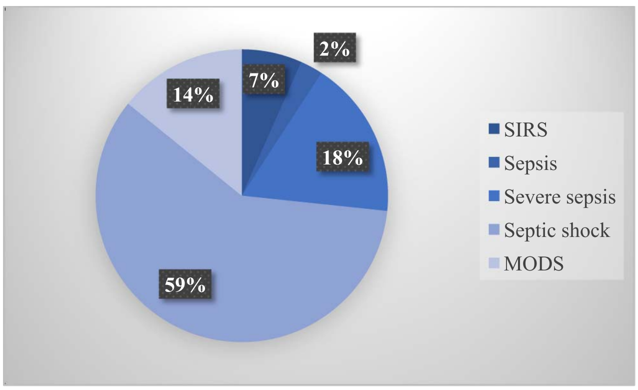

Figure 4. Assessment of severity of infections

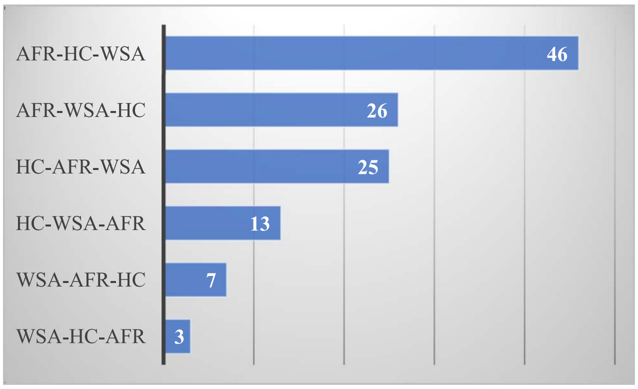

Figure 5. Management plan of the patient. WSA: wide spectrum antibiotic; HC: obtaining haemoculture; AFR: adequate fluid replacement

targeting administration of wide spectrum antibiotics, then obtaining haemoculture, followed by adequate fluid replacement. Seven responders chose administration of wide spectrum antibiotics, then adequate fluid replacement, followed by obtaining haemoculture. Thirteen chose obtaining haemoculture, then administration of wide spectrum antibiotics, followed by adequate fluid therapy; 25 obtaining haemoculture, then adequate fluid therapy, followed by administration of wide spectrum antibiotics; 26 voted for adequate fluid therapy, then administration of wide spectrum antibiotics, followed by obtaining haemoculture; and the majority, 46, voted for adequate fluid therapy, then obtaining haemoculture, followed by administration of wide spectrum antibiotics. The majority of the responders chose the correct management plan for the patient (Figure 5).

DISCUSSION AND CONCLUSIONS

To the best of authors' knowledge, this has been the only survey on the prehospital recognition of sepsis in Hungary, apart from one intrahospital study focusing on sepsis recognition, treatment, and disposition of patients in Hungarian emergency departments [7].

There have been some efforts made with promising results regarding this issue in other countries [8, 9], and the data obtained from this study suggest a worse EP recognition, which raises some questions that remain to be answered.

It seems that in the prehospital care, sepsis is now a potentially recognized condition by the paramedics, but the knowledge of other staffs who are dealing with patients out of the hospital still needs significant improvement, which is in accordance with previous findings [8, 9]. It is rather promising that some degree of prompting (i.e., more details) governs the majority of the responders toward the right diagnosis.

It is surprising that the number of those who are being aware of the quick SOFA score is low, although use of quick SOFA is questionable even in the intrahospital settings [10, 11]. Hungarian emergency departments have adopted the Canadian Triage Acuity System where the recognition of sepsis is still based on identification of general variables and presence of SIRS. The accuracy of this triage system is high; therefore, introduction of quick SOFA will need quite an amount of consideration.

It is quite reassuring to see that the majority of the responders would choose the right initial therapy for a septic patient, i.e., giving fluids, taking a sample, and staring antibiotics as soon as possible.

Use of sepsis scores in the prehospital settings is not new. The Prehospital Early Sepsis Detection (PRESEP) score [12], using consensus criteria for sepsis analyzed 14.399 Emergency Medical Services records, focused on vital parameters and easily measurable values, i.e., temperature >38 and <36 °C, SpO_2 <92%, RR >22 breaths/min, heart rate (HR) >90/min, non-invasive blood pressure <90 mm Hg systolic, GCS score <15, and blood glucose level >6.6 mM/L, and concluded that it has a specificity of 86%, a sensitivity of 85%, a positive predictive value of 63%, and a negative predictive value (NPV) of 95%. In terms of NPV, the score is rather promising, although widespread use is not obvious yet. It is based on the well-known early warning systems (EWS) in both adults and children (paediatric EWS) [13–15], which were later simplified to achieve rapid results and became known as modified EWS [16].

However, the scores are used for different purposes [17], and its best utilization is to follow-up patients and to predict certain risks. In our clinical practice, MEWS is used on a daily basis. Introducing scores in prehospital sepsis recognition might be influenced by the findings of a study that revealed the usefulness of the PRESEP score in the recognition of sepsis (area under the curve – AUC: 0.67 [0.51–0.84]), while finding quick SOFA the least useful (AUC: 0.40 [0.22–0.59]) [18]. Unfortunately, the rather small sample size of 37 makes the results questionable. In this study, the usefulness of any predictive score was not revealed; however, it might be necessary in the future.

The Prehospital Sepsis Score [19] utilizes vital parameters similarly to other scores, calculating with MAP, HR, RR, and shock index (SI). Body temperature higher than 38 °C, arbitrarily chosen as an obligate variable, adds one more point to the score. SI ≥0.7 adds two points and RR ≥22 breaths per minute adds another point to the score to a total maximum of 4 points. Patients are stratified as Prehospital Sepsis Project – Severity (PSP-S): 1 – low risk, PSP-S: 2 – moderate risk, and PSP-S: 3 and 4 – high risk. Use of this scoring system is easy; therefore, it might well be applied in our prehospital care.

A systematic approach might overcome the difficulties resulting from lack of knowledge and lack of adequate tools in acute care, but we surely need more training to understand the pathophysiology, early recognition, treatment, and rehabilitation of those who are at risk or suffering with the disease.

The Hungarian National Ambulance now issued a protocol on sepsis in accordance with the Hungarian Emergency Medical Society focusing on the cornerstones of recognition and treatment. Although the protocol is not strictly based on the standard early warning signs or the quick SOFA, it gives a clear instruction and a to-do-list in case sepsis is suspected.

The authors believe that teaching alongside with workshops and hands-on experience will improve early recognition and early treatment of sepsis. They are aware of the inhomogeneity of the sample, but this originates from the multitude of healthcare providers employed by the Hungarian National Ambulance. It is clear that, in future, we need to follow up the results of the new guideline and implement the necessary changes if indicated.

ABBREVIATIONS

SpO_2	: percutaneous oxygen saturation
mM/L	: millimole per litre
BP	: non-invasive blood pressure
SIRS	: systemic inflammatory response syndrome
SOFA	: Sequential Organ Failure Assessment
MODS	: multiple organ dysfunction syndrome

Authors' contribution: PK and TB summarized the scientific background of the paper, RS collected the data and performed the necessary calculations, GYM carried out the statistical analysis, and IH finalized the text.

Ethical approval: Due to the anonymity of the questionnaires, no formal ethical approval was acquired other than the written permission of data collection from the Chief Medical Officer of the Hungarian National Ambulance.

Conflict of Interest: The authors declare no conflict of interest and no financial support was received for this study.

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