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Research paper

Prehospital clinical presentation in patients with acute coronary syndrome complicated by cardiogenic shock: A single center study

Filip Jaskiewicz, PhD *
Marzenna Zielinska, PhD

Intensive Cardiac Therapy Clinic, Medical University of Lodz, Poland

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ABSTRACT

Background: The development of cardiogenic shock remains the most important factor affecting the prognosis of patients with acute coronary syndrome. Despite significant advances in treatment, achieved in the last two decades, the mortality rate is still very high. The development of knowledge about the pathophysiology of cardiogenic shock, necessitates a thorough and comprehensive assessment of its progress at all stages of medical care.
Objectives: The aim of the study was to assess the prehospital clinical presentation in patients with acute coronary syndrome complicated by cardiogenic shock.
Methods: The population of our study consisted of 40 patients with acute coronary syndrome complicated by cardiogenic shock who were transported to the Intensive Cardiac Therapy Clinic by ambulances directly from place of the event in order to implement primary coronary intervention. The control group was selected among age, gender and infarct location-matched patients with acute coronary syndrome uncomplicated by shock. The clinical presentation in investigated patients was assessed on the basis of the data contained in the medical records of Emergency Medical Services teams.
Results: In univariate logistic regression analysis eight prehospital clinical symptoms proved to be statistically significant predictors of the development of cardiogenic shock: fainting and/or impaired consciousness, pale skin, cold skin, clammy skin, dyspnea, pulmonary congestion, peripheral cyanosis and hyperglycemia >11,1 mmol/l. In the multivariate model significant predictors of cardiogenic shock development were: pale skin and hyperglycemia >11.1 mmol/l. A risk prediction model was constructed. It proved to differentiate patients from study and control group highly significantly ($p < 0.001$).
Conclusions: Patients with acute coronary syndrome who develop cardiogenic shock, present a different clinical symptoms at the moment of the first medical contact. The proposed 4S Scale can be used for quick assessment of risk in patients with acute coronary syndrome before the development of a fully-blown cardiogenic shock with severe, long-lasting hypotonia.

1. Introduction

The development of cardiogenic shock (CS) remains the most important factor affecting the prognosis of patients with acute coronary syndrome (ACS).[1] Despite significant advances in treatment, achieved in the last two decades, the mortality rate among patients with CS still reaches 30%–80%.[2] Some authors report that symptoms of CS complicating ACS are already present on admission in 30% of cases.[3] Especially in this group, it is crucial to determine the early diagnosis, priorities of care, and proper organisation of the treatment process from the moment of the first medical contact(FMC).[4]

The heterogeneity of patients, various clinical manifestations, and dynamics of CS development cause problems with identifying its unified definition. However, CS can be usually diagnosed on the basis of clinical criteria that are easy to assess without the need for advanced haemodynamic monitoring.[1] Increasing knowledge about patient characteristics and better understanding of the CS pathophysiology encourage researchers and clinicians to revise the classic definition.

Scientific databases are constantly being updated with reports on the effectiveness, diagnostics development, and treatment of CS

* Corresponding author at: Intensive Cardiac Therapy Clinic, Medical University of Lodz, Pomorska Street 251, 92-213 Lodz, Poland.
E-mail address: cparamedikus@gmail.com (F. Jaskiewicz).

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complicating ACS. Unfortunately, fewer and fewer authors are paying attention to the early clinical characteristics of patients who develop CS. Analysis of the literature showed a lack of data concerning prehospital clinical presentation and prompted us to take interest in this group of patients.[1–7]

2. Aim

The aim of the study was to assess the prehospital clinical presentation of patients with ACS complicated by CS.

3. Methods

3.1. Study population

The population of our study consisted of 40 consecutive patients with ACS complicated by CS (CS [+] group), hospitalised in the Intensive Cardiac Therapy Clinic during the period from December 2011 to June 2015, and treated with primary percutaneous coronary intervention (PCI). Every next patient with the same sex, age, and infarct location who was admitted to the clinic because of ACS uncomplicated by CS was included to the control group (CS [−] group). All patients involved in the study were transported to the clinic by emergency medical service (EMS) ambulances directly from the place of an event to implement PCI. Eight patients enrolled in the study died before coronary angiography was performed. Coronary angiography and PCI were carried out on 32 patients from the study group and in all patients from CS [−] group.

3.2. Study protocol

The inclusion criteria were as follows: (a) diagnosis of ACS by ambulance personnel and its confirmation in the hospital; (b) for patients from the study group, development of CS on the prehospital or at the hospital stage before PCI was performed; (c) transport to the hospital by EMS ambulances directly from the place of the event. Exclusion criteria were the following: (a) patients transported to the clinic from other hospitals; (b) incomplete EMS medical documentation.

The clinical presentation of patients involved in the study was assessed on the basis of the data contained in the unified medical records of EMS teams (Fig. 1). Medical interview and all measurements were made during the first examination of patients before the implementation of therapeutic management (including administration of fluids or inotropic drugs). The prehospital stage covers the period from the FMC until the transfer of the patient to the emergency room.

The study received an approval of the Bioethics Committee of the Medical University of Lodz.

3.3. Statistical analysis

Statistical analysis of the data was carried out using PQStat set, ver. 1.4.8.322. Quantitative variables are presented using basic descriptive statistics: the arithmetic mean, standard deviation, minimum and maximum values, and positional measures—median and quartiles (Q25, quartile I; Q75, quartile III). Comparisons between groups were performed using the chi-*square* test with Yates correction and Fisher's exact test, descriptive statistics tables, and Mann–Whitney U test. To assess the predictive value of prehospital clinical symptoms for CS development, we performed univariate and multivariate logistic regression analysis. Discriminant analysis of the CS development risk scale was performed using receiver operating characteristic curves. Statistical significance was assumed at a p value of <0.05. The probability at p value < 0.01 was considered highly significant.

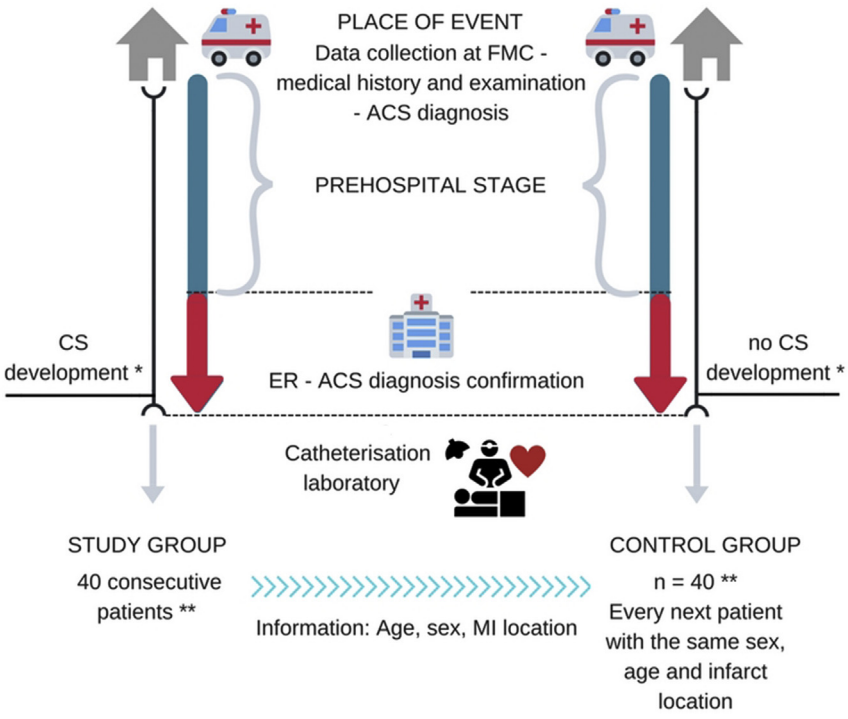

Fig. 1. Study protocol presentation.*Shock diagnose was based on clinical and haemodynamic criteria—systolic blood pressure <90 mm Hg lasting >30 min or the need for vasopressors to achieve systolic blood pressure ≥90 mmHg and signs of organ hypoperfusion (disturbance of consciousness/confusion/lethargy, pale, cold, or clammy skin). **Patients with complete EMS medical documentation. EMS, emergency medical service; ACS, acute coronary syndrome; CS, cardiogenic shock; ER, emergency room; FMC, first medical contact; MI, myocardial infarction.

4. Results

The study group consisted of 40 consecutive patients with ACS complicated by CS (CS [+] group). The control group (CS [−] group) was selected among age-, gender-, and infarct location–matched patients with ACS uncomplicated by CS. The localisation of myocardial infarction in both groups was identical (respectively, presented by the number of patients: anterior, 13; anterolateral, 9; lateral, 2; inferior, 11; inferior with concomitant right ventricular myocardial infarction, 5). Besides previous stroke, there were no statistically significant differences in risk factors between patients with or without CS (Table 1).

The main reason for calling EMS in both groups was chest pain. There was no statistically significant difference in the incidence of this symptom in both groups (Table 2). However, a highly significant difference was found in the time passage from the onset of chest pain to admission. For patients from the CS [+] group, mean delay was shorter than that in the control group (5.64 ± 5.13 vs. 12.58 ± 12.52 h, respectively, $p < 0.001$). Three patients (one from the study group and two from the control group) were transported to the hospital to perform PCI after more than 12 h from the onset of stenocardia. It was caused by initially mild chest pain ignored by patients. Decision to call an ambulance was made after further worsening of symptoms.

Table 1
Baseline characteristic of the patients from study and control group.

Parameter	CS (+), n = 40		CS (-), n = 40		p value
Age (years; mean [SD])	71.5 ± 11.1		71.6 ± 11.1		>0.05
Male	20	(50%)	20	(50%)	>0.05
STEMI	36	(90%)	35	(88%)	>0.05
NSTEMI	4	(10%)	5	(12%)	>0.05
Previous ACS	10	(25%)	11	(28%)	>0.05
Prior CABG/PCI	6	(15%)	9	(23%)	>0.05
Previous stroke	6	(15%)	1	(3%)	**<0.05**
CAD history	21	(53%)	22	(55%)	>0.05
Family history of CAD	6	(15%)	3	(8%)	>0.05
Hypertension	18	(45%)	24	(60%)	>0.05
Diabetes	7	(18%)	4	(10%)	>0.05
Smokers	9	(23%)	8	(20%)	>0.05
Fatal outcome	22	(55%)	0	(0%)	**<0.001**

SD, standard deviation; ACS, acute coronary syndrome; CABG, coronary artery bypass graft; CAD, coronary artery disease; CS (+), study group, patients with cardiogenic shock; CS (−), control group, patients without cardiogenic shock; NSTEMI, non–ST-segment elevation myocardial infarction; PCI, percutaneous coronary intervention; STEMI, ST-segment elevation myocardial infarction.

Table 2
Clinical characteristic of the patients from study and control group at the moment of the first medical contact.

Prehospital clinical symptoms	CS [+]		CS [−]		p value
	n = 40	%	n = 40	%	
Chest pain	33	82.5	37	92.5	0.310
Dyspnoea	15	37.5	2	5	**0.001**
Fainting	16	40	4	10	**0.004**
Abdominal pain	4	10	2	5	0.237
Impaired consciousness	14	35	–	–	**< 0.001**
Pulmonary congestion	10	25	3	7.5	**0.033**
Peripheral cyanosis	5	12.5	–	–	**0.027**
Pale skin	33	82.5	3	7.5	**< 0.001**
Cold skin	19	47.5	3	7.5	**< 0.002**
Clammy skin	20	50	2	5	**< 0.001**
Glycaemia >11.1 mmol/l	31	78	2	5	**< 0.001**

CS [+], study group, patients with cardiogenic shock; CS [−], control group, patients without cardiogenic shock.
The bolded text in Table should pay attention to statistically significant results.

For assessment of vital signs at the FMC, measurements of heart rate and systolic blood pressure (SBP) were made. There were no significant differences in heart rate between the study and control group (respectively mean 88.45 ± 47.43 vs. 83.6 ± 22.10 per minute, $p = 0.925$). Statistically significant difference was found in results of SBP, which were lower in patients from the study group (respectively mean 86.35 ± 37.59 vs. 133.75 ± 21.17 mmHg, $p < 0.001$). Despite this, for half of the patients from CS [+] group, SBP was higher than 80 mmHg and in 25% of patients, higher than 100 mmHg (median = 80, Q25 = 60, Q75 = 100). All measurements were made during the first examination of patients before the implementation of therapeutic management (including administration of fluids or inotropic drugs).

Statistically significant difference was observed in the incidence of the following symptoms: dyspnoea, fainting (before calling an ambulance), impaired consciousness, pulmonary congestion, pale, cold, or clammy skin, peripheral cyanosis, and glycaemia >11.1 mmol/l (Table 2).

During the FMC, members of EMS teams assessed the state of consciousness of all patients. We analysed the results on the basis of standard Glasgow Coma Scale (GCS). Substantial part of the study group had reduced level of consciousness (GCS ≤ 14). This symptom did not occur in the patients from the CS [−] group. Fainting and/or impaired consciousness was observed in more than half the patients from the study group (Table 2). In the control group, fainting before ambulance arrival was reported in four patients.

Clinical symptoms forming the prehospital clinical presentation of patients with ACS complicated by CS were analysed in univariate and multivariate model to identify early predictors of the development of fully blown CS, understood as the coexistence of organ hypoperfusion signs with long-term drop of SBP. In univariate logistic regression analysis, eight prehospital clinical symptoms proved to be statistically significant predictors of CS development (Table 3). In the multivariate model, highly significant ($p < 0.001$) predictors of the CS development were pale skin and blood glucose concentration >11.1 mmol/l (Pseudo R2 = 0.6701, R2 [Nagelkerke] = 0.8067, R2 [Coxa-Snella] = 0.6051).

A risk prediction model for CS development in patients with ACS was constructed (Table 4). It was based on four variables: fainting and/or impaired consciousness, pale skin, dyspnoea, and blood glucose concentration >11.1 mmol/l.

It proved (Table 5) to differentiate patients from CS [+] and CS [−] group highly significantly ($p < 0.001$). Ability of risk prediction model was assessed by the area under the receiver operating characteristic curve, and it exhibited excellent discrimination with an area under the ROC (AUC) of 0.9516 (95% confidence interval 0.9058–0.9973, $p < 0.001$) and the cutoff point of 2 (Fig. 2).

Table 3
The predictive value of prehospital clinical symptoms for the development of fully blown CS—univariate logistic regression analysis.

Prehospital clinical symptoms	OR	−95% CI	+95% CI	p value
Impaired consciousness	2.49	0.00	NA	0.997
Dyspnoea	11.40	2.40	54.22	**0.002**
Peripheral cyanosis	1.85	0.00	NA	0.998
Pulmonary congestion	4.11	1.04	16.29	**0.044**
Fainting	6.00	1.79	20.15	**0.003**
Pale skin	58.14	13.89	243.35	**< 0.001**
Cold skin	19.00	4.03	89.62	**< 0.001**
Clammy skin	11.16	2.95	42.20	**< 0.001**
Glycaemia >11.1 mmol/l	65.44	13.16	325.42	**< 0.001**
Fainting and/or impaired consciousness	12.18	3.64	40.77	**< 0.001**

OR, odds ratio; CI, confidence interval; CS, cardiogenic shock.
The bolded text in Table should pay attention to statistically significant results.

Table 4
The 4S—the scale of fully blown CS development risk in patients with ACS.

Prehospital clinical symptoms	Number of points
Pale skin	1
Glycaemia >11,1 mmol/l	1
Fainting and/or impaired consciousness	1
Dyspnoea	1
The maximum number of points: 4	

4S, 4 Simple Shock Symptoms Scale; ACS, acute coronary syndrome; CS, cardiogenic shock.

Table 5
The 4S—analysis of the predictive value for the development of fully blown CS in patients with ACS.

Number of points	CS [−]		CS [+]	
	n = 40	%	n = 40	%
0	31	77.5	2	5
1	7	17.5	3	7.5
2	2	5	12	30
3	0	0	17	42.5
4	0	0	6	15
X	0.27		2.55	
Median	0		3	
SD	0.55		1.01	
Min	0		0	
Max	2		4	
Q25	0		2	
Q75	0		3	
p value	<0,001			

4S, 4 Simple Symptoms Shock Scale; SD, standard deviation; X, arithmetic mean; ACS, acute coronary syndrome; CS, cardiogenic shock; CS [+], study group, patients with cardiogenic shock; CS [−], control group, patients without cardiogenic shock.

5. Discussion

Among all the complications that may occur in ACS patients, CS is associated with the worst prognosis.[1,5] At the moment, the knowledge about patients with ACS complicated by CS comes from studies and registries conducted at the hospital stage. Mostly, they analyse the effects of new treatment methods or evaluate the effectiveness of already widely used therapy. Unfortunately, the initial clinical picture before the hospitalisation is very poorly known. Analysis of the data obtained from the medical records of EMS teams created a unique opportunity to evaluate its course.

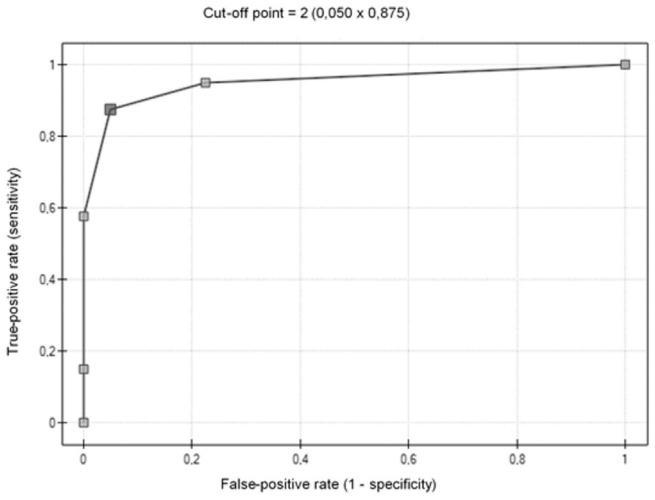

Fig. 2. Receiver operating characteristic curve analysis—the predictive value of 4S for the development of fully blown CS in patients with ACS. ACS, acute coronary syndrome; CS, cardiogenic shock; 4S, 4 Simple Shock Symptoms Scale.

Chest pain was the main reason for calling EMS in patients from CS [+] group and in patients with uncomplicated ACS. In the present study, patients who developed CS were reaching the hospital faster than patients from the control group. The reason for a shorter time delay is that there could have been a greater number of disquieting symptoms in the study group. It probably had an influence on calling medical help earlier. Analysis of factors associated with prolonged time from the onset of symptoms to admission in patients with ACS presented by Perkins-Porras et al.[8] indicates that the delay was significantly shorter in patients who presented multisymptomatic manifestation of ACS.

Some studies have reported that symptoms of CS complicating ACS in 30% of patients are already present at admission.[3] In a multicenter CardShock study, 24% of 177 patients with ACS complicated by CS had symptoms of CS at admission and in 62% of the patients, shock developed in the first 24 h.[6] It is worth noticing that in the global utilization of streptokinase and tissue plasminogen activator for occluded coronary arteries (GUSTO-I) trial, which was conducted two decades ago, CS at admission was observed only in 11% of patients.[7] The reason for this situation remains unclear. Perhaps progress in the organisation and quality of health care in the field of EMS now enable the patients, who previously were dying in the prehospital period, to access hospitals. Moreover, the definition and criteria of shock diagnosis could have been changed. It is essential that in all studies conducted so far, hypotension was prerequisite for the CS diagnosis. Currently more and more doubts are arising concerning the meaning of hypotension as a criterion required for recognition of CS. In their study, Vincent et al.[9] suggested that CS diagnosis should be based on the presence of tissue hypoperfusion signs. This argument was supported in the recommendations of the task force of the European Society of Intensive Care Medicine in 2014[10] by pointing out three organs available for simple clinical examination called “windows of the body”. According to them, the assessment of skin perfusion, state of consciousness, and kidney function should be the main criterion leading to suspicion and recognition of the CS development. What is more, the European Society of Intensive Care Medicine does not treat hypotension, despite its frequent occurrence, as an indispensable diagnostic requirement. Also the German–Austrian S3 guidelines[2] report that at the initial stage, hypotension may be absent even in 25% of patients with CS.

Analysis of prehospital clinical presentation in patients with ACS complicated by CS drew attention to a number of symptoms occurring before the hypotension. The same symptoms were practically absent in patients from the control group. It allowed creating a CS risk development scale that can be useful for quick and simple assessment from the FMC. 4 Simple Symptoms Shock Scale (4S) consists of four prehospital clinical signs: pale skin, fainting and/or impaired consciousness (representing two “windows of the body” which are easy to assess from the FMC), glycaemia >11.1 mmol/l, and dyspnoea.

Symptoms of peripheral hypoperfusion are present in the definitions and inclusion criteria in many studies as a part of a full-blown CS clinical picture.[2,6,11] Unfortunately, there is usually a lack of quantitative data on the frequency of their occurrence. They are also differently defined by the authors—usually as cold extremities[5,12] or cold and clammy skin.[3] In the CardShock study[6] that was analysing hospital clinical presentation of patients with ACS complicated by CS, signs of peripheral hypoperfusion were qualified as “cold periphery” and present in 94% of patients. In our research, 47.5% of the study group had cold skin. In the univariate analysis, it was associated with higher risk of CS development. However, our attention was drawn to another symptom of

peripheral hypoperfusion—pale skin. In the prehospital stage, it occurred considerably more frequently. Pale skin was a highly significant prehospital predictor of CS development in both univariate and multivariate analyses. For this reason, this symptom, which is easy to assess from the FMC, was included in the proposed 4S as a “window of body".[9]

Another symptom included in the proposed scale was glycaemia >11.1 mmol/l. The phenomenon of hyperglycaemia in acute illnesses was the subject of many studies conducted in recent years, but its mechanism in patients with CS is not fully explained. Some authors have confirmed hyperglycaemia's predictive value for the CS development in patients with ACS.[13] Others suggest it as an adverse prognostic factor for those patients.[14] At the moment, it is not clear whether hyperglycaemia is not just a manifestation of the ongoing process arising from an acute life-threatening condition.[15] In this meaning, in patients with ACS it can become an excellent, fast and available diagnostic tool and part of the CS risk development assessment. In this study, glycaemia >11.1 mmol/l was a highly significant predictor of the CS development in both univariate and multivariate analyses. For this reason, it was included in the proposed 4S.

In this attempt of showing the prehospital clinical presentation in patients with ACS complicated by CS, in reference to the recommendations of ESCIM,[10] we also paid special attention to the presence of brain hypoperfusion symptoms. Although they are defined differently by authors (often as confusion, lethargy, altered mental status), in patients with CS, they are undeniably a part of the clinical picture during hospitalisation.[5,6,11] In the present study, among patients from the CS [+] group, symptoms of brain hypoperfusion, defined as impaired consciousness (GCS $\leq$ 14), occurred significantly more frequently than in the control group. Interestingly, in CardShock study,[6] impaired consciousness, defined as confusion, was observed twice as often (71%). Greater frequency of these symptoms occurring in patients with CS during hospitalisation is mainly an effect of progressive haemodynamic decompensation caused by the long-term, severe hypotonia that is often not present in the prehospital period. That is why, initially all, even slightly expressed signs of reduced brain perfusion, are important. Fainting may be the first symptom noticeable for patients or their surroundings. In our study, some of the patients who reported fainting before calling an ambulance had no altered consciousness at the time of the FMC. It should also be noted that there were no observed haemodynamically unstable arrhythmias or conduction disturbances in these patients. If we assume that fainting was a consequence of a reduction in cardiac output, supine position and activation of compensatory mechanisms could contribute to the improvement of the cerebral perfusion, and, at least temporarily, maintain the correct state of consciousness. Therefore, in the search of early predictors of CS development, in the present study, we analysed the potential symptoms of brain hypoperfusion expressed both as fainting and/or impaired consciousness. In the univariate analysis, these symptoms were associated with a 12-fold higher risk of developing fully blown CS in patients with ACS and have been included into the 4S as one of the “windows of body” available for assessment at the FMC.

On the basis of other research results and analysis of our data, we identified the fourth prehospital symptom that proved to be useful as a part of the proposed scale. Numerous studies have reported poor prognosis and a greater number of complications in patients with ACS presenting dyspnoea during hospitalisation. In El-Menyar et al. study,[16] a higher rate of CS development complicating ACS was reported in a group (11% of patients), in which dyspnoea was the predominant symptom. In patients with ACS, dyspnoea can be both a symptom of the left ventricular failure and the equivalent of the chest pain. It may also have noncardiac etiology. Hellenkamp et al.[17] analysed 9169 patients with ACS, among whom 28.4% complained of dyspnoea. In this group, symptoms of heart failure at admission were observed significantly more often (21.0% vs. 5.3%, respectively, $p < 0.05$). In some patients, dyspnoea may also be an equivalent to angina pectoris or, as in the case of patients with CS, an expression of a reduced supply of oxygen caused by impaired blood flow to tissues.[9] Some authors[18,19] describe dyspnoea as the only clinical manifestation in up to 26–49% of patients with atypical presentation of ACS. In our study, dyspnoea reported by patients at the FMC was significantly more common among patients from the study group and usually accompanied by pulmonary congestion. In patients with ACS, dyspnoea should be treated as a highly alarming symptom, regardless of its suspected etiology. In the present study, in univariate analysis, dyspnoea was associated with a highly significant risk of fully blown CS development and became the fourth prehospital symptom included into the 4S.

The development of knowledge about the pathophysiology of CS complicating the course of ACS necessitates a thorough and comprehensive assessment of its progress at all stages of medical care. Analysis of the data obtained from the medical records of EMS teams created this unique opportunity to assess the clinical presentation of patients with ACS complicated by CS from the first moments of its development. In difficult prehospital conditions, there is a need for possible simplest, yet most effective, clinical tools. Maybe, after further studies, 4S will become one of them.

6. Limitations of the study

This is a single center study. The primary limitation of this study was the small number of patients. The relatively low incidence of CS as a complication of ACS and the exclusion of patients transported from other hospitals resulted in a significant reduction of the study group size. Further studies on larger groups of patients should be conducted.

7. Conclusions

The development of CS remains the most important factor affecting the prognosis of patients with ACS. Especially in this group, it is crucial to determine the early diagnosis, priorities of care, and proper organisation of the treatment process from the moment of the FMC. In patients with ACS complicated by CS, the main reason for calling medical help is still chest pain. Patients with ACS, who develop CS, in reference to the onset of symptom occurrence, get to the hospital no later than other patients with ACS. They also represent a different clinical presentation from the moment of the FMC. Apart from chest pain, symptoms appearing in the prehospital period include fainting before calling an ambulance, impaired consciousness, dyspnoea, pulmonary congestion, peripheral cyanosis, pale, cold, or clammy skin, and higher blood glucose levels. They often appear before severe hypotonia.

The proposed 4S can be used for a quick assessment of risk in patients with ACS before development of a fully blown CS with severe, long-lasting hypotonia. It may have a predictive value for the CS diagnosis when we consider the fact that the definition also includes hypotonia or has a diagnostic value, if we assume that hypotonia does not have to be a crucial symptom.

Ethical approval and consent to participate

The study received a positive opinion of the Bioethics Committee of the Medical University of Lodz (decision number—RNN/76/11/KE). No consent of participation was required.

CRediT authorship contribution statement

Filip Jaskiewicz: Conceptualization, Methodology, Validation, Formal Analysis, Investigation, Data Curation, Writing – Original Draft, Visualization. **Marzenna Zielinska:** Resources, Supervision, Project Administration.

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