Estimation of short-term and medium-term survival from sudden cardiac death based on the initial rhythm

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ABSTRACT

The aim of our study was to investigate short- and medium-term survival in patients with sudden cardiac death (SCD) after resuscitation. We continued a retrospective study at the University of Pécs from April 2018 to December 2019. 192 patients with SCD were selected. Exclusion criteria were incomplete documentation and unstable rhythm, after which we continued the study with 181 patients. Our data were obtained from documents recorded by the Emergency Department. The study population was divided into two groups, with proven shockable (I) and non-shockable (II) initial rhythm, and their data were compared at hospital discharge, at 1 month, and at 3 months. The main endpoint was the mortality between the two groups. Our results already showed that hospital survival was significantly higher in the shockable rhythm group than in the non-shockable group (62% *vs*. 38%, P=0.002). We also obtained similar results for 1-month survival (54% *vs*. 16%, P=0.004). When risk factors were examined, there was a significant difference in the survival of diabetic (P=0.001) and hypertensive patients (P=0.001). Patients with shockable rhythm have significantly better survival rates.

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Introduction

Sudden cardiac death (SCD) is a clinical syndrome, defined according to the most commonly accepted definition as: sudden, premature, natural death of a cardiac patient or a person without known cardiac disease from a cardiogenic cause, preceded by sudden loss of consciousness and occurring within one hour of the onset of acute symptoms.[1] Over the last 20 years, there have been many innovations in the care of SCD, resuscitation protocols have been developed and changed, yet mortality rates have not improved significantly. The incidence of SCD ranges from 15-48%, depending on geographic and demographic situation. Age differences are observed in terms of aetiology. The WHO Lancet 2001 prediction that ischaemic heart disease would be the leading cause of death worldwide by 2020 has been proven.[2] About half of cardiovascular deaths are sudden unexpected cardiac (arrhythmia) deaths, which currently account for about 17 million deaths worldwide each year. SCD is one of the most common causes of death.[3] It accounts for 15-20% of all fatalities, with a higher mortality rate compared to deaths from lung,

breast, colorectal, and prostate cancers.[4] In Europe, approximately 275,000 people suffer an out-of-hospital SCD each year, compared to 359,800 cases per year in the United States.[5,6] In European countries has been found that the average number of patients per 100,000 population who suddenly dies from cardiac causes is 84.[7] Despite improving diagnostic capabilities and increasingly effective preventive practices, the incidence of SCD has unfortunately not changed significantly in recent years, with the lowest incidence in Cyprus (4/100,000 cases), the highest in the United Kingdom (1536/100,000 cases).[7,8] In Hungary, precise data are not yet available, but some estimates suggest that there are 25000-26000 SCD events per year in our country, with an average of 50-60 deaths per day.[6]

Most SCDs occur out of the hospital, with a very low chance of survival, with only 10% of patients with return of spontaneous circulation. 3-5% of survivors leave the hospital without significant neurological deficits.[9] The number of SCDs has decreased in recent decades due to effective treatment and prevention.[4] In young athletes there is usually a congenital or hereditary disease such as cardiomyopathies, congenital coronary anomalies, Wolf-Parkinson-White syndrome, or Brugada syndrome. In the elderly (over 60 years), coronary heart disease, heart failure, and valvular heart disease are the most common causes of SCD. Regarding other aetiology male gender is also a risk factor, as SCD is 2-3 times more frequent in men, but it can also be caused by electrolyte imbalance, activation of the autonomic nervous system, or even by the proarrhythmic effect of antiarrhythmic drugs. The risk factors for SCD are the same as those for coronary heart disease, such as high blood lipids, hypertension, smoking, physical inactivity, obesity, diabetes, elevated serum CRP, excessive alcohol consumption, and a positive family history of coronary heart disease and myocardial infarction.[10] The Hungarian Resuscitation Society, in accordance with international recommendations, revises the basic and advanced resuscitation protocols every 5 years, focusing on which rhythms were detected in the background of SCD. It can be classified reanimatologically into two groups: shockable (ventricular tachycardia, ventricular bradycardia) and non-shockable (asystole, pulseless electrical activity.[11] SCD requires immediate attention in terms of the time window, as even brief hypoperfusion can cause irreversible brain and myocardial and target organ damage. In addition to artificial maintenance of circulation, great emphasis should be placed on the recognition and care of reversible causes.[12] Survival is influenced by many factors, including the time elapsed between clinical death and first care, the patient's general condition, underlying medical history, and the classification of the initial rhythm, which has been studied by several studies and which we also supported.[10] Post-resuscitation care is also of great importance, as the 24 hours after SCD are crucial for survival.[13] In the case of SCD, acute care is defined by the initial rhythm. While in shockable rhythms, even one single DC shock can rapidly eliminate a life-threatening arrhythmia, non-shockable rhythms require more complex interventions. In the case of non-shockable rhythms, in addition to basic and advanced resuscitation measures, efforts should be made to detect and address any aggravating reversible causes such as tamponade, tensional pneumothorax, toxin effects, thromboembolism, hyper- or hypokalemia, hypovolemia, hypothermia, hypoxia (4H, 4T).[12]

The aim of our study was to compare short- and medium-term survival between the shockable and non-shockable groups in terms of risk factors. We were interested to see which comorbidities showed an association with survival in the initial rhythms. We examined survival rates at hospital discharge, 1 month and 3 months, with particular attention to the presence of risk factors.

The ethical approval of the research was issued by the Regional Research Ethics Committee of the University of Pécs (approval number 7143 PTE 2018).

Materials and Methods

In our retrospective study, we used data recorded at the Emergency Department of the University of Pécs, Hungary. We conducted our research among patients admitted to the Emergency Department from 6 April 2018 to 31 December 2019 who were likely to have cardiac death of cardiological origin. We selected 192 patients for our study and then followed up with 181 patients according to our exclusion criteria. We excluded patients with incomplete documentation and patients in whom the type of the initial rhythm was not clearly established. The 181 patients who were finally selected were divided into two groups, shockable and non-shockable, according to the resuscitation protocol. They were then further subdivided into subgroups based on comorbidities, where survival was compared. The source of our data was MedSolution and the National Ambulance Service documentation provided to the Emergency Department.

Statistical analysis was performed using IBM SPSS for Windows 20.0. Descriptive statistics included absolute and relative frequencies, average, standard deviation, t-test, correlation and ANOVA to analyze the relationship between the variables under study.[14]

Results

A total of 192 patients were included in the study, and 181 patients remained in the study after the exclusion criteria were taken into account. Of these, 112 had

shockable (62%) and 69 non-shockable (38%) rhythms. There was no difference in demographic data between the two groups. The average age of the non-shockable group (63.4; SD=8.7) was insignificantly higher than that of the shockable group (55.2; SD=6.8), which was in line with the data reported in the literature. The proportion of people aged 60 years and over was thus 70% in the non-shockable group and 58% in the shockable group, significantly higher in both groups (P=0.002) (P=0.004) In terms of gender distribution, male gender was predominant in both groups. This is summarized in Table 1.

The distribution of risk factors is detailed in Table 2.

We compared the two groups in terms of risk factors and found significant differences in several areas, such as at hospital discharge in the hypertension group (P=0.001) and at one-month survival in the diabetes group (P=0.001). The most striking numerical difference was in the hypertension group in favor of the shockable group. We also examined diabetes and lipid values, where the abnormal blood glucose value showed a significant difference being higher in the shockable group. We were also interested in some aspects beyond the study objectives that might be informative in terms of estimating survival. We looked at the relation between the time elapsed between first care and survival and there was no significant difference in resuscitation times between the two groups in either case, although the return of spontaneous circulation was higher in patients with non-shockable rhythms. The main endpoint of our study was to examine short- and medium-term survival. Our results showed that even in-hospital survival was significantly higher in the shockable rhythm group than in the non-shockable group (62% *vs*. 38%, P=0.002). Similar results were obtained for 1-month survival (54% *vs*. 16%, P=0.004). We further subdivided the survival data beyond the two basic groups into subgroups based on risk factors and compared the shockable and non-shockable groups. Similar to survival, we found significant differences in this case for hypertension and diabetes. We were unable to examine 3-month survival because only 1 person remained in the non-shockable group, so the results were statistically insignificant, but the numbers are still informative. These data are summarized in Table 3.

In the hospital records, data on body mass index

Table 1. Gender distribution of sudden cardiac death patients in the study population.

	Shockable rhythm	Non-shockable rhythm
Gender male/female	75/37	41/28
Average age	55,2 years	63,4 years
Percentage of over 60s	58%	70%

Table 2. Main risk factors for sudden cardiac death in the study population.

Risk factors	Shockable rhythm n=112	Non-shockable n=69	P
Hypertension	80 (71%)	54 (78%)	0.575
Hyperlipidaemia	32 (29%)	25 (36%)	0.753
Diabetes	36 (32%)	9 (13%)	0.018

Table 3. Survival data at hospital discharge and after 1 month.

Survival at hospital discharge	Shockable n=69	Non-shockable n=26	P
Hypertension	21	18	0.001
Hyperlipidaemia	34	15	0.134
Diabetes	28	9	0.265
Survival after 1 month	**n=37**	**n=4**	
Hypertension	21	2	0.576
Hyperlipidaemia	23	2	0.547
Diabetes	10	1	0.001

(BMI) were found in most cases, with 72 cases (40%) confirming obesity (BMI>25) and 109 cases (60%) with normal body weight. In the case of obesity, 41 subjects (56%) did not regain circulation, while 30 patients (44%) were successfully resuscitated. These results showed no significant relation between body weight and the outcome of resuscitation (P=0.2766; r=0.04).

In 90% of cases, we obtained data on whether a previous myocardial infarction (MI) had taken place. We found 48 cases (26.5%) with a previous MI and 133 patients (73.5%) with no previous infarction. Resuscitation was unsuccessful in 35 cases (62.5%) and successful in 21 cases (37.5%) in the post-infarct patients. Based on these results, we found no significant relation between previous myocardial infarction and the outcome of resuscitation (P=0.4579; r=0.007).

Of 181 patients, 13 (7%) had a history of previous treatment for stroke. In 8 cases (61.5%) of patients treated with stroke, resuscitation was unsuccessful and spontaneous circulation returned in 5 cases (38.5%). No significant relation was detected between the previous stroke and the outcome of resuscitation (P=0.439; r=0.0104).

Moving beyond the endpoints, we were interested to see how the number of patients undergoing percutaneous coronary intervention (PCI) in the study population evolves and to what extent coronary artery disease is a factor in SCD. In the shockable group, 50 patients underwent PCI, of whom 37 were diagnosed with coronary artery disease and 13 with other structural heart disease. In the non-shockable group, 31 patients underwent PCI, of whom 27 were diagnosed with coronary artery disease and 4 with myocardial disease or arrhythmia. Of the 31 people, 18 had a previous PCI and another interesting finding was that cardiomyopathy was significantly higher in this group (P=0.003) We also looked at the one-year survival in this population and found that only 6 people in the original sample were alive at one year, which means a rate of 7% survival. (Table 4).

Discussion

The prognosis and long-term outcome of patients who are resuscitated and survive SCD (aborted cardiac death) are significantly influenced by underlying comorbidities and the mechanism of ventricular arrhythmia. In our study, it was also shown that certain comorbidities have a significant impact on survival. Koldobskiy *et al*. found that renal failure, immunosuppression, and obesity negatively affect the outcome of resuscitation.[15] Herlitz *et al*. studied the data of 33,453 patients and concluded that initial heart rate, lay resuscitation and patient age were associated with the outcome of resuscitation.[16] SCD is often the first and only "symptom" of myocardial infarction. In the United States, nearly half of all coronary patients die from SCD.[17] With regard to SCD from acute coronary syndrome, cardiac rehabilitation, timely detection and treatment of lipid abnormalities, and effective control of comorbidities improve long-term prognosis even in these severe cases.[18]

Looking at international studies, there is no consensus on gender affecting SCD. In a 2015 meta-analysis published in the Journal of Resuscitation, Bougouin, and colleagues reported that women who leave the hospital show better survival compared to men.[19] In a study published in 2016 by Chih-Hung Wang *et al*. concluded that women have a higher percentage of permanent neurological damage and that there is no significant difference in survival of in-hospital cardiac arrest (IHCA) between the two genders.[20] In a study published in 2010, Topjian *et al*. examined approximately 95,000 IHCA patients between 2000 and 2008. Younger female patients (aged 15 to 44 years) had a significantly better prognosis after IHCA, while female patients aged 56 years and older did not show this significant difference.[21]

In terms of age, significantly lower survival can be observed in older patients. This data may be explained by the lower proportion of patients over 70 years of age who are resuscitated. A study based on the Neurological Rehabilitation and Clinical Research Pathways database has shown that children discharged home recovered in much higher percentages after resuscitation following IHCA compared to their adult counterparts (27% *vs*. 18%).[22] Overall, only 20% of patients who have suffered an IHCA survive to be emitted at home and 28% of them live with some form of permanent neurological impairment.[21,22] The present study also supports the idea that age influences the outcome of SCD.

Table 4. Percutaneous coronary intervention and underlying disease trends.

	Shockable	Non-shockable	P
PCI	50	31	0.162
Coronary artery disease	37	27	0.235
Other heart disease (myocardial disease/rhythm disorder predisposing disease)	13	4	0.087
Cardiomyopathy	2	14	0.003

PCI, percutaneous coronary intervention.

In the population we studied, the hypothesis – which has been supported by several studies – that in the case of SCD, patients with shockable rhythms have significantly better survival rates than those with non-shockable rhythms, has been confirmed. Over the last 20 years, there have been many developments and changes in the protocols of care for SCD, but despite this, mortality rates have not improved significantly.[23] A 2011 study found that the non-shockable group had a higher number of elements of the initial rhythm recorded in SCD.[24] In our study, the proportion of those with a shockable rhythm was higher, but survival rates were in line with previous studies, showing that survival rates for those with a non-shockable rhythm were worse than those with a shockable rhythm. Our study also revealed that hypertension and diabetes, as the two most common risk factors for sudden death, affected survival rates and resulted in significantly worse survival in the non-shockable group. Our research at the University of Pécs also clearly shows the importance of the initial rhythm, since a patient with a shockable rhythm has a much better chance of short- and medium-term survival than a patient with a non-shockable rhythm. In view of the literature, there have been several studies on this topic, with Tatsuma Fukuda and colleagues and Nadine and colleagues reporting similar results in international studies. In Hungary, a similar study has also been done previously and has been referred to in several points, and a study by Tímea Szigethi *et al*. at the Városmajori Heart and Vascular Clinic, Semmelweis University, Budapest, also supports the previous findings.[10,25,26]

Among the factors influencing survival identified in the European Resuscitation Society guidelines 2010-2015, the immediate circumstances of resuscitation are significant. Among them, the time elapsed from the moment of circulatory collapse to resuscitation and the duration of resuscitation plays an important role.[12]

To summarise our study, if we consider only the number of elements, 6 of the 181 patients included remained at the 3-month follow-up. Looking at the number of patients controlled at each time point, we can conclude that in the shockable group, we observed more favorable mortality data at all three-time points examined. In the shockable group, the in-hospital survival (62%) was significantly higher than in the non-shockable group (38%). This was also true for the 1-month (54% *vs*. 16%) and 3-month control (60% *vs*. 20%). We could not draw any far-reaching conclusions about the 3-month survival because only 1 patient remained in the non-shockable group.

It can therefore be concluded that in SCD, the initial rhythm is a good predictor of short- and medium-term survival. Both the literature and our own research suggest that shockable rhythm is a prognostically positive factor in SCD.

Conclusions

We concluded that the survival rate of SCD has improved with advances in medicine, but not significantly. However, an examination of risk factors revealed that many factors adversely affect the outcome of SCD. Our results suggest that pathological factors involved in left ventricular wall thickening, such as obesity, may indirectly be important pathogenetic factors for survival. We would like to draw attention to the importance of prevention and to the fact that in many cases SCD could be prevented if the population were to undergo appropriate screening and eat more healthily and consciously, as diabetes has a very significant impact on the outcome of heart disease. Around the 5 components of metabolic syndrome, high blood glucose levels have the worst lifetime effects on the heart.[27]

A further long-term plan for our study was to ensure that lay help in the event of sudden death is provided as early and as competently as possible. To this end, we would like to draw attention to basic resuscitation education. In 2017, a study among primary school children found that, although the ability to perform resuscitation depends on the physical development of the child, a high percentage of children are able to perform resuscitation successfully.[28]

Data reported in the 2021 European Resuscitation Council recommendation suggest that survival of IHCA in Europe at 30-day follow-up ranges from 15% to 34%.[29,30] Important factors influencing survival are the initial rhythm, the site of the collapse, and, most importantly, the proper performance of cardiopulmonary resuscitation, which highlights the importance of proper resuscitation education in all areas of healthcare.[30]

References

1. Préda I, Czuriga I, Édes I (eds). Hirtelen szívhalál, Kardiológia Alapok és irányelvek. 1st ed. Medicina, 2010.
2. Böttiger BW, Bode C, Kern S, et al. Efficacy and safety of thrombolytic therapy after initially unsuccessful cardiopulmonary resuscitation: a prospective clinical trial. Lancet 2001;357:1583-85.
3. Berdowski J, Berg RA, Tijssen JG, Koster RW. Global incidences of out-of-hospital cardiac arrest and survival rates: Systematic review of 67 prospective studies. Resuscitation 2010;81:1479-87.
4. Jazayeri MA, Emert MP. Sudden Cardiac Death: Who Is at Risk? Med Clin North Am 2019;103:913-30.
5. Perkins GD, Lall R, Quinn T, et al. Mechanical versus manual chest compression for out-of-hospital cardiac arrest (PARAMEDIC): a pragmatic, cluster randomised controlled trial. Lancet 2015;385:947-55.
6. Go AS, Mozaffarian D, Roger VL, et al. Heart disease and stroke statistics-2014 update: a report from the American Heart Association. Circulation 2014;129:e28-e292.
7. Gräsner JT, Lefering R, Koster RW, et al. EuReCa ONE-27 Nations, ONE Europe, ONE Registry: A prospective

one month analysis of out-of-hospital cardiac arrest outcomes in 27 countries in Europe. Resuscitation 2016;105:188-95.
8. Becker LB, Han BH, Meyer PM, et al. Racial differences in the incidence of cardiac arrest and subsequent survival. The CPR Chicago Project. N Engl J Med 1993;329:600-6.
9. Al-Khatib SM, Stevenson WG, Ackerman MJ, et al. 2017 AHA/ACC/HRS Guideline for Management of Patients With Ventricular Arrhythmias and the Prevention of Sudden Cardiac Death: Executive Summary: A Report of the American College of Cardiology/American Heart Association Task Force on Clinical Practice Guidelines and the Heart Rhythm Society. J Am Coll Cardiol 2018;72:1677-749.
10. Szigethi T, Pileczky D, Pap Z, et al. Hosszú távú túlélés és iniciális ritmus közötti összefüggés hirtelen szívhalál esetén Cardiol Hung 2017;47:30-3.
11. Monsieurs KG, Nolan JP, Bossaert LL, et al. European Resuscitation Council Guidelines for Resuscitation 2015: Section 1. Executive summary. Resuscitation 2015;95:1-80.
12. Nolan JP, Soar J, Zideman DA, et al. European Resuscitation Council Guidelines for Resuscitation 2010 Section 1. Executive Summary. Resuscitation 2010;81:1219-76.
13. Rittenberger JC, Callaway CW. Post-cardiac arrest management in adults. http://www.uptodate.com/contents/post-cardiac-arrest-management-in-adults (Cited 2023 July 24)
14. Pakai A, Kívés Z. Research for nurses part 2: methods of sampling and data collection in health science research. Nővér 2013;26:20-43.
15. Koldobskiy D, Groves S, Scharf SM, Cowan MJ. Validation of Factors, Affecting the Outcome of Cardiopulmonary Arrest in a Large, Urban, Academic, Medical Center. J Crit Care Med 2014;168132.
16. Herlitz J, Engdahl J, Svensson L, et al. Factors associated with an increased chance of survival among patients suffering from an out-of-hospital cardiac arrest in a national perspective in Sweden. Am Heart J 2005;149:61-6.
17. Myerburg RJ, Kessler KM, Castellanos A. Sudden cardiac death: epidemiology, transient risk, and intervention assessment. Ann Intern Med 1993;119:1187-97.
18. Bunch TJ, Mahapatra S, Murdock D, et al. Ranolazine reduces ventricular tachycardia burden and ICD shocks in patients with drug-refractory ICD shocks. Pacing Clin Electrophysiol 2011;34:1600-6.
19. Bougouin W, Mustafic H, Marijon E, et al. Gender and survival after sudden cardiac arrest: A systematic review and meta-analysis. Resuscitation 2015;94:55-60.
20. Wang CH, Huang CH, Chang WT, et al. Associations among gender, marital status, and outcomes of adult in-hospital cardiac arrest: A retrospective cohort study. Resuscitation 2016;107:1-6.
21. Topjian AA, Localio AR, Berg RA, et al. Women of childbearing age have better inhospital cardiac arrest survival outcomes than do equal-aged men. Crit Care Med 2010;38:1254-60.
22. Nadkarni VM, Larkin GL, Peberdy MA, et al. First Documented Rhythm and Clinical Outcome From In-Hospital Cardiac Arrest Among Children and Adults. JAMA 2006;295:50-7.
23. Nagy B, Kiss B, Pál-Jakab Á, et al. Hirtelen szívhalál, újraélesztés a European Resuscitation Council 2021-es ajánlása tükrében Cardiol Hung 2022;52:239-45.
24. Nolan JP. Optimizing outcome after cardiac arrest. Curr Opin Crit Care 2011;17:520-6.
25. Kitamura T, Iwami T, Kawamura T, et al. Japanese Circulation Society Resuscitation Science Study Group. Nationwide improvements in survival from out-of-hospital cardiac arrest in Japan. Circulation 2012;126:2834-43.
26. Goto Y, Maeda T, Nakatsu-Goto Y. Prognostic implications of conversion from nonshockable rhythms in out-of-hospital cardiac arrest. Crit Care 2014;18:528.
27. Keczeli V, Al-Sadoon I, Máté O, et al. Prevalence and impact of metabolic syndrome on outcomes of acute coronary syndrome patients in two different countries. Acta Angiol 2022;28:44-51.
28. Bánfai B, Pandur A, Pék E, et al. Hány éves kortól képesek a gyermekek újraéleszteni? Orv Hetil 2017; 158:147-52.
29. Perkins GD, Graesner JT, Semeraro F, et al. European Resuscitation Council Guidelines 2021: Executive summary. Resuscitation 2021;161:1-60.
30. Sandroni C, Nolan J, Cavallaro F, Antonelli M. In-hospital cardiac arrest: incidence, prognosis and possible measures to improve survival. Intensive Care Med 2007;33: 237-45.