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ORIGINAL RESEARCH

Long-term disability level of 1-month survivors after out-of-hospital cardiac arrest: a nationwide cohort study in Korea using data from 2009 to 2018

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Abstract

Recent guidelines identified recovery from cardiac arrest as an additional link in the chain of survival. However, data on the disability level and long-term survivorship in such patients are limited. We aimed to determine the long-term disability level, including disability type and severity, in patients with out-of-hospital cardiac arrest (OHCA) 1 month after discharge. This nationwide observational study used data from the National Health Insurance Service of Korea. We included adult OHCA patients who presented to the emergency departments (ED) of all hospitals in Korea between 2009 and 2018. The main outcome was disability level between 1 month after discharge and the 2-year follow-up. The average disability level was divided into six grades: most severe (grade 1) to mild (grade 6). Among 224,520 OHCA patients, 25,598 (11.4%) survived at 30 days. After excluding 3143 patients with a follow-up less than 2 years, 22,455 patients were included. Newly-developed disabilities were observed in 2664 patients (11.9%) and were more frequent in 1-year survivors than non-survivors (16.7% *vs*. 4.4%, $p < 0.01$). The most common type of disability was encephalopathic (54.2%), followed by renal (16.1%), physical (10.5%), and cardiac (4.2%) disabilities. Grade 1 disability was most frequent, followed by grade 2 and 3 (45.7%, 23.5%, 10.9%, respectively). Among patients who survived at 30 days after OHCA, 11.9% developed disabilities, including encephalopathic, physical, renal, and cardiac disabilities. Physicians should be aware of the risk of these disabilities and efforts to treat these disabilities in OHCA survivors should be increased.

Keywords

Cardiac arrest; Long-term disability; Disability level; Population-based study

1. Background

Out-of-hospital cardiac arrest (OHCA) is a major health problem worldwide [1]. Despite recent advances in post-cardiac arrest care, OHCA survivors may experience long-term disabilities due to hypoxic brain injury [2–4]. Several studies reported that OHCA survivors have cognitive, emotional, and fatigue problems during long-term follow-up [5–7]. With increasing interest in determining the long-term outcomes of OHCA survivors, recent guidelines included recovery from cardiac arrest in the chain of survival to emphasize the importance of rehabilitation after post-cardiac arrest [8]. Recovery expectations and survivorship strategies that address treatment, surveillance, and rehabilitation should be provided to cardiac arrest survivors and their caregivers at hospital discharge to address the sequelae of cardiac arrest and optimize transition of care to independent physical, social, and emotional roles [9, 10]. However, previous studies mainly focused on functional outcomes using the Cerebral Performance Category (CPC) and modified Rankin Scale (mRS) scores. Limited evidence is available regarding physical function, particularly persistent disability, of OHCA survivors. To better understand the prevalence of long-term disability in 30-day OHCA survivors, we used the data from the National Health Insurance Service (NHIS) of Korea. This study aimed to evaluate long-term disability in a large and representative group of OHCA survivors using this nationwide population data on disability grade.

2. Material and Methods

2.1 Study setting and data collection

This population-based case-control study used data from the Korean NHIS from January 2009 to January 2018. The Korean NHIS requires all Korean citizens to register for national healthcare insurance. The use of health services, prescription or procedure records, and diagnosis codes from the 10th revision of the International Statistical Classification of Diseases

and Related Health Problems are documented in the NHIS database. Our data covers almost all Koreans (approximately 50 million people) and records the clinical data from all healthcare facilities in Korea [11]. Data on the population number and sex, age groups, and disability status were obtained from the National Health Information Database (NHID) provided by the NHIS in Korea [12]. Data on previous comorbidities were retrieved from the diagnosis codes provided by the NHIS. All data were obtained from the diagnosis codes registered within 1 year before a cardiac arrest.

This study was approved by legal representatives of South Korea. In South Korea, patient consent or approval from an ethics committee is not necessary for this type of study. The data were provided by the Health Insurance Review & Assessment Service of Korea.

2.2 Disability types and grades

In this study, people with a disability were defined as those who were officially registered with the Korean government after cardiac arrest as having a disability. Based on the Welfare of Disabled Persons Act, Korea has registration and grading systems for people with disabilities [13–15]. The act classified disabilities into the following 15 types: physical abilities, brain lesion disorders, visual impairment, hearing impairment, language disabilities, intellectual disabilities, autistic disorder, mental disabilities, renal impairment, cardiac impairment, respiratory impairment, hepatic impairment, facial disfigurement, intestinal or urinary fistula, and epilepsy disorder. The act established specific criteria for determining disability grades for each type of disability. The grades range from 1 to 6. Grade 1 is given to a person with the most severe grade of disabilities, and grade 6 to a person with the least severe grade of disabilities. Mild disability means that the disability severity index is between 3 and 6; severely disabled means that the disability severity index is one or two. Mild disability includes people who can take care of themselves, even if some of them require personal support. Severe disabilities include those who are highly dependent on personal assistance or assistive devices. Each type of disability was established by the specialized physician's judgment after a considerable treatment period. For example, the diagnosis of encephalopathic disabilities is made by the specialist on neurology or rehabilitation with at least six months of treatment period after an illness. If the grade of disability can be improved after specific treatment, reevaluation should be made two years after the first diagnosis. The criteria for each grade for each type of impairment are described in the Welfare of Disabled Persons Act. The registration and grading systems provide uniform and standardized health and welfare services to people with disabilities of the same type and grade. In this study, we used information on the type and grade of disabilities in OHCA survivors.

2.3 Statistical analysis

Categorical variables are expressed as numbers with percentages, and continuous variables are expressed as means with standard deviations. Hazard ratios (HRs) and 95% confidence intervals (CIs) for all-cause 30-day mortality were estimated using Cox proportional hazard regression analyses. Statistical analyses were performed using the SAS Enterprise Guide software (version 7.1; SAS Institute Inc., Cary, NC, USA). A two-tailed p-value of <0.05 was considered statistically significant.

3. Results

3.1 Study Populations

Of 224,520 OHCA patients identified during the study period, 25,598 (11.4%) survived at 30 days. We excluded 3143 patients with a follow-up less than 2 years. Among the 22,455 patients included, 13,552 patients survived at the 1-year follow-up. Disabilities had developed in 2269 (16.7%) 1-year survivors and 395 (4.4%) non-survivors (Fig. 1).

3.2 Baseline characteristics

Table 1 presents the baseline characteristics of the study population. The mean age was higher in non-survivors than 1-year survivors (67.4 ± 15.8 *vs.* 59.1 ± 15.1; $p < 0.001$). Among 1-year survivors, patients aged between 50 and 59 years were most frequent, followed by those between 60 and 69, 70 and 79. Otherwise, patients aged between 70 and 79 years were most frequent in non-survivors, followed by those between 80 and 89, 60 and 69. Female sex were more frequent in non-survivors than 1-year survivors (37.6% *vs.* 32.7%; $p < 0.001$).

Diabetes with or without complications was the most frequent comorbidity in both groups, followed by chronic pulmonary disease, cerebrovascular disease, and congestive heart failure. In 1-year survivors, congestive heart failure, diabetes, and chronic renal disease were significantly more frequent than in non-survivors. The incidence of myocardial infarction did not significantly differ between both groups. However, cerebrovascular disease, dementia, chronic liver disease, any tumour, and metastatic solid tumour were significantly more frequent in non-survivors than in 1-year survivors.

3.3 Disability level in 30-day survivors and comparison of disability level between 1-year survivor and non-survivor

Newly-developed disabilities were observed in 2664 (11.9%) 30-day survivors (Table 2). Among 1-year survivors, 2269 patients (16.7%) developed disabilities, and among non-survivors, only 395 patients (4.4%) developed disabilities. The total follow-up duration is up to 10 years. The Median follow-up duration was 3.5 (1.6–5.9) years for patients with newly developed disabilities and 1.6 (0.2–4.6) years for patients without disability. The level of disability was divided into six grades. Grades 1 to 3 indicated severe disability, and grades 4 to 6 indicated mild disability. A severe disability grade was diagnosed in 1791 patients (78.9%) and 342 patients (86.6%) in the 1-year survivor and non-survivor groups, respectively. Grade 1 was the most frequent, followed by grade 2 and 3 (46.1% *vs.* 22.0% *vs.* 10.8%, respectively) in 1-year survivors. A similar trend was observed in the non-survivors. However, grades 4 to 6 were distributed relatively evenly.

The most frequent type of disability was encephalopathic

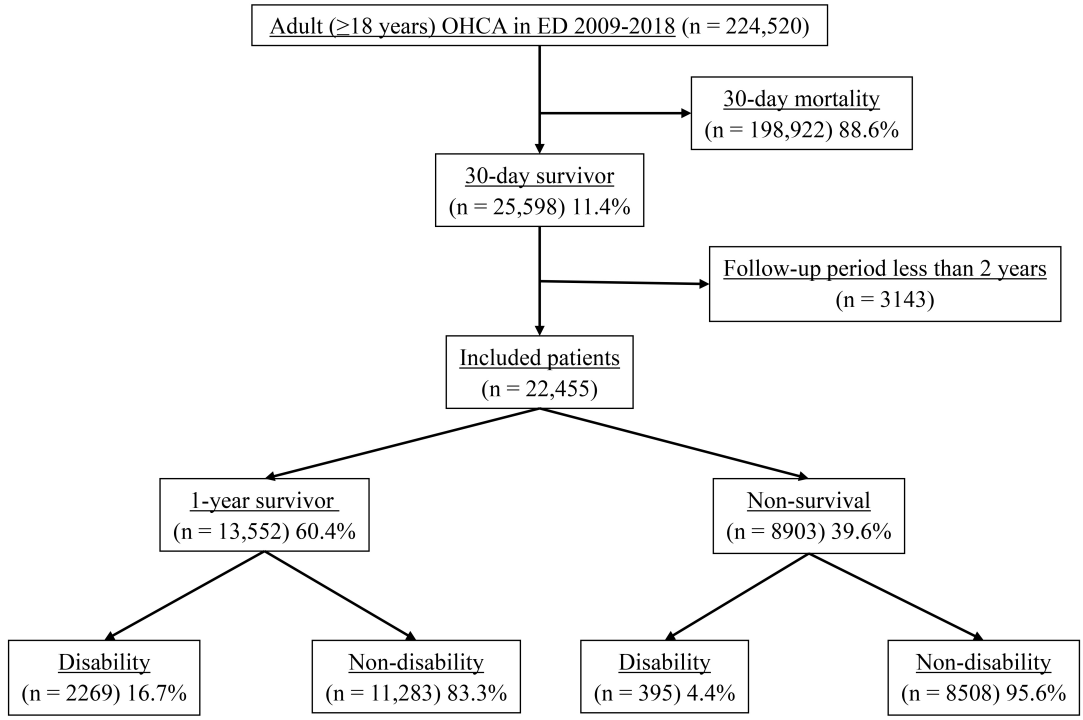

FIGURE 1. Patient enrolment flow diagram. OHCA—out-of-hospital cardiac arrest. ED—emergency department.

TABLE 1. Baseline characteristics and hazard ratios for 30-day mortality among the study population.

Characteristics	1-year survivors	Non-survivors	Univariate Analysis		
	(n = 15,364)	(n = 209,156)	HR	95% CI	*p*-value
Age, years	59.1 ± 15.1	67.4 ± 15.8	1.031	1.030–1.032	<0.001
18–29	542 (3.5)	4560 (2.2)	Reference		<0.001
30–39	1038 (6.8)	7187 (3.4)	0.823	0.737–0.919	0.001
40–49	2371 (15.4)	17,947 (8.6)	0.9	0.814–0.992	0.036
50–59	3938 (25.6)	32,441 (15.5)	0.979	0.890–1.076	0.664
60–69	3330 (21.7)	37,378 (17.9)	1.334	1.211–1.467	<0.001
70–79	2812 (18.3)	57,504 (27.5)	2.431	2.204–2.675	<0.001
80–89	1227 (8.0)	43,912 (21.0)	4.254	3.825–4.725	<0.001
Female	5029 (32.7)	78,629 (37.6)	1.238	1.196–1.282	<0.001
Comorbidity					
Myocardial infarction	1073 (7.0)	13,897 (6.6)	0.948	0.889–1.011	0.104
Congestive heart failure	2556 (16.6)	40,358 (19.3)	1.198	1.147–1.252	<0.001
Diabetes without complications	5141 (33.5)	78,776 (37.7)	1.201	1.161–1.244	<0.001
Diabetes with complications	2755 (17.9)	37,884 (18.1)	1.012	0.970–1.057	0.573
COPD	4880 (31.8)	80,726 (38.6)	1.35	1.304–1.399	<0.001
Cerebrovascular disease	2410 (15.7)	46,921 (22.4)	1.555	1.487–1.626	<0.001
Dementia	1148 (7.5)	35,859 (17.1)	2.565	2.411–2.725	<0.001
Chronic renal disease	1607 (10.5)	20,635 (9.9)	0.937	0.888–0.989	0.018
Chronic liver disease	215 (1.4)	6711 (3.2)	2.336	2.043–2.686	<0.001
Any tumour*	1385 (9.0)	35,245 (16.9)	2.045	1.934–2.165	<0.001
Metastatic solid tumor	201 (1.3)	9903 (4.7)	3.749	3.267–4.329	<0.001

Values are expressed as the mean ± standard deviation or number (%).
**Includes leukaemia and lymphoma.*
HR—Hazard ratio. CI—confidence intervals. COPD—Chronic obstructive pulmonary disease.

TABLE 2. Disability level in 30-day survivors and comparison of disability level between 1-year survivors and non-survivors.

Variables	Total (n = 22,455)	1-year survivors (n = 13,552)	Non-survivors (n = 8903)	*p*-value
Disability developed	2664 (11.9)	2269 (16.7)	395 (4.4)	<0.001
Disability grade				<0.001
Severe (1–3)	2133 (80.1)	1791 (78.9)	342 (86.6)	
1	1217 (45.7)	1045 (46.1)	172 (43.5)	
2	626 (23.5)	500 (22.0)	126 (31.9)	
3	290 (10.9)	246 (10.8)	44 (11.1)	
Mild (4–6)	531 (19.9)	478 (21.1)	53 (13.4)	
4	161 (6.0)	141 (6.2)	20 (5.1)	
5	207 (7.8)	188 (8.3)	19 (4.8)	
6	163 (6.1)	149 (6.6)	14 (3.5)	
Types of disability				<0.001
Physical	279 (10.5)	227 (10.0)	52 (13.2)	
Encephalopathic	1445 (54.2)	1261 (55.6)	184 (46.6)	
Visual	69 (2.6)	55 (2.4)	14 (3.5)	
Auditory	101 (3.8)	90 (4.0)	11 (2.8)	
Language	17 (0.6)	15 (0.7)	2 (0.5)	
Intellectual	64 (2.4)	63 (2.8)	1 (0.3)	
Mental	49 (1.8)	30 (1.3)	19 (4.8)	
Renal	428 (16.1)	350 (15.4)	78 (19.7)	
Cardiac	113 (4.2)	103 (4.5)	10 (2.5)	
Pulmonary	61 (2.3)	44 (1.9)	17 (4.3)	
Hepatic	16 (0.6)	12 (0.5)	4 (1.0)	
Others	22 (0.9)	19 (0.8)	3 (0.8)	

Values are expressed as the number and percentage.

in both groups, followed by renal, physical, and cardiac disabilities. The prevalence of encephalopathic disabilities was higher in 1-year survivors than in non-survivors (55.6% *vs*. 46.6%), while renal (15.4% *vs*. 19.7%) and physical (10.0% *vs*. 13.2%) disabilities were more frequent in non-survivors. Cardiac disability was more frequent in 1-year survivors (4.5% *vs*. 2.5%), while pulmonary disability was more frequent in non-survivors (1.9% *vs*. 4.3%). Intellectual disability was diagnosed in 63 1-year survivors, and in one non-survivor.

3.4 Disability grade according to category

Fig. 2 presents a detailed disability grade according to the category. Most patients with an encephalopathic disability were grade 1 in both groups (77.0% *vs*. 78.8%). Among patients with a cardiac disability, grade 3 was the most frequent in both groups (54.4% *vs*. 60.0%). In the 1-year survivor group, 26 patients (25.2%) were assigned to grade 5, which was the second most frequent. Pulmonary disability was most severe in both groups; however, the order differed. Among 1-year survivors, grade 2 was the most frequent, followed by grades 1 and 3 (36.4% *vs*. 34.1% *vs*. 25.0%, respectively). On the other hand, grade 1 was the most frequent among non-survivors, followed by grades 2 and 3 (52.9% *vs*. 23.5% *vs*. 17.6%, respectively). With respect to physical disability, a mild disability grade was more frequent in 1-year survivors than in non-survivors (61.2% *vs*. 40.4%). The distribution of the degree of physical disability was relatively even in both groups. A detailed number of patients in each group are presented in **Supplementary Table 1**.

4. Discussion

The main finding of this study was that 11.9% of 30-day OHCA survivors had newly developed disabilities, including encephalopathic, physical, renal, and cardiac disabilities, among others. Further, approximately 80% of patients with disabilities had severe grade disabilities.

In this study, approximately 40% of OHCA survivors died within the 1-year follow-up. This rate was much higher than that in the previous study that reported a 1-year mortality of 8.2% when assessing long-term outcomes of OHCA survivors [16]. However, Chocron *et al*. [17], who evaluated an association between functional status at discharge and long-term survival, reported that survivors with unfavourable outcomes showed a 1-year mortality of 44.2%, which is similar to the

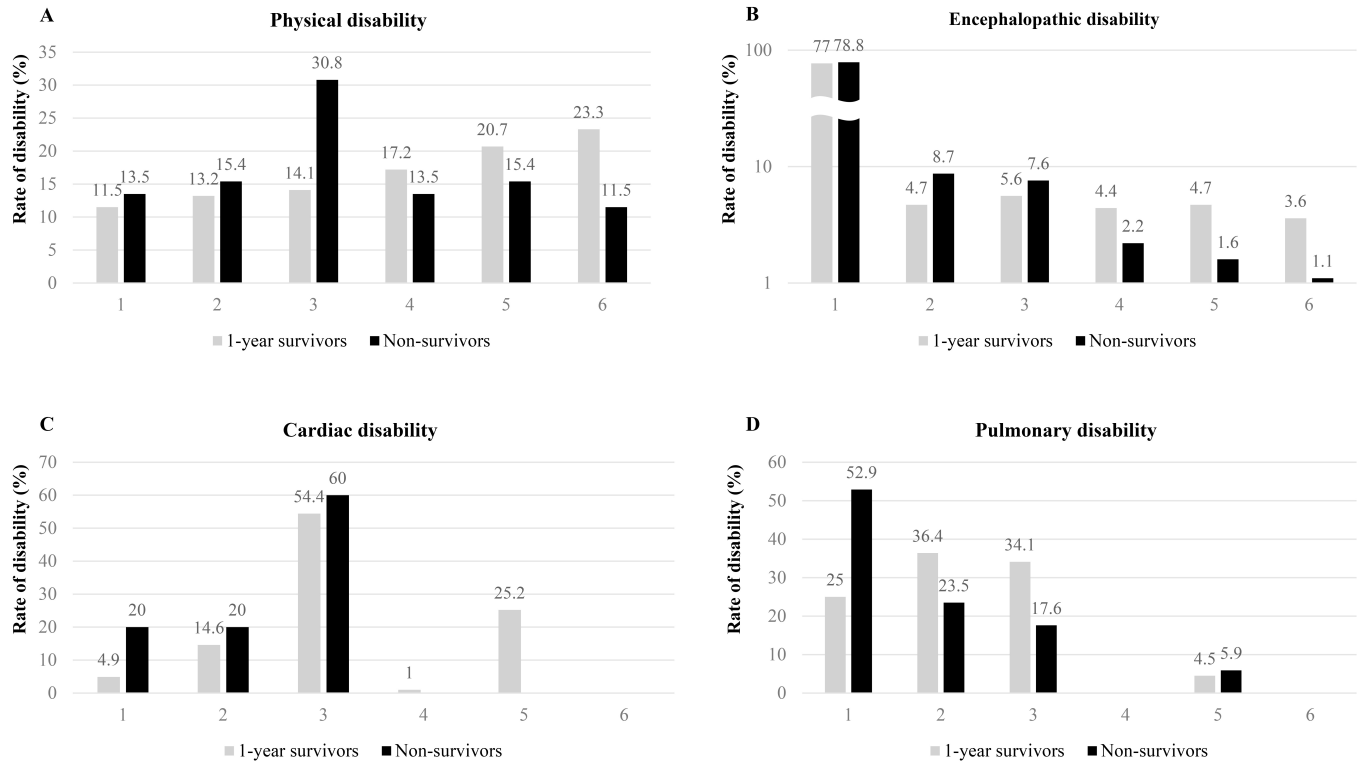

FIGURE 2. Disability grade according to category. (A) Physical disability; (B) Encephalopathic disability; (C) Cardiac disability; (D) Pulmonary disability.

result of our study. An explanation for this discrepancy might be that this study was not conducted in a country where withdrawal of life-sustaining treatment is not widely practiced. This suggests that our study included more patients with poor outcomes.

The prevalence of disability was higher in 1-year survivors than in non-survivors. This does not necessarily indicate that patients with a disability have a better chance of long-term survival. Rather, since diagnosing a disability requires a considerable observation period, most non-survivors might die before a diagnosis is made. The frequency of encephalopathic and intellectual disability was lower in non-survivors. Patients with these disabilities, which are mainly associated with cerebral function, had poor neurologic outcomes. As discussed above, patients with a poor CPC died earlier; thus, the mortality was higher before a diagnosis of disability in 1-year non-survivors.

Among 1-year survivors with disabilities, most patients are diagnosed with severe grade disabilities other than physical disabilities. This suggests that patients are more likely to develop severe disability. The reason for the discrepancy between physical and other disabilities might be due to differences in pathogenesis. Previous studies reported that patients admitted to the intensive care unit owing to critical illness developed physical dysfunction [18–20]. Thus, physical disability after OHCA might be caused by intensive care post-cardiac arrest, and not by hypoxic brain injury caused by cardiac arrest itself.

However, approximately 20% of patients with disabilities had a mild grade. As there was no established follow-up plan for OHCA survivors during the study period, it is possible that that there were more patients with a mild form of disability, who may have been lost to follow-up. Patients who are still in a comatose state or in an unresponsive state of wakefulness one month after cardiac arrest rarely recover [3, 21]. However, Peskine *et al*. [22] evaluated the long-term disability of patients who awakened during the first 2 weeks, and found that patients who developed a disability could recover within 18 months after cardiac arrest. This suggests that patients with a mild disability could potentially recover with rehabilitation. A previous randomized controlled trial found that early intervention in cardiac arrest survivors led to faster recovery with cost-effectiveness [23, 24]. In 2020, Korean guidelines for Cardiopulmonary Resuscitation were updated [25]. The guideline recommends that cardiac arrest survivors have multimodal rehabilitation assessment and treatment for physical, neurological, cardiopulmonary, and cognitive impairments before hospital discharge. Still, structured follow-up plans for individuals and specific rehabilitation system were not widely established and applied. Specific long-term care plans would be helpful for physicians to use. For example, it would be practical to set a particular follow-up date with multidisciplinary evaluation for impairment, such as at 4, 6, and 12 months after discharge. Telephone consultation might be an alternative approach for patients who cannot visit the outpatient clinic. Future multicentre study is needed to follow up patients and assess the effectiveness of early rehabilitation for long-term disability in OHCA survivors.

The World Health Organization (WHO) defines disability as the outcome of the interaction between a person's health condition and the context in which the person lives [26]. It compasses three aspects of the interaction, including impair-

ments, activity limitations, and participation restriction. However, the Korean disability grading system was mainly focused on measuring disability in terms of impairments. The reason for dividing people with disability into various grades is that not only do they have different medical needs, but also some benefits are determined by this definition of severity [27]. This study has strength in evaluating newly appeared disability after cardiac arrest as an objective measure. Still, accompanying limitation exists that subjective feeling and difficulty might not be not fully assessed.

Our study has several strengths. First, this was a large, nationwide study assessing patients admitted over a substantial period to all emergency departments. Second, most studies that evaluated the long-term outcomes of OHCA survivors generally used the CPC or mRS scores, which are mainly associated with neurological outcomes [2, 28]. This study used disability grade, which encompasses physical and medical disabilities, which cannot be differentiated with CPC and mRS. Furthermore, as the specialist of each department diagnosed the disability grade, with considerable time to confirm a diagnosis, this was a more objective measure of outcome. However, this study also has several limitations. First, there is an inherent methodological limitation of a nationwide observational study. The potential impact of confounding factors would be significant, and the generalizability of these data is thus limited. Second, the NHIS database does not include each CPR's clinical data; therefore, we could not analyse the risk factors associated with a long-term disability. Third, data about the conditions for which patients are presented in the emergency room and the period of survival after the acute episode is missing. This information could be important to analyze specific risk factors for developing disability and the effect of disability on the patient's survival. Fourth, there could be a possibility that disabilities can result not only from post-cardiac arrest syndrome and but also from other specific underlying disease progressions. Due to inherent limitation of population-based study, the specific reason for developing disability could not be proven. However, this type of study deals with a large number of patients so that it could provide valuable information about the trends of developing disability after cardiac arrest. Fifth, as approaches to measuring disability vary across countries, the results of this study would not be generalized to other developing countries.

5. Conclusions

Among 30-day OHCA survivors, 11.9% of patients developed various disabilities, including encephalopathic, physical, renal, and cardiac disabilities. Physicians should be aware of the risk of the development of such disabilities and efforts to treat these disabilities in OHCA survivors should be increased.

AUTHOR CONTRIBUTIONS

WYK—Conceptualization; WYK, YeJK, YounJK, SMK—Methodology; YeJK, YounJK, SMK—Data curation; WYK, YeJK, YounJK, SMK—Formal analysis; YeJK, YounJK, SMK—Validation; YounJK, SMK—Visualization; YJK, SMK—Writing original draft preparation; WYK—Writing review and editing; WYK—Supervision, all authors have read and approved the manuscript.

ETHICS APPROVAL AND CONSENT TO PARTICIPATE

Not applicable.

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CONFLICT OF INTEREST

The authors declare no conflict of interest. Won-Young Kim is serving as one of the Guest editors of this journal. We declare that Won-Young Kim had no involvement in the peer review of this article and has no access to information regarding its peer review. Full responsibility for the editorial process for this article was delegated to OK.

SUPPLEMENTARY MATERIAL

Supplementary material associated with this article can be found, in the online version, at https://oss.signavitae.com/mre-signavitae/article/149678371686257 4592/attachment/SV2021120802-Supplementary%20Table%201-layout1.docx.

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