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Determinants of cognitive outcome in survivors of out-of-hospital cardiac arrest☆

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ABSTRACT

Aim: To describe cognitive functioning with neuropsychological tests and examine predictors of cognitive outcome in adult survivors of out-of-hospital cardiac arrest (OHCA) of cardiac cause.
Method: The study was prospective and took place at the University hospital of North-Norway. Only patients eligible of neuropsychological assessment three months after OHCA were asked to participate. Cognitive test performance was compared to large samples of age-corrected normative data. General linear models were used to determine predictors of a cognitive composite score and performance on separate cognitive tests. The predictors assessed were coma duration, hypothermia treatment and time to restoration of spontaneous circulation. We aimed to control for demographic variables, medical comorbidity and affective symptoms.
Results: 45 survivors (4 women) completed the assessment. Neuropsychological tests of fine motor functioning, memory, attention and executive functions were significantly below normative means. Depending on the test, impairment ranged from 9 to 31%. For twenty-five survivors (56%), all cognitive tests were within the normal range. Shorter coma duration and induced hypothermia treatment were associated with favourable cognitive outcomes and explained 45% of the variability in the cognitive composite score. Coma duration was predictive across all cognitive tests, hypothermia treatment of specific tests of memory, attention and executive functioning.
Conclusions: Cognitive outcome was normal in more than half of the survivors. Shorter coma duration and induced hypothermia were associated with favourable cognitive outcomes in the participating survivors three months after OHCA.
Institutional protocol number: 2009/1395.

1. Introduction

Survivors of out-of-hospital cardiac arrest (OHCA) are at risk of cognitive impairments resulting from hypoxic–ischaemic encephalopathy.[1] Concern exists that persistent, mild to moderate cognitive disability is underdiagnosed because sensitive measures are not systematically applied during outcome evaluations.[1–4]

Clinical neuropsychological assessment provides standardised, objective and reliable measures of cognitive functioning using psychometrically sophisticated and well-validated procedures. Assessment has been proven useful for differential diagnosis purposes, for allocating rehabilitation resources and for predicting patients' real-world activities after brain injury in general and hypoxic–ischaemic injury specifically.[5–10]

Few previous prospective studies have investigated residual cognitive deficits in OHCA survivors using standard neuropsychological measures. Systematic reviews of the research literature conclude that only five prospective, qualitatively sound studies are informative of cognitive outcome after OHCA.[1,11] From these studies, it can be generalised that cognitive impairments occur in 20–50% of survivors and are most often mild to moderate

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in severity. Simultaneous impairment in executive functions, attention and memory functions are most frequently reported, as are deficits in fine-motor functioning and visual–spatial conceptualisation.[1,4,5,11–15]

The variability in cognitive outcome severity is reliably predicted by the duration of unconsciousness. Patients who spend shorter periods in coma and those awake at hospital admission have the best cognitive prospects.[1,4,5,11,12] Inconsistent and contradictory results have been reported regarding the impact of resuscitation times, demographic variables and medical comorbidities on cognitive outcome.[1,4,5,12,13,15] Therapeutic hypothermia is recommended for all patients with a shockable cardiac rhythm who remain unconscious after restoration of spontaneous circulation (ROSC).[16] Hypothermia treatment has increased survival rates and reduced the prevalence of survivors with severe functional disability.[17–19] Only two studies have investigated the impact of hypothermia treatment on cognitive functioning using standard neuropsychological measures, and no significant effects could be documented.[1,11,14] There is still no evidence that therapeutic hypothermia reduces the risk of mild to moderate cognitive impairment.[20]

In the present prospective study, neuropsychological tests were administered 45 OHCA survivors three months after successful resuscitation. Our first aim was to describe cognitive functioning with neuropsychological tests. We expected tests of memory, attention and executive functions to be most frequently impaired.[11,21] Our second aim was to identify predictors from the acute stage that could account for variability in cognitive outcome. The predictors examined were coma duration, time to ROSC and hypothermia treatment. We controlled for demographic variables, previous cardiac disease and affective symptoms that can influence cognitive performance.[9] We hypothesised that coma duration would predict outcome severity.[22]

2. Methods

2.1. Patients

We aimed to prospectively include all survivors of sudden, non-traumatic, normothermic OHCA of presumed cardiac aetiology, aged 18–85 years, discharged alive from the cardiac ward at the University Hospital of North-Norway between August 2010 and September 2013 and who were able to perform neuropsychological testing three months post-resuscitation.

The hospital is the regional hospital of the northern health region in Norway, covering the three northernmost counties with a combined population of 456,000 distributed over a geographic area of 112,000 km^2. The hospital serves smaller local hospitals in a regional manner. According to hospital records 197 patients were treated at the cardiac ward for an OHCA in the study period. Patients that died before or during hospital admission were not registered. 129 of these OHCA's were of cardiac cause with survival to discharge. Predefined exclusion criteria (Fig. 1) were designed to control for suboptimal cognitive functioning prior to OHCA or conditions that might have interfered with the validity of test recordings. The study was approved by The Regional Committee for Medical Research Ethics in North-Norway, institutional protocol number 2009/1395.

2.2. Procedure

The procedure was a neuropsychological examination consisting of an anamnestic interview, neuropsychological testing and completion of the Hospital Anxiety and Depression Scale (HADS).[23] The patients' work and living situations before OHCA and at the time of assessment were recorded. The procedure lasted approximately 3 h, including breaks. The assessments were conducted by different certified neuropsychologists at the Department of Rehabilitation where the assessment took place. The Hospital Anxiety Depression Scale (HADS) was included to screen for affective symptoms, which can influence the outcome of cognitive tests.[24] Neuropsychological tests were selected to cover several cognitive domains such as psychomotor speed, attention, working memory, executive functions, fine-motor functions, verbal- and visual learning and memory in addition to indicators of general intelligence. All tests have well-established test procedures and are available in Norwegian translations. The published norms used in this study are well-known, and the data used for each test are based on large samples of age-matched subjects. Table 2 displays the neuropsychological tests included.

Medical data, data concerning the OHCA and resuscitation were collected from the patient's medical records where resuscitation variables are recorded according to the Utstein criteria.[31] Coma duration was calculated from estimated time of arrest to any documentation of purposeful behaviour. Therapeutic hypothermia was, according to the medical records, performed as recommended by international guidelines for hypothermia treatment[16] where a body temperature of 32–34 °C was reached as soon as possible for patients that remain unconscious after ROSC, unless contraindications for hypothermia were present.[16]

2.3. Statistical analyses

All continuous variables used in the statistical analyses were normally distributed according to the Kolmogorov–Smirnov test. Correlation analyses were performed using Pearson product-moment correlations (two-tailed). Group comparisons were performed using general linear model analysis of variance. Raw scores from the different neuropsychological tests were first transformed to normative scores (*T*-scores, Wechsler scores or scaled scores) using age-corrected published normative data. Then, all test scores were standardised to *Z*-scores (mean = 0, SD = 1) to allow for comparisons between test scores from different distributions. One-sample *t*-tests were used to examine whether the *Z*-scores for the mean of each neuropsychological test were significantly different from 0. The cut-off for impaired versus normal performance for the mean of the separate neuropsychological tests (displayed in Table 3) was set to ≤ -1.5 standard deviations (SDs) below the normative mean. A cut-off of ≤ -1.5 SD was deemed more reasonable than a cut-off of ≤ -1.0 SD because a large number of subtests were administered to each patient.[10]

The cut-off criteria for the HADS total score were set to 15 points. An eight-point cut-off was used for both the depression and the anxiety subscales when they were assessed separately.[23]

To reduce the number of dependent variables in the regression analyses, a single cognitive composite score was calculated using the mean of the *Z*-scores across all neuropsychological tests. When using *Z*-scores, all included tests weight equally in the composite score due to normalisation. IQ was not included in the cognitive composite score. Overlapping variance across neuropsychological tests is well known, even when each test is designed to target one main function, and the sample size was not large enough to assign different test scores to separate functional domains using factor analysis.[9,11] The composite score gives a convenient estimate of average cognitive performance across tests for each individual to be used in the regression analysis, however it is not informative about domain specific impairments and has no normative data.

Linear stepwise regressions (backwards selection) were conducted using the cognitive composite score as the dependent variable and the following predictors: coma duration (in hours), time to ROSC (in minutes), previous cardiac disease (yes/no), HADS

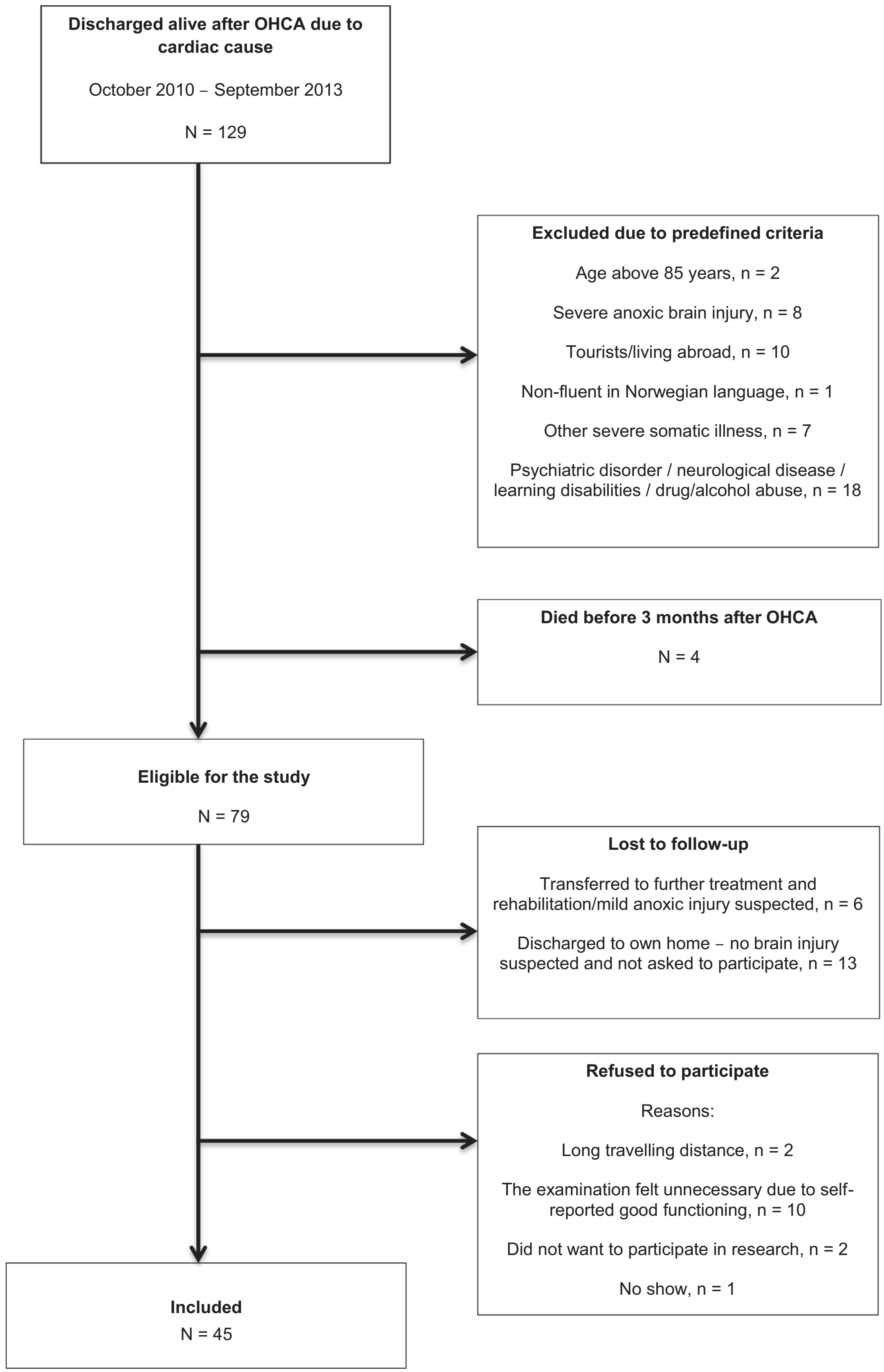

Fig. 1. Overview of enrolment and exclusion. In addition to the predefined exclusion criteria shown in Fig. 1, previous cardiac arrest and cardiac surgery during the last year before OHCA were set as predefined reasons for exclusion. None of the patients included had experienced previous cardiac arrest nor had they cardiac surgery in the last year before OHCA.

Table 1
Characteristics of the sample. N = 45. CPR = cardiopulmonary resuscitation. DC = direct current. VF = ventricular fibrillation. AF = atrial fibrillation. ROSC = return of spontaneous circulation. PCI = percutaneous coronary intervention. CABG = coronary artery bypass grafting. ICD = implanted cardioverter defibrillator.

Variable	Number (%)	Mean (SD)	Min–max
Baseline info of patients before OHCA (N = 45)			
Age		60.4 (12.4)	18–83
Age > 70 years	9 (20)		
Male	41 (91.1)		
Female	4 (8.9)		
Marital status			
Married	36 (80)		
Unmarried	9 (20)		
Years of education		11.5 (4)	5–22
Education >12 years	15 (33.3)		
Employed	23 (51.1)		
Not employed	22 (48.9)		
Any previous diagnosed cardiac condition			
Yes	21 (46.7)		
No	24 (53.3)		
Previously diagnosed cardiac condition			
Myocardial infarction	10 (22.2)		
Ischaemia	2 (4.4)		
Hypertension	9 (20)		
Diabetes			
Yes	3 (6.7)		
No	42 (93.3)		
Cardiac arrest and resuscitation			
Witnessed arrest			
Yes	44 (97.8)		
No	1* (2.2)		
Bystander CPR			
Yes	45 (100)		
No	0 (0)		
Number of DC shocks (n = 45)		2.7 (2.4)	1–11
First registered cardiac rhythm			
VF	43 (95.6)		
AF	1 (2.2)		
Asystole	1 (2.2)		
Minutes to ROSC from collapse		17.6 (12.5)	1–60
Minutes from collapse to ambulance arrival		12	1–40
Presumed cause of arrest			
Infarction	36 (80)		
Arrhythmia	7 (15.6)		
Unknown	2 (4.4)		
Coma duration in hours		39.9 (51)	2 min to 192 h
Cardiac treatment			
Awake upon admission	13 (28.9)		
Hypothermia treatment			
Yes	19 (42.2)		
No**	26 (57.8)		
PCI			
Yes	36 (80)		
No	9 (20)		
CABG			
Yes	2 (4.4)		
No	43 (95.6)		
ICD implantation after arrest			
Yes	15 (33.3)		
No	30 (66.7)		
Neurological deficits (paresis)			
Yes	3 (6.7)		
No	42 (93.3)		
Length of hospital stay in days			
Intensive Care Unit		5.05 (3.97)	1–14
Cardiac Ward		12.05 (7.25)	5–41

* The patient with an unwitnessed arrest displayed neuropsychological scores within the normal range and had no neurological deficits at 3 months post-arrest.
** For the 14 patients unconscious at admission that did not receive hypothermia treatment, the following contraindications were present: pneumonia (n = 3), probable severe bleedings (n = 4), uncertain level of consciousness after admission (n = 4), surgical procedures (n = 3).

Table 2
Overview of the neuropsychological tests used in the present study.

Test name	Cognitive domains
California Verbal Learning Test II.[26]	Verbal learning (List A Trials 1–5), memory interference (List B), short- and long term memory (free and cued recall of List A) and long-term recognition of List A.
Rey's complex Figure Test.[28]	Visuo-spatial ability, short- and long-term visual memory (copy-trial, immediate recall, delayed recall and visual recognition)
Wechsler Memory Scale-3[29]:	
Memory Span: Verbal- and Visual span, both forwards and backwards.	Attention and working memory.
Delis–Kaplan Executive Functioning System (D–K)[27]:	
D–K Trail–Making Test 1–5.	Psychomotor speed and executive functioning.
D–K Color-Word.[27]	Executive functioning. Selective attention and response inhibition.
D–K Verbal Fluency.[27]	Executive functioning. Rapid word generation and verbal flexibility.
Grooved Pegboard[25] – both hands.	Fine motor functioning.
Wechsler Abbreviated Scale of Intelligence (WASI).[30] Subtests:	
Matrix Reasoning, Block Design, Vocabulary and Similarities.	General cognitive ability (IQ).

scores and hypothermia treatment (yes = 1, no = 0). To control for the potential confounding with years of education and age, these variables were included in the initial model.[9] Other possible predictor variables such as sex, marital status, initial cardiac rhythm, observed cardiac arrest, bystander resuscitation and cardiac treatment (PCI/CABG) were omitted because of very little variability (see Table 1). A multivariate general linear model was used to further examine the impact of the significant predictor variables from the regression analysis on the separate neuropsychological tests.

Missing data for two patients were replaced by the individual mean. Missing data were found in two tests for one patient and in three tests for another. Thus, five values were replaced with the mean of the variable for which data were missing. All data were analysed using the IBM SPSS v.21 package. A p-value ≤ 0.05 was considered significant for all analyses.

3. Results

3.1. Sample characteristics

After exclusion due to the predefined criteria, loss to follow-up and refusal to participate (Fig. 1), 45 survivors completed the neuropsychological assessment three months post-resuscitation. Demographic and clinical characteristics of the included survivors are displayed in Table 1.

Table 3
Neuropsychological results. SD: standard deviation. All scores are displayed as transformed Z-scores to allow comparison between tests (mean = 0, standard deviation = 1), with the exception of WASI IQ, which is displayed in terms of Wechsler scores (normative mean = 100, standard deviation = 15). CVLT II: California Verbal Learning Test II. WMS-3: Wechsler Memory Scale 3. DK = Delis–Kaplan Executive Function System. WASI: Wechsler Abbreviated Scale of Intelligence.

Variable	Mean	SD	Min	Max	% Below 1.5 SD
CVLT II	−.53*	1.05	−3.17	1.42	13.3
Rey's complex figure	−.16	1.77	−3.33	2.17	30.8
WMS-3 Memory Span	−.27	1.09	−3.67	1	9.8
DK Trail-Making test	−.10	1.10	−3.60	1.60	8.9
DK Color-Word	−.40*	1.23	−4.0	1.75	15.4
DK Verbal Fluency	−.26	1.30	−4.0	2.25	12.5
Grooved Pegboard	−.66*	1.02	−3.25	1.5	12.2
Cognitive composite score	−.31*	.94	−3.22	1.02	13.3
WASI IQ	99.39	13.23	65	126	15.9

* Z-scores that are significantly ($p < 0.05$) different compared with the expected normative value (0).

3.2. Functional outcome

Of the twenty patients who were working prior to their OHCA, four (9%) had returned to work at the time of the neuropsychological assessment. All of the survivors had been independent in their daily life prior to the cardiac arrest. The living situation at follow-up was unaltered in 43 patients, while two patients still received in-hospital rehabilitation.

Total HADS scores were generally low indicating absence of clinical significant symptoms of anxiety or depression (mean HADS total = 4.8, SD = 4.41, min = 0, max = 16). Five patients (11.1%) scored above the cut-off on the HADS anxiety subscale (mean = 3.13, SD = 2.93, min = 0, max = 11) indicating increased anxiety level. None of the patients scored above the cut-off on the depression subscale (mean = 1.68, SD = 1.94, minimum = 0, max = 6).

Neuropsychological results are displayed in Table 3. The CVLT-II, the Grooved Pegboard and the D-Kefs' Color-Word Test scores were significantly lower compared with normative values from the reference populations. Depending on the test, impairment ranged from 9 to 31% when the cut-off for impairment was ≤−1.5 SD from the normative mean. Twenty-five patients (55.6%) had all average tests scores above the cut-off, indicating absence of any cognitive impairment. Six patients (13%) had more than three average test scores below −1.5 SD, and fourteen patients (31%) had one or two average tests scores at or below the cut-off. We suggest that this gives an indication of the number of survivors in the unimpaired, moderate to severely impaired and mild impairment range. If this selected test battery consisting of 6 neuropsychological tests with an average correlation of $r = .54$ had been used in a general population, the percentage of the population expected to produce 1 or more test scores below −1.5 SD would be 18.64%. This assumption was based on data estimating the proportion of cognitive impairment in the general population when the average correlation between the tests is $r = .50$.[32,33]

3.3. Associations of demographic and medical factors with functional outcome

The mean time from OHCA to neuropsychological examination was 114 days (range 80–131). There was no significant correlation between time to administration of testing and the cognitive composite score ($r = 0.23$, $p = 0.3$). Significant correlations between the

Table 4
Stepwise regression analyses with the cognitive composite score as the dependent variable. Coma duration is displayed in hours. Hypothermia treatment was coded as 0 = no (hypothermia treatment) and 1 = yes. A previously diagnosed cardiac condition was coded as 0 = yes (previous cardiac condition) and 1 = no. Time to ROSC indicates the time in minutes from collapse to the return of spontaneous circulation. Excluded variables were removed in the second step of the analysis for regressions 1 and 2. Collinearity statistics displayed variance inflation factors (VIFs) < 1.04 for the significant predictors in regression 1 and VIFs < 1.01 for regression 2. No outliers more than 2 standard deviations from the regression line were detected in the significant models.

Regression 1: All patients. ($R^2 = .45$, $F(2, 44) = 17.34$, $p < 0.001$), $n = 45$.				
Included variables	B	t	β	p
Coma duration	−.01	−5.81	−.68	<.001
Hypothermia	.44	2.06	.24	.046
Excluded variables	B	t	Partial correlation	p
Years of education	.15	1.26	.19	.21
Previously diagnosed cardiac condition	.17	1.47	.22	.15
Time to ROSC	−.20	−1.73	−.26	.09
Age above 70	.004	.03	.005	.97
HADS	−.11	−.88	−.14	.38
Regression 2: Patients who were unconscious upon admission. ($R^2 = .48$, $F(2, 31) = 13.55$, $p < 0.001$), $n = 32$.				
Included variables	B	t	β	p
Coma duration	−.01	−4.55	−.61	<.001
Hypothermia	.56	2.08	.28	.046
Excluded variables	B	t	Partial correlation	p
Years of education	.01	.08	.02	.94
Previously diagnosed cardiac condition	.17	1.23	.22	.23
Time to ROSC	−.18	−1.39	−.26	.17
Age above 70	.03	.21	.04	.84
HADS	−.06	−.44	−.08	.66

Table 5
Multivariate linear analysis of variance. The association between significant predictors (coma duration in hours and hypothermia treatment) for the cognitive composite score and performance on specific neuropsychological tests. CVLT II: California Verbal Learning Test II. WMS-3: Wechsler Memory Scale 3. DK = Delis–Kaplan Executive Function System. η^2 = eta squared.

	Coma duration			Hypothermia		
	F	η^2	*p*	*F*	η^2	*p*
CVLT II	20.35	.33	<.001	4.21	.09	.047
Rey's complex figure	16.25	.28	<.001	.1	.003	.75
WMS-3 Memory span	20.26	.33	<.001	4.38	.043	.10
DK Trail-Making test 1–5	5.36	.12	.03	.14	.003	.71
DK Color-Word	12.70	.24	.001	13.76	.25	.001
DK Verbal Fluency	6.37	.13	.02	7.24	.15	.01
Grooved Pegboard	8.81	.18	.005	.49	.01	.49

cognitive composite score and other demographic and resuscitation variables from Table 1 were found for coma length ($r = -.45$, $p = .02$) and for IQ ($r = .62$, $p < 0.001$). There were no significant correlation between HADS scores and the cognitive composite score ($r = .11$, $p = .48$), or HADS and employment status at follow-up ($r = .29$, $p = .08$). Employment status had no significant correlation with the cognitive composite score ($r = .09$, $p = .53$). Length of hospital stay were not correlated with the cognitive composite score ($r = .27$, $p = .17$) One-way ANOVA revealed no group differences in the cognitive composite score related to ICD or the variable "previous cardiac disease", PCI treatment, age above 70 years, hypothermia treatment or patients awake upon hospital admission (all *F*'s < 3.6, all *p* values >.07). No significant group differences between the patients who received therapeutic hypothermia and those who did not were found for any of the following variables: IQ, age, education, "previous cardiac disease", PCI, coma duration, time to ROSC or HADS scores (all *F*'s < 1.82, all *p*-values >.19). Leaving out patients awake at admission did not significantly change the above mentioned differences (all *F*'s < 2.3, *p*-values >.14).

3.4. General linear models

The regression model explained 45% of the variance in the cognitive composite score ($R^2 = .45$, $F(2, 44) = 17.34$, $p < 0.001$). Coma duration and hypothermia treatment had significant impact on the cognitive composite score. Leaving out patients who were awake upon their arrival at the hospital and therefore not considered for therapeutic hypothermia did not change the impact of the significant predictors found in the total sample ($R^2 = .48$, $F(2, 31) = 13.55$, $p < 0.001$). Table 4 presents the full statistics of the models.

The results from the multivariate analysis are displayed in Table 5. Coma duration had a significant effect on every cognitive test separately, while hypothermia treatment significantly predicted better performance on the following cognitive tests: the CVLT-II, the Memory span tests from WMS-III and the Color-Word and the Verbal-Fluency tests from the D-Kefs battery.

4. Discussion

We prospectively evaluated cognitive performance in a sample of 45 adult OHCA survivors three months after successful resuscitation with neuropsychological tests. The scope was twofold; to describe cognitive functioning and determine predictors of the variability in cognitive outcome.

Small sample size and possible selection bias are obvious limitations. The survivors examined were predominantly men. They survived a witnessed cardiac arrest, of cardiac cause, with initial shockable registered cardiac rhythm. Bystander CPR was initiated and ROSC was achieved within 60 min for all participants. It is affirmed that OHCA victims who receive CPR from a bystander or an emergency medical service provider, and those who are found in shockable rhythms (VF/VT), and who achieve ROSC before hospital admission are much more likely to survive that those who do not.[31,34] Further, we included only survivors able to perform neuropsychological assessment after three months, which is not the case for every cardiac arrest survivor.

A three-month interval from resuscitation to neuropsychological testing was chosen because cognitive recovery is assumed to be limited after this period of time, although it might not be the end-point[1,13,15,21] Also, there might be different trajectories of cognitive recovery for different cognitive functions, different potential of recovery according to the severity of the hypoxic event as well and individual differences in recovery potential.[22]

A minority of the participating survivors had obvious cognitive disability with poor performance across a large number of neurocognitive test. The most common result was cognitive functioning in the normal range or less-pronounced impairments. However, even milder forms of cognitive decline following from OHCA can hamper return to previous social roles and premorbid level of functioning.[1,4,10,22,35] For the group as a whole, fine-motor functioning, aspects of memory, attention and executive functions were significantly impaired, as expected based on previous reports.[1,11,12,14,15] Our results support that cognitive measures administered after OHCA should include a focus on executive functions, attention and memory functions.[20] However, these are highly complicated and interrelated neurocognitive processes,[5,21,36] and the diagnosis of subtle cognitive decline can be challenging.[10,11] At present, we do not know which cognitive tests are best able to diagnose residual neurocognitive deficits following OHCA.[8]

Coma duration and hypothermia treatment were significant predictors for the cognitive composite score, and the total variance explained was approximately 45% for both the whole-sample model and for the model consisting of only patients who were unconscious upon admission. Time to ROSC was not a significant predictor. The lack of significance may be a result of the limited sample size. However, previous studies using time to ROSC as a predictor for neuropsychological tests found both good and poor cognitive outcomes for the same delays.[1,5,15]

We expected longer coma duration to predict worse cognitive outcome.[1,4,5,11,12,22] Accordingly, our analysis of the impact of coma duration on separate cognitive tests showed that performance on all included tests was negatively affected by longer coma duration. We did not expect to observe hypothermia treatment as a predictor of cognitive outcome.[11,14] Hypothermia treatment predicted better cognitive results on both the cognitive composite score and the specific cognitive tests.

Large clinical trials have documented improved survival rates and better neurological outcomes after hypothermia treatment.[17,18] It is currently debated whether cooling or temperature management in general is the central component in the outcome improvement observed.[19] Whether controlling or manipulating temperature influences milder, more subtle cognitive impairments has not been documented yet.[19] The present design is unable to show the true effect of hypothermia treatment on cognitive outcome.[37] Our results may indicate which cognitive functions are most relevant to assess and which neuropsychological tests to include in future scientific investigations of the impact of hypothermia treatment or temperature management on cognitive outcome. In the present study hypothermia treatment was actually a stronger predictor compared with coma duration for performance on the specific executive function tests.

To reduce uncertainty about the cause of cognitive impairment, survivors with various comorbidities were excluded from this study. Such exclusions most likely skewed both the cognitive scores and HADS scores in the positive direction.[1,38] Still, neuropsychological tests are not conclusive about the cause of impairment.

Neither can they detangle the proportion of cognitive decline due to OHCA from other factors. For instance, all the OHCA survivors have experienced critical illness and spent time as intensive care patients, factors that are associated with cognitive impairments regardless of OHCA.[39] Simultaneously, studies comparing cognitive performance between cardiac patients without OHCA and OCHA survivors,[11,13,22] have shown OHCA survivors to perform significantly worse in several cognitive domains compared to the controls. Thus, OHCA can create specific cerebral injuries that explain a significant proportion of the cognitive impairments observed.[40]

Conclusively, the present study adds to the existing prospective neuropsychological reports that do find cognitive impairments to be present in OHCA survivors with otherwise good functional recovery when sensitive neuropsychological measures are applied in outcome evaluations.[22] Future neuropsychological studies should further inform about an abbreviated selection of tests most suitable of cognitive screening after OHCA.[8] Coma duration is consistently reported as a predictor of cognitive outcome after OHCA, but additional risk factors of cognitive impairments may also exist in this patient group. Thus, in clinical practice, the threshold for referring OHCA survivors to neuropsychological assessment should be low.[5,6]

Conflict of interest statement

The authors report no conflicts of interest.

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