Cognitive impairments in survivors of out-of-hospital cardiac arrest: a systematic review

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Review article

Cognitive impairments in survivors of out-of-hospital cardiac arrest: A systematic review[☆]

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ABSTRACT

Objective: To describe the current evidence on the frequency and nature of cognitive impairments in survivors of out-of-hospital cardiac arrest.

Design: Systematic review.

Data sources: Pubmed, Embase, PsychInfo and Cinahl (1980–2006). No language restriction was imposed.

Review methods: The following inclusion criteria were used: participants had to be survivors of out-of-hospital cardiac arrest, 18 years or older, and there had to be least one cognitive outcome measure with a follow-up of 3 months or more. Case reports and qualitative studies were excluded. The articles were screened on title, abstract and full text by two reviewers. All selected articles were reviewed and assessed by two reviewers independently using a quality criteria list.

Results: Out of the 286 articles initially identified, 28 were selected for final evaluation. There was a high heterogeneity between the studies with regard to study design, number of participants, outcome measures and duration of follow-up. In general, the quality of the articles appeared low, with a few positive exceptions.

The reported frequency of cognitive impairments in survivors of out-of-hospital cardiac arrest ranged from 6% to 100%. Memory problems were the most common cognitive impairment, followed by impairments in attention and executive functioning. Three high-quality prospective studies found that cognitive problems occurred in about half of the survivors of out-of-hospital cardiac arrest.

Conclusion: There are few good studies on the frequency of cognitive impairments after out-of-hospital cardiac arrest. However, cognitive problems, in particular memory problems, seem common in survivors of out-of-hospital cardiac arrest.

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[☆] A Spanish translated version of the summary of this article appears as Appendix in the final online version at [doi:10.1016/j.resuscitation.2008.10.034](https://doi.org/10.1016/j.resuscitation.2008.10.034).

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1. Introduction

During a cardiac arrest the brain can suffer from a temporary limitation in blood supply, which can lead to hypoxic brain injury. One of the main clinical consequences of hypoxic brain injury is cognitive impairment. Although cognitive impairments may not be directly visible, they can affect a person's life greatly in daily activities, in participation in society and in quality of life.^{1–3} It is currently unclear how often cognitive impairments occur after a cardiac arrest, and what kind of cognitive problems occur most frequently. Existing publications, dedicated to cognitive function after cardiac arrest, vary in study design, research population and outcome measures used. Some studies report that the incidence of neurological sequelae is remarkably low,^{4,5} while others state that survivors of out-of-hospital cardiac arrest are seriously disabled because of their neuropsychological deficits.^{6,7} To our knowledge, evidence on this topic has not yet been reviewed systematically. The aim of this study is to review systematically current evidence on the frequency and nature of cognitive impairments in survivors of out-of-hospital cardiac arrest.

2. Methods

A systematic literature search was performed using the databases Pubmed, Embase, PsychInfo and Cinahl. Details on the search strategies are presented in Appendix 1. The literature search was performed by the first reviewer (VM) in March 2007. The publications for this review were selected based on the inclusion criteria as described in Table 1.

Two independent reviewers (VM+JV) selected eligible articles (see Fig. 1 for flowchart of the selection process). If the two reviewers disagreed and consensus could not be reached, the third reviewer (CvH) made the final decision. An additional hand search was performed in which the references of the articles selected (*n* = 36) were tracked and personal files of the first reviewer were searched.

Of the 43 articles that were read in full text, all except four were written in English. There were two articles written in German, one in French and one in Hungarian. The Hungarian and French articles were reviewed after translation by native speakers with medical backgrounds.

2.1. Data extraction

The first reviewer (VM) extracted the following data from the articles on a structured form: author, year of publication, study

design, in/exclusion criteria, years of data collection, number of participants, age distribution, characteristics of the control group (if present), outcome measures used, duration of follow-up and the frequency and kind of cognitive impairments. The second reviewer checked the extracted data.

2.2. Quality assessment

The methodological quality of the selected studies was assessed by the two reviewers independently using an adapted version of the quality criteria scoring list of Hayden.⁸ The original criteria scoring list was adapted for our research: one of the six original domains, 'measurement of prognostic factors', was removed because this was beyond the scope of our review. The final quality criteria scoring list intends to measure the risk of bias on five important methodological domains in prognostic cohort studies, namely study participation, study attrition, outcome measurement, study confounding and statistical analysis/presentation. The risk of bias per domain was summarised as low, moderate, or high. To compare the quality of the various studies, we combined the scores on the five domains into one overall quality score. Domains with a low risk of bias received two points, domains with moderate risk of bias one point, and in case of high risk of bias no points were given. This resulted in a total score ranging from 0 (indicating very poor quality) to 10 (indicating excellent quality). A copy of the quality criteria list used can be provided on request to the first author.

3. Results

The initial literature search resulted in 286 titles, extracted from the four databases. Further selection based on title, abstract and full text, resulted in a final selection of 28 articles (see Fig. 1). In Table 2, the inter-observer agreement in the different stages of the selection process can be found.

3.1. Quality assessment

Consensus on quality was reached in all except three articles, for which the third reviewer was consulted. The total quality scores ranged between 0 (very poor) and 10 (excellent). The majority of the articles, 22 (79%), received a score of 6 or below. Only six studies had a total score higher than 6.^{9–14} The study of van Alem was the only study that received the maximum score of 10.¹²

Table 1
Inclusion criteria for the selection of publications.

Participants	Survivors of out-of-hospital cardiac arrest and >18 years old
Type of study	No case-reports or qualitative studies
Outcome measure	Cognitive functioning
Follow-up	>3 months after the cardiac arrest
Year of publication	1-1-1980–31-12-2006
Language	No restriction

Table 2
Agreement between the reviewers during selection process of the articles.

Selection of articles based on	Direct agreement between first and second reviewer	Agreement based on consent	Decision by third reviewer
Title	243 (85%)	34 (12%)	9 (3%)
Abstract	47 (68%)	14 (20%)	8 (12%)
Hand search	9 (56%)	7 (44%)	–
Full text	43 (100%)	–	–

Table 3

Evidence table of the selected studies with a case-control, cross-sectional or retrospective cohort design.

Author, year of publication	Quality score	Study design	N	Measurement instrument(s)	Follow-up in months, mean/median (S.D./range)	Frequency of cognitive impairments	Measured domains that were affected are shown in bold <i>Measured domains that were not affected are shown in italics</i>
Bergner, 1985 ³⁶	2	Case-control	308	Interview	7	38% versus 18%	Memory
Bertini, 1990 ⁴	4	Case-control	30	2 np tests	30 (3–57)	'Remarkably low'	Memory <i>Attention/concentration</i>
Drysdale, 2000 ²²	4	Case-control	10	2 np tests	36	'More than controls'	Memory (recall, recognition and episodic)
Hopkins, 1995 ¹⁷	5	Case-control	11	4 np tests	12	'More than controls'	Memory (especially for novel info) <i>Frontal lobe functioning and visual memory span</i>
Nielsen, 1983 ¹⁸	2	Case-control	13	Interview + 10 np tests	12–36	54% versus 31%	Memory, subtraction, language, abstraction
Grubb, 1996 ⁹	8	Cross-sectional + Case-control	35	3 np tests	7 (4.4)	37% versus 0%	Episodic long-term memory (especially verbal and spatial) <i>Short term recall</i>
Grosswasser, 1989 ¹⁶	1	Cross-sectional	31	Not described	>36	68%	Thought processes, memory
Sauvé, 1995 ²⁰	3	Cross-sectional	61	Interview	21 (11)	41%	Memory, concentration, comprehension
Barat, 1989 ¹⁵	1	Retrospective cohort	11	7 np tests	12	91%	Memory, aphasia, apraxia
Bunch, 2004 ²⁵	6	Retrospective cohort	79	Questionnaire	59 (36)	'More than controls'	Memory
Earnest, 1980 ²⁷	3	Retrospective cohort	20	4 np tests	44	43%	Memory
Kotila, 1984 ⁶	0	Retrospective cohort	10	np tests, not described	7 (2.5–8)	88%	Memory, visual intelligence
Lim, 2004 ²³	2	Retrospective cohort	11	12 np tests	23 (22)	91%	Memory, executive functioning
Longstreth, 1983 ³⁷	3	Retrospective cohort	279	Classification from medical records	>24	33%	Not specified
Middelkamp, 2007 ³	5	Retrospective cohort	16	Questionnaire	24–84	'High'	Not specified
Nunes, 2003 ¹⁹	2	Retrospective cohort	11	20 np tests	21 (10–36)	45%	Verbal, visual and spatial memory, verbal fluency, perceptual speed and performance, language, executive functioning
Peskine, 2004 ²⁴	0	Retrospective cohort	12	11 np test	?	100%	General cognitive functioning, memory, executive functioning, attention, apraxia, communication
Pubbwald, 2000 ⁷	3	Retrospective cohort	12	8 np tests	25 (7–98)	100%	Visual perception, memory, attention, orientation
Roewer, 1985 ³⁸	1	Retrospective cohort	28	Interview	31 (21)	68%	Memory, concentration
Sunnerhagen, 1996 ²¹	5	Retrospective cohort	20	MSSE only	23 (17–44)	35%	Not specified

MMSE = Mini-Mental State Examination; np test = neuropsychological test.

Fig. 1. Flowchart of the literature search and selection process.

3.2. Study population

The characteristics and results of the reviewed articles are summarised in Tables 3 and 4. In Table 3 the studies with a case-control, cross-sectional or retrospective cohort design are described briefly. In Table 4 the eight prospective studies are presented in more detail.

The study populations all included survivors of out-of-hospital cardiac arrest but several studies also contained other groups of survivors, for example, survivors of in-hospital cardiac arrest, respiratory arrest or carbon monoxide poisoning.^{1,15–21} Several studies used selected populations. In six studies participants were selected based on the presence of cognitive problems or referral for rehabilitation.^{3,7,16,22–24} In four studies participants were excluded if they had severe cognitive impairments.^{7,20,25,26}

The number of subjects per study ranged from 10 to 308. In 11 (39%) of the studies there were less than 20 subjects. In 10 (36%) studies the number of subjects was between 20 and 50. Only the remaining seven (25%) studies had more than 50 subjects.

The mean age of the participants varied between 37 years¹⁶ and 70 years.²²

3.3. Study design, measurement instruments and follow-up

Study designs varied considerably: five case-control studies, two cross-sectional studies, one combination of a case-control and a cross-sectional study, 12 retrospective cohort studies, seven prospective cohort studies and one study reported data from a randomised controlled trial.

The outcome measures used to assess cognitive functioning were varied: interviews, questionnaires, the Mini-Mental State Examination (MMSE) and/or other neuropsychological tests. The cognitive domains that were measured in one or more studies were orientation, attention, memory, perception, executive functioning, apraxia, verbal function and language skills, construction and concept formation/reasoning. Memory was measured most frequently, in 22 of the studies, and was further classified into episodic long-term, short-term, recall, recognition and/or visual memory. The duration of follow-up from the time of the cardiac arrest to the

measurement moment showed a mean or median follow-up from 6 to 59 months, often with a wide range.

3.4. Outcomes of the studies

All except two studies reported that cognitive problems are common after out-of-hospital cardiac arrest. The frequency of cognitive problems ranged from 6% to 100%. The three prospective studies with the highest quality scores, in which a battery of neuropsychological tests had been administered, reported cognitive problems in 42%, 48% and 50% of the participants, respectively.^{10,12,14}

Most of the cognitive domains assessed were affected, and no domain escaped impairment. The most frequently impaired domains were memory, attention and executive functioning. Memory problems were reported to occur in 12–100% of the participants. Memory for novel information and delayed recall seemed to be affected most frequently.^{7,11,17}

Five of the prospective studies reported on the changes in cognitive function over time. Two studies showed no significant changes in cognitive functioning during the follow-up period of 1 year.^{14,26} In contrast, two other studies showed a significant improvement in cognitive function (attention, orientation, early retention, delayed recall, reasoning and motor speed) during the first 3 months, but no further improvements up to 6 months.^{10,11} Scores on the MMSE showed improvements in the first months only.^{1,14}

In some studies possible confounding factors were examined. In two studies a positive relationship was found between better cognitive outcome and several resuscitation variables (fast start of resuscitation, the presence of witnesses, early start of CPR, early defibrillation, no need for and/or no delay of advanced life support, and short time to return of spontaneous circulation).^{12,13} In contrast, four studies did not show any relation between resuscitation variables and cognition.^{5,9,14,25} Co-morbidity,^{9,13} time since the cardiac arrest^{9,22} and sex^{5,14} were not related to cognitive outcome. Younger age was related to better cognitive outcome in one study,¹⁶ while the opposite was shown in the study of Bunch et al.²⁵ In addition, several other studies showed no relationship between cognitive outcome and age at all.^{5,9,13,14} The influence of depression was examined in a number of studies. Although four

Table 4

Evidence table of the selected studies with a prospective design.

Author, year of publication	Quality score	Study population	Measurement instrument(s)	Follow-up in months	Frequency of cognitive impairments	Measured domains that were affected are shown in bold <i>Measured domains that were not affected are shown in italics</i>
		In: Inclusion criteria Ex: Exclusion criteria N: Number of participants A: Age mean (S.D.)/median (range)	<i>Cognitive domain</i> Named measurement instruments			
Dougherty, 1994 ²⁶	6	In: Primary VF + ICD. Ex: No partner, too physiologically or neurologically impaired, acute myocardial infarction in conjunction with cardiac arrest. N: 15 A: 57	<i>Global neurocognitive functioning</i> Neurobehavioural cognitive status examination Trail making test A + B	12	'Deficits', number not specified	Memory, construction <i>Alertness, attention, comprehension</i>
Horsted, 2007 ⁵	5	In: OHCA, survival > 6 months. Ex: Obvious signs of death. N: 33 A: ?	<i>Screening test for dementia</i> MMSE	6–10	6%	<i>Signs of dementia were uncommon</i>
Lundgren, 2005 ¹	4	In: Survivors of a cardiac arrest (most OHCA, but also some in-hospital cardiac arrest). N: 26 A: 60 (22–75)	<i>Cognitive function</i> MMSE	12	29%	Cognitive functioning
Roine, 1993 ¹⁴	8	Randomised controlled trial of a drug (nimodipine) study. In: Patients resuscitated from VF OHCA, BLS started < 10 min, ALS < 20 min, return spontaneous circulation < 30 min Ex: Previous severe brain damage or chronic disorder causing loss of independence. Patient who responded to verbal commands immediately after resuscitation. N: 58 A: 65 (11)	MMSE <i>Intellectual ability</i> Wechsler Adult Intelligence Scale (WAIS), partial <i>Memory</i> Wechsler Memory Scale (WMS), partial <i>Verbal skills</i> Word fluency Naming Comprehension of short sentences <i>Reading, writing and arithmetic skills</i> According to method of Christensen <i>Visual perception</i> Poppelreuter's overlapping figures Thematic picture <i>Visual constructive functions</i> Copying a cube and 3D cross Drawing clock faces <i>Programming of activity</i> Observation of planning, attention, perseveration, and initiative	12	No difference between intervention and control group. 3 months: 60%, 12 months: 48%	Delayed recall memory, reading, writing, dyscalculia, visuoconstructive dyspraxia, planning

Table 4 (Continued)

Author, year of publication	Quality score	Study population	Measurement instrument(s)	Follow-up in months	Frequency of cognitive impairments	Measured domains that were affected are shown in bold <i>Measured domains that were not affected are shown in italics</i>
		In: Inclusion criteria Ex: Exclusion criteria N: Number of participants A: Age mean (S.D.)/median (range)	<i>Cognitive domain</i> Named measurement instruments			
Sauvé, 1996 ¹⁰	9	In: Survivors of sudden cardiac death. N: 45 A: 61 (11)	<i>Intellectual function</i> Neurobehavioural cognitive status examination <i>Attention</i> Symbol-digit modalities test Visual scanning task <i>Memory</i> Rey auditory verbal learning test Memory scanning task <i>Reasoning</i> Controlled oral word association test	6	50%	Memory (especially delayed recall and recognition) and other cognitive functions (numbers per domain not specified)
Sauvé, 1996 ¹¹	7	In: Survivors of 'aborted sudden cardiac death' referred for electrophysiology study, serial drug testing, or implantation of ICD Ex: History of prior brain pathologic condition or psychiatric illness requiring ongoing drug therapy N: 25 A: 59 (11)	<i>Intellectual function</i> Neurobehavioural cognitive status examination <i>Attention</i> Symbol-digit modalities test Visual scanning task <i>Reasoning</i> Controlled oral word association test <i>Motor speed</i> Tapping test <i>Memory</i> Rey auditory verbal learning test Memory scanning task	6	29%	Delayed recall memory, motor speed, attention <i>Reasoning</i>
Van Alem, 2004 ¹²	10	In: Witnessed VF OHCA, discharged alive Ex: Witnessed by EMS, impaired cognition prior to OHCA. N: 57 A: 63 (12)	<i>Memory</i> Rey's auditory verbal learning test (AVLT) <i>Attention and response inhibition</i> Stroop colour word test <i>Divided attention, mental flexibility, and motor speed</i> Trail making test A + B <i>Verbal fluency</i> Controlled oral word association test	6	42%	Memory (12–19%) Attention, response inhibition, mental flexibility and motor speed (19–28%) Verbal fluency (21%)
Van Alem, 2004 ¹³	8	In: OHCA, discharged alive. N: 174 A: 62 (12)	<i>Cognitive functioning</i> MMSE	7 (4–20)	16%	Cognitive functioning

VF = ventricular fibrillation; ICD = internal cardioverter defibrillator; OHCA = out-of-hospital cardiac arrest; MMSE = Mini-Mental State Examination; EMS = emergency medical system; BLS = basic life support; ALS = advanced life support.

studies reported a relationship between cognitive impairments and depressive symptoms.^{17,21,11,14} this finding was not confirmed in the study of Grubb et al.⁹ Being awake at admission²⁷ and a short time to post-arrest awakening (meaning a short duration of coma) were consistently related to better long-term cognitive functioning in three studies.^{10,11,16}

4. Discussion

This systematic review revealed only a few high quality studies on the nature and frequency of long-term cognitive impairments after out-of-hospital cardiac arrest. After critically reviewing all selected articles, only three relatively large ($n = 45, 57$ and 58), qualitatively sound, prospective studies remained in which cognition was measured with a battery of neuropsychological tests.^{10,12,14} The results suggest that cognitive impairments are common after out-of-hospital cardiac arrest and that all cognitive domains can be affected, with memory being the most commonly and severely affected domain, followed by attention and executive functioning. Improvement in cognitive function over time was seen in some of the studies, but during the first 3 months only, suggesting that recovery of cognitive functioning may be limited to 3 months. However, the quality of the current evidence is not sufficient to draw final conclusions on this issue.

The quality of the reviewed articles was in general low. Therefore, caution is needed with regard to generalising the results from the reported studies to the whole population of out-of-hospital cardiac arrest survivors. Only six studies had a quality score of 7/10 or above on the quality criteria list which was predominantly influenced by study design: prospective studies scored better while case-control, cross-sectional and retrospective studies tended to receive lower quality scores because they have a higher intrinsic risk of bias.

The low quality of most studies can be attributed to four important methodological weaknesses. First of all, the study populations themselves often showed a high risk of bias. Several studies described a population that did not consist of survivors of out-of-hospital cardiac arrest alone. Other studies had selected populations such as patients already referred for specialised treatment or already having evident cognitive problems; these will probably be more seriously affected patients. On the other hand, there were also studies that excluded severely impaired patients.

Second, the sample size was small in most of the studies. Only seven studies included 50 subjects or more. The small sample sizes coupled with the biases already discussed make it difficult to generalise the results to the whole population of survivors of out-of-hospital cardiac arrest.

Third, cognitive functioning was measured differently in each study, probably because there is no standard protocol for testing cognitive function in hypoxic brain injured patients. Due to the heterogeneity of the studies statistical pooling was not possible. In four studies the assessment of cognitive function was solely based on the Mini-Mental State Examination (MMSE) which has been shown to be insensitive at detecting cognitive impairments.²⁸ These studies reported a lower frequency of cognitive impairments than other studies using a battery of neuropsychological tests. Nevertheless, a substantial number of studies did conduct a good battery of neuropsychological tests but still the cut-off scores, used to define cognitive impairment, differed between the studies.

Lastly, possible confounding factors were not consistently taken into account. Most of the studies that did consider confounding factors showed contradictory results. It is currently unclear how age, depression, the duration of the cardiac arrest and other variables related to the resuscitation affect cognitive functioning. However, there was agreement between several studies that co-morbidity, time since the cardiac arrest and sex are not related to the sever-

ity of cognitive impairment. In addition, being awake at admission and a short duration of coma were consistently related to better long-term cognitive functioning.

This systematic review also might have been subject to bias. Although we performed an extensive literature search without language restriction, it is possible that we have missed some articles. Furthermore, bias may arise both in abstracting data and in scoring quality. We tried to limit the risk of subjectivity by using a standardised criteria list and by using two people to abstract and check data independently. Lastly, using a quality score makes it easier to compare studies but takes away the detailed information sometimes needed to judge the quality of a study.

One main finding of this systematic review is that cognitive problems seem common in survivors of out-of-hospital cardiac arrest. In the three best prospective studies, cognitive problems were reported in 42%, 48% and 50% of the participants, respectively.^{10,12,14} This indicates that about half of the survivors of out-of-hospital cardiac arrest suffer from cognitive impairments. The cognitive domains that were affected most frequently were memory, attention and executive functioning but these were also the domains that were measured most often. Memory problems were reported most frequently. A possible explanation for this is that the hippocampus, a brain structure important for the storage of information, is very sensitive to decreased cerebral perfusion.^{29,30} Furthermore, memory seems to be affected by the global cerebral atrophy seen after out-of-hospital cardiac arrest.³¹ Global cerebral atrophy may also explain why so many cognitive domains can be impaired after cardiac arrest. The biological mechanisms involved in the development of global ischaemic brain injury are complex and the subject of ongoing research.

Hypothermia in comatose cardiac arrest survivors improves so-called neurological outcome.³² However, a study by Tainen et al. could not demonstrate significant positive effects of hypothermia on cognitive functioning.³³ This discrepancy may arise because neurological outcome is often measured using the Glasgow-Pittsburgh Cerebral Performance Categories (CPC), as is recommended in the 'Utstein' criteria.³⁴ Although a CPC score of 1 or 2 is commonly regarded as 'good outcome', it includes subjects with 'mild to moderate' cognitive impairments, such as dysphasia and permanent memory or mental changes. Furthermore, the CPC seems insensitive to more subtle cognitive impairments. Therefore, we advocate the use of neuropsychological testing (including at least tests for memory, attention and executive functioning) in determining outcome after cardiac arrest. A neuropsychologist can be consulted to select and administer an appropriate set of neuropsychological tests. Suggestions of neuropsychological tests can be found in a design article by Moolaert et al.³⁵

For clinicians it is important to be aware that cognitive impairments occur frequently after out-of-hospital cardiac arrest. Unfortunately, cognitive impairments can be easily overlooked so that, unless one explicitly screens for them, they can easily be missed. This is of concern because cognitive problems may have a high impact on a person's daily functioning and quality of life. A large prospective trial is now needed to collect reliable data on the prevalence, severity and course of cognitive problems after a cardiac arrest, and to relate the cognitive losses identified to possible limitations in daily life, participation in society and quality of life.

Ethical approval

Ethical approval was not required.

Contributions

V. Moolaert was the first reviewer, performed the literature search and is the guarantor of this study. J. Verbunt acted as second

reviewer. Both reviewers read all the selected titles and abstracts and selected the final articles for the review. C. van Heugten was the third reviewer and acted as a mediator in case of disagreement between the two reviewers and then made the final decision. All authors participated in the selection of a quality criteria scoring list and contributed to the protocol and final manuscript.

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Conflict of interest

The authors declare that they have no competing interests.

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Appendix A. Keywords and limits used in the literature search

Database	Keywords		Limits
	Population	Cognitive outcome	
Pubmed	HEART ARREST Heart arrest* Asystole* Cardiac arrest* Cardiopulmonary arrest* Circulatory arrest* Cardiac sudden death* Sudden cardiac death* RESUSCITATION Resuscitation* Cardiopulmonary resuscitation* cpr	COGNITION DISORDERS Cognition disorder* Cognitive MEMORY DISORDERS Memory disorder* Amnesia NEUROPSYCHOLOGICAL TESTS Neuropsychological test*	All adults: 19+ 1980–2006
PsychInfo	Heart arrest* Asystole* Cardiac arrest* Cardiopulmonary arrest* Circulatory arrest* Cardiac sudden death* Sudden cardiac death* Resuscitation* Cardiopulmonary resuscitation* cpr	COGNITIVE IMPAIRMENT MEMORY–DISORDERS NEUROPSYCHOLOGICAL ASSESSMENT	Adult (18+) 1980–2006
Cinahl	HEART ARREST Asystole* Cardiac arrest* Cardiopulmonary arrest* Circulatory arrest* DEATH-SUDDEN-CARDIAC RESUSCITATION Cardiopulmonary resuscitation* cpr	COGNITION DISORDERS MEMORY DISORDERS NEUROPSYCHOLOGICAL TESTS	And adult 1980–2006
Embase	HEART ARREST ASYSTOLE Cardiac arrest Cardiopulmonary arrest* Circulatory arrest* SUDDEN DEATH RESUSCITATION Cardiopulmonary resuscitation* cpr	COGNITIVE DEFECT MEMORY DISORDER NEUROPSYCHOLOGICAL TEST	And adult 1986–2006

MesH or thesaurus terms are indicated in capital letters. Text words are indicated in regular letters.

* Truncation.

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