The outcome of in- and out-hospital cardiopulmonary arrest in the older population: a scoping review

Rina Zanders1 · Patrick Druwé2 · Nele Van Den Noortgate3 · Ruth Piers3

Received: 8 September 2020 / Accepted: 16 January 2021 / Published online: 8 March 2021
© European Geriatric Medicine Society 2021

Key summary points
Aim We aimed to collect the available evidence on outcome regarding survival and quality of life after CPR following both IHCA and OHCA in the older population.
Findings Hospital survival rates following IHCA and OHCA in the older population improved in the recent decade, though do not exceed 28.5% and 11.1%, respectively. The effect of age on outcome remains controversial and age should not be used as the sole decision criterium whether to initiate CPR.
Message Future research should study frailty and resilience as an independent predictor regardless of age, and add broader, extensive QoL measures as outcome variables.

Abstract
Purpose We aimed to collect the available evidence on outcome regarding survival and quality of life after cardiopulmonary resuscitation (CPR) following both in-hospital cardiac arrest (IHCA) and out-of-hospital cardiac arrest (OHCA) in the older population.
Methods A scoping review was performed studying published reviews after 2008, focusing on outcome of CPR in patients aged ≥ 70 years following IHCA and OHCA. In addition, 11 (IHCA) and 19 (OHCA) eligible studies published after the 2 included reviews were analyzed regarding: return of spontaneous circulation, survival until hospital discharge, long-term survival, neurological outcome, discharge location or other measurements for quality of life (QoL).
Results The survival until hospital discharge ranged between 11.6 and 28.5% for IHCA and 0–11.1% for OHCA, and declined with increasing age. The same trend was seen regarding 1-year survival rates with 5.7–25.0% and 0–10% following IHCA and OHCA, respectively. A good neurological outcome defined as a Cerebral Performance Category (CPC) 1–2 was found in 11.5–23.6% (IHCA) and up to 10.5% (OHCA) of all patients. However, the proportion of CPC 1–2 among patients surviving until hospital discharge was 82–93% (IHCA) and 77–91.6% (OHCA). Few studies included other QoL measures as an outcome variable. Other risk factors aside from age were identified, including nursing home residency, comorbidity, non-shockable rhythm, non-witnessed arrest. The level of frailty was not studied as a predictor of arrest outcome in the included studies.
Conclusions Hospital survival rates following IHCA and OHCA in the older population improved in the recent decade, though do not exceed 28.5% and 11.1%, respectively. The effect of age on outcome remains controversial and age should not be used as the sole decision criterium whether to initiate CPR. Future research should study frailty and resilience as an independent predictor regardless of age, and add broader, extensive QoL measures as outcome variables.

Keywords Age · CPR · Functional state · Neurological outcome · Quality of life · Survival
Introduction

A cardiopulmonary arrest can be defined as the cessation of cardiac mechanical activity as confirmed by the absence of signs of circulation [1]. When this condition occurs in a hospital setting, it is referred to as an in-hospital cardiac arrest (IHCA). An out-of-hospital cardiac arrest (OHCA) takes place in prehospital environments.

Cardiac arrests are more frequently seen in people with advanced age. A study in Japan reported that patients aged 65 years and older accounted for more than 80% of all patients with OHCA [2]. In view of the rapid, worldwide expansion of this older section of the population, a higher rate of cardiac arrests can be expected [3].

Cardiopulmonary resuscitation (CPR) can be lifesaving for persons with cardiopulmonary arrest. However, patients who survive the initial resuscitation are at risk of anoxic brain damage [4, 5]. In addition, significant emotional disorders such as anxiety, depression and post-traumatic stress disorder (PTSD) are frequent in those who survive [6]. Therefore, in some cases, the use of CPR may lead to prolongation of the dying phase and suffering without adding to quality of life.

As such, it is important that resuscitation attempts occur in accordance with the preferences of the well-informed patient [7–9]. The driving force for their decision regarding resuscitation is quality of life post-resuscitation. Many patients are unrealistically optimistic about the results of CPR and thus make uninformed choices. Relevant and correct information, once provided, influences the final decision considerably [10]. It is up to the healthcare professional to explain the success rate and possible harmful effects of CPR to the patient and their family [11].

To provide accurate information and make the optimal decision for each individual, it is important for healthcare professionals to identify those subgroups with good chances of a satisfactory post-arrest quality of life [12, 13].

In this scoping review, we aimed to collect all available and recent evidence on outcome regarding survival and quality of life after CPR following both IHCA and OHCA in the older population, including indicators of poor prognosis.

Methodology

Search strategy

A search was conducted to find the most recent systematic reviews concerning survival and quality of life following IHCA and OHCA in patients 70 years or older. Subsequently, a search was conducted to find all primary studies published after these systematic reviews to acquire the most recent available evidence. This was done separately for IHCA and OHCA, using analogous search entries.

Review selection The MEDLINE, EMBASE, PubMed and Google Scholar databases were electronically searched in October 2018 to find reviews concerning CPR outcomes in the older population. The search strategy cross-referred ‘elderly’, ‘resuscitation’ and ‘functional outcome’ using appropriate synonyms, medical subject headings (MeSH), keywords and filters (Appendix 1 in ESM). The references from relevant reviews were also scanned for additional studies. The remaining titles were scanned to exclude other study types (such as randomized controlled trials, observational studies, editorials, case reports, case-series, and narrative reviews), duplicates and articles in a language different from Dutch or English or of which no free full text could be obtained.

Other reasons for exclusion were reviews that lacked relevant outcomes, focused on the effect of a specific treatment or specifically investigated the association with a pathology (such as malignancies or pneumonia). Reviews with irrelevant study populations (too young) or conditions (such as victims of avalanches) were also excluded (Fig. 1). Indistinct cases were discussed and resolved by consensus with RP, NVDN and PD.

Two systematic reviews were found using the search strategy mentioned above, concerning IHCA and OHCA, respectively [14, 15].

Primary study selection To find complementary primary studies published after these systematic reviews, a search was conducted by cross-referencing ‘elderly’, ‘resuscitation’, ‘functional outcome’ and ‘in-hospital’ or ‘out-of-hospital’, using appropriate medical subject headings (MeSH), keywords and filters in MEDLINE, EMBASE and PubMed to find observational studies and RCTs (Appendix 2 in ESM). The search period for the primary studies was determined by the end of the search period of the two included reviews: November 2012 to October 2018 concerning IHCA, and from May 2011 until October 2018 concerning OHCA. Other publication dates, unrelated articles, duplicates and articles in a language different from Dutch or English were excluded. Other reasons for exclusion were articles that focused on irrelevant outcomes, populations or contexts; comparisons of scores, guidelines, measurement tools or models, and the effect of a specific pathology or treatment on outcome (Figs. 2, 3). In total, 11 articles were included concerning IHCA [16–26] and 19 articles concerning OHCA [27–45].
Quality assessment

For quality assessment of the reviews, the AMSTAR measurement tool was applied. This checklist consists of 11 items. A review was considered to be of low, moderate or high quality when, respectively, \( \leq 5 \), \( 6–8 \), or \( \geq 9 \) of the requirements were fulfilled. Both reviews proved to be of moderate quality (Appendix 3 in ESM).

The STROBE checklist was used to assess the quality of the primary studies. A review was considered to be of low, moderate or high quality when, respectively, \( \leq 10 \), \( 11–16 \), or \( \geq 17 \) of the requirements were fulfilled. For the primary articles concerning IHCA and OHCA, all included studies proved to be of high quality after assessment (Appendix 4 in ESM). In 7 IHCA articles and 14 OHCA articles, Utstein-style guidelines were used to report the data.

Data extraction

Data extraction was performed by RZ and subsequently verified by RP, NVDN and PD. These data concerned: author, place and research period, study design, sample size, sample characteristics, study characteristics and outcomes of interest. We collected both unadjusted
and adjusted data. Outcomes were chosen a priori, and consisted of: return of spontaneous circulation (ROSC), survival until hospital discharge, long-term survival (≥ 6 months following the event), discharge location and other quality of life measurements. These outcomes were structured and presented separately for the IHCA review (Table 1), the OHCA review (Table 2), the primary IHCA articles (Table 3) and the primary OHCA articles (Table 4), and additionally according to age (Table 5).

Secondary variables concerning the condition and location of the arrest such as initial cardiac rhythm, type of ward, witnessed event, bystander-initiated CPR and emergency medical services (EMS) response time were reported when registered specifically for the older population. Risk factors positively or negatively associated with survival or quality of life outcomes were also documented.

Post-resuscitation neurological and functional state were mostly analyzed using the Cerebral Performance Category scale (CPC scale) [46]. This measurement tool uses a score of 1–5 for the categories: 1: “good cerebral performance”; 2: “moderate cerebral disability”; 3: “severe cerebral disability”; 4: “coma or vegetative state” and 5: “dead or brain death” [47]. In this review, scores of 1 or 2 are considered to be good neurological outcomes.
Results

Survival rates

The systematic review concerning IHCA consisted of 29 studies. An overall ROSC was found in 38.6% of the resuscitated patients. Overall survival rates were lowest in the category of 90 years and older (11.6%), followed by octogenarians (15.4%), and highest in patients aged 70–79 years (18.7%). Long-term survival (6 months to 1 year) varied between 5.7 and 20.9% concerning patients aged 70 years and older.

In the complementary IHCA studies, overall survival until hospital discharge was systematically higher and varied...
Table 1  Review in-hospital

| First author       | Year | Country       | Study design | Sample size (n) | Inclusion | ROSC                                                                 | Survival to discharge | Long-term survival | Quality of life | Functional status |
|--------------------|------|---------------|--------------|----------------|-----------|----------------------------------------------------------------------|-----------------------|-------------------|------------------|--------------------|
| Van Gijn, M. et al | 2014 | The Netherlands | Systematic review | 417 | All patients 70 years or older | 10 studies investigated the ROSC for patients aged 70 years and older | Including all wards: 17.3% (6 studies) | Including all wards except emergency settings: 18.7% (4 studies) | 1-week survival: 8.4% | One study showed that all successfully resuscitated patients of 70 years and older (n = 7) enjoyed a level of independence similar to their level before the resuscitation, measured 1 month after the resuscitation. Another study with 42 successfully resuscitated patients of 70 years and older (54% of total) also found that there were no significant differences in the functional level of the survivors at the time of hospital discharge compared with their pre-arrest status. In a study with 24 patients older than 80 years, only 20% of the survivors were capable of independent functioning outside of institutionalized care. |
|                    |      |               | 1968–2012    | 190            | All patients aged 70 years and older | The rate of ROSC varied between 20.8 and 57.9%, with a pooled rate of 38.6% | Including patients aged 70 years and older: 18.7% (range 8.2–35.7%) (11 studies) | Including patients aged 80 years and older: 15.4% (range 4.0–31.0%) (10 studies) | 1-month survival: 7.0% | Discharge location: In one study of 50 patients who survived to hospital discharge: 19 were discharged home. 9 were placed in a nursing home. 12 were admitted to a rehabilitation or psychiatric facility. 10 were transferred to a chronic care hospital with ventilator capabilities. |
|                    |      |               | 20 studies included |  |   |   | Including all wards: 17.3% (6 studies) | Including all wards except emergency settings: 18.7% (4 studies) | Including geriatric wards: 14.8% (1 study) | 6-month survival: 5.7% |  | |
|                    |      |               | Retrospective 17 |  |   |   | Including patients aged 70 years and older: 18.7% (range 8.2–35.7%) (11 studies) | Including patients aged 80 years and older: 15.4% (range 4.0–31.0%) (10 studies) | Including patients aged 80 years and older: 10.5% (1 study) |  |  |
|                    |      |               | Prospective: 12  |  |   |   | Including all wards: 17.3% (6 studies) | Including all wards except emergency settings: 18.7% (4 studies) | Including patients aged 80 years and older: 15.4% (range 4.0–31.0%) (10 studies) |  |  |
|                    |      |               | General hospital: 13 |  |   |   | Including all wards: 17.3% (6 studies) | Including all wards except emergency settings: 18.7% (4 studies) | Including patients aged 80 years and older: 15.4% (range 4.0–31.0%) (10 studies) |  |  |
|                    |      |               | Tertiary hospital: 8 |  |   |   | Including all wards: 17.3% (6 studies) | Including all wards except emergency settings: 18.7% (4 studies) | Including patients aged 80 years and older: 15.4% (range 4.0–31.0%) (10 studies) |  |  |
| First author         | Study design | Sample size (n) | Inclusion | Conditions ≥ 65 years | ROSC | Survival until hospital discharge and 30 days after | Quality of life/Neurological state/Discharge destination |
|---------------------|--------------|-----------------|-----------|-----------------------|------|-----------------------------------------------------|--------------------------------------------------------|
| Al-Dury, N. et al   | Study design Prospective study using the National quality register of OHCA and IHCA | 14,933 | Inclusion Patients who suffered a cardiac arrest and underwent CPR within the hospital perimeter | – | Survival until hospital discharge and 30 days after | Patients ≥ 65 years: 24.2% (2777/11 474) | Good neurological state (CPC 1–2) At hospital discharge: Survivors ≥ 65: 93.1% All patients ≥ 65: 20.1% |
|                     | Mean age (years) 72.7 (13.4) | | Exclusion Patients younger than 18 years | | | | |
|                     | Age categories (years) ≥ 65 Men (%) 62.4 | | | | | | |
| Chan P. S. et al    | Study design Prospective study using Get With The Guidelines (GWTG)-Resuscitation registry | 48,841 | Inclusion Patients 18 years of age or older with an index IHCA enrolled in GWTG-Resuscitation | Conditions Not available for patients aged ≥ 65 years | – | Survival until hospital discharge | Derivation cohort: 60–69 years: 21.9% 70–79 years: 23.2% 80–89 years: 21.9% Validation cohort: 60–69 years: 21.8% 70–79 years: 23.3% 80–89 years: 21.5% |
|                     | Mean age (years) 65.6 (16.1) | | Exclusion Patients with do-not-resuscitate (DNR) orders | | | | |
|                     | Age categories 60–69 years 70–79 years ≥ 80 years Men (%) 58.3 | | | | | | |
| First author | Year | Country | Study design | Methods | Sample size (n) | Inclusion | Conditions | ROSC | Survival from ICU | Survival until discharge | Long-term survival | Quality of life | Neurological state | Discharge location |
|--------------|------|---------|--------------|---------|----------------|-----------|------------|------|------------------|--------------------------|---------------------|----------------|------------------|------------------|
| Chan P. S. et al | 2013 | USA | Study design | Study using the national Get with the Guidelines Resuscitation registry of inpatient cardiac arrests and Medicare files 523 acute care hospitals 2000–2008 | 6972 | Patients 65 years of age or older who survived to hospital discharge after IHCA | Inclusion | Initial rhythm | Asystole: 24.5% PEA: 29.1% VF: 30.5% PCT: 15.9% | Survival rate of survivors to discharge | At 30 days: 82.0% At 3 months: 72.0% At 1 year: 58.5% At 2 years: 49.6% | 1-year survival of survivors to discharge | Risk-adjusted: 65–74 years: 63.7% 75–84 years: 58.6% ≥ 85 years: 49.7% Risk-adjusted based on CPC score at discharge: CPC1: 72.8% CPC2: 61.1% CPC3: 42.2% CPC4: 10.2% | Good neurological state (CPC 1–2) | Survivors at hospital discharge: CPC1 = 48.1% CPC2 = 34.3% Discharge location: Among survivors: Inpatient skilled nursing facility: 55.3% Home: 40.0% Hospice: 4.8% Readmission: At 1 year: 65.6% At 2 years: 76.2% |
| DeVoe B. et al | 2016 | USA | Study design | Retrospective cohort study A large tertiary care hospital in a metropolitan area, focusing on two units, Cardiac Care and Cardiothoracic Telemetry Cardiac patients 2007–2013 | 417 | Patients 18 years and older, who experienced IHCA and were treated with ACLS were included in the study | Inclusion | Conditions | ROSC > 20 min | Survival until hospital discharge | 65–84.9 years: 18% (45/247) 85–100 years: 12% (8/64) | – | – | – | – |

Inclusion
- Patients 65 years of age or older who survived to hospital discharge after IHCA
- Patients younger than 65 years of age who survived to hospital discharge after IHCA
- Patients with do-not-resuscitate orders
- For patients who had a cardiac arrest during multiple hospitalizations, we used the first hospitalization as the index hospitalization

Exclusion
- Patients who were under do not resuscitate (DNR) or do not intubate (DNI) orders, admitted to the ICU, or treated in the operating suites or emergency department
- If a patient had more than one CA on the floor during the hospitalization, only the first event was included
- Not available for patients aged ≥ 65 years
| First author       | Year  | Country | Study design          | Sample size (n) | Inclusion                                                                 | Conditions Location | ROSC                                                                 | Survival from ICU | Quality of life |
|-------------------|-------|---------|-----------------------|----------------|----------------------------------------------------------------------------|---------------------|---------------------------------------------------------------------|-------------------|----------------|
| Gershen-gorn, H.  | 2012  | USA     | Study design          | 6518           | Inclusion: Patients who survived to admission and received CPR while in the ICU | Conditions: Not available for patients aged ≥ 65 years | =                                                                  | Survival until hospital discharge | Discharged destination |
| et al             |       |         | Retrospective cohort  |                | Exclusion:Patients younger than 30 years old at ICU admission Patients cared for in a separate neurologic unit Patients who had a do-not-resuscitate (DNR) order at the time of in-ICU CPR |                      |                                                                 | 65–84 years: 16.2% (476/2941) | Among all patients: |
|                    |       |         | study                 |                |                                                                           |                      |                                                                     | ≥ 85 years: 11.3% (52/461)   | Home, independent: 3.3% |
| Hessulf F. et al  | 2017  | Sweden  | Study design          | 18,069         | Inclusion: All unique (i.e., the first occasion for those with multiple CAs during the study period) IHCAs in patients ≥ 18 years of age or older | Conditions: Not available for patients aged ≥ 65 years | ROSC during resuscitation 61% Alive when resuscitation was terminated 50% | Survival until hospital discharge 28.5% (5150/18 069) 30-day survival 28.3% (5114/18 069) 1-year survival 25.0% (4517/18 069) | Good neurological state (CPC 1–2) Among all patients: 23.6% (4262/18 069) At hospital discharge: 93.0% (4730/5150) |
|                    |       |         | Retrospective study   |                |                                                                           |                      |                                                                     |                   |                |
| First author        | Year | Country | Study design          | Sample size (n) | Inclusion                                                                 | Conditions | ROSC | Survival from ICU | Quality of life | Long-term survival | Discharge destination |
|---------------------|------|---------|-----------------------|-----------------|---------------------------------------------------------------------------|------------|------|-------------------|----------------|-------------------|----------------------|
| Hirlekar, G. et al  | 2017 | Sweden  | Retrospective observational cohort study | 11,396          | Patients at least 70 years of age who had an IHCA                              |            | -   | -                 | -              | -                 | -                    |
|                     |      |         | The Swedish Cardiopulmonary Resuscitation Registry 2007–2015 |                 | Patients with multiple IHCA during the study period were only included once (the first occasion) |            | -   | -                 | -              | -                 | -                    |
| Age categories      |      |         | (years)               |                 | 70–79 years = 28%                                                          |            | -   | -                 | -              | -                 | -                    |
|                     |      |         |                       |                 | 80–89 years = 20%                                                          |            | -   | -                 | -              | -                 | -                    |
|                     |      |         |                       |                 | ≥ 90 years = 14%                                                           |            | -   | -                 | -              | -                 | -                    |
| Men (%)             |      |         |                       |                 | 70–79 years: 64.3                                                         |            | -   | -                 | -              | -                 | -                    |
|                     |      |         |                       |                 | 80–89 years: 55.6                                                         |            | -   | -                 | -              | -                 | -                    |
|                     |      |         |                       |                 | ≥ 90 years: 43.8                                                          |            | -   | -                 | -              | -                 | -                    |
| Kazaure H. S. et al | 2013 | USA     | Retrospective analysis of The Nationwide Inpatient Sample 2000–2009 | 813,493         | Adult patients (≥ 18 years) who underwent CPR (ICD-9 code: 99.60) during their hospitalization were abstracted |            | -   | -                 | -              | -                 | -                    |
|                     |      |         |                       |                 | Patients who had cardiopulmonary arrest as a primary diagnosis were excluded to avoid including patients who experienced an out-of-hospital event in our analyzes |            | -   | -                 | -              | -                 | -                    |
| Age categories      |      |         | (years)               |                 | 65–74 years                                                               |            | -   | -                 | -              | -                 | -                    |
|                     |      |         |                       |                 | 75–84 years                                                               |            | -   | -                 | -              | -                 | -                    |
|                     |      |         |                       |                 | ≥ 85 years                                                                |            | -   | -                 | -              | -                 | -                    |
| Mean age (years)    |      |         |                       |                 | 2000–2001: 68.7                                                          |            | -   | -                 | -              | -                 | -                    |
|                     |      |         |                       |                 | (0.04)                                                                   |            | -   | -                 | -              | -                 | -                    |
|                     |      |         |                       |                 | 2008–2009: 67.1                                                          |            | -   | -                 | -              | -                 | -                    |
| Median age (years)  |      |         |                       |                 | 2000–2001: 72                                                            |            | -   | -                 | -              | -                 | -                    |
|                     |      |         |                       |                 | (59–80)                                                                   |            | -   | -                 | -              | -                 | -                    |
|                     |      |         |                       |                 | 2008–2009: 69                                                            |            | -   | -                 | -              | -                 | -                    |
|                     |      |         |                       |                 | (57–80)                                                                   |            | -   | -                 | -              | -                 | -                    |
| Men (%)             |      |         |                       |                 | 2000–2001: 54.3                                                          |            | -   | -                 | -              | -                 | -                    |
|                     |      |         |                       |                 | 2008–2009: 55                                                            |            | -   | -                 | -              | -                 | -                    |

| Study design          | Sample size (n) | Inclusion                                                                 | Conditions | ROSC | Survival from ICU | Quality of life | Long-term survival | Discharge destination |
|-----------------------|-----------------|---------------------------------------------------------------------------|------------|------|-------------------|----------------|-------------------|----------------------|
| Hirlekar, G. et al 2017 | 11,396          | Patients at least 70 years of age who had an IHCA                              |            | -   | -                 | -              | -                 | -                    |
| Study design          | Sample size (n) | Inclusion                                                                 | Conditions | ROSC | Survival from ICU | Quality of life | Long-term survival | Discharge destination |
| Hirlekar, G. et al 2017 | 11,396          | Patients with multiple IHCA during the study period were only included once (the first occasion) |            | -   | -                 | -              | -                 | -                    |
| Kazaure H. S. et al 2013 | 813,493         | Adult patients (≥ 18 years) who underwent CPR (ICD-9 code: 99.60) during their hospitalization were abstracted |            | -   | -                 | -              | -                 | -                    |
| Kazaure H. S. et al 2013 | 813,493         | Patients who had cardiopulmonary arrest as a primary diagnosis were excluded to avoid including patients who experienced an out-of-hospital event in our analyzes |            | -   | -                 | -              | -                 | -                    |
| First author     | Year | Country | Study design                                                                 | Sample size (n) | Inclusion | Conditions | ROSC | Survival from ICU | Discharged destination |
|------------------|------|---------|-------------------------------------------------------------------------------|-----------------|-----------|------------|------|------------------|------------------------|
| Menon, P.        | 2014 | USA     | Epidemiological study using Medicare Provider Analysis and Review (MedPAR) 1992–2005 | 421,394         | Patients ≥ 65 years who underwent CPR during the study period | Not available for patients aged ≥ 65 years | –    | One CPR event: 17.7% (73 172/413 403) | One CPR event: 43.7% (31 976/73 172) |
| Thompson, L. E.  | 2017 | USA     | Observation of The Guidelines-Resuscitation Registry 2000–2011               | 45,567          | Patients aged 65 years or older with cardiac arrests occurring in an intensive care unit or inpatient ward who received CPR | Patients with arrests that occurred in operating rooms, procedural suites, or emergency departments, as cardiac arrests in these settings have distinct clinical circumstances and outcomes | –    | One CPR event: 6.6% (7564/45 567) | One CPR event: 13.6% (6209/45 567) |

**Inclusion**
- Patients ≥ 65 years who underwent CPR during the study period
- Patients with incomplete CPR claims data
- Patients with incomplete CPR claims data concerning time of death and/or hospital discharge

**Conditions**
- Not available for patients aged ≥ 65 years

**Survival until hospital discharge**
- One CPR event: 17.7% (73 172/413 403)
- Multiple CPR events: 8.8% (703/7991)

**Discharged destination**
- Home: One CPR event: 43.7% (31 976/73 172)
- Skilled nursing facility: One CPR event: 22.8% (16 683/73 172)
- Another hospital: One CPR event: 31.6% (23 122/73 172)
- Multiple CPR events: 42.6% (299/703)

**Initial rhythm**
- VF: 12.5%
- PVT: 7.8%
- Asystole: 37.6%

**Location**
- ICU: 53.6%
- Monitored: 25.3%
- Non-monitored: 21.2%
### Table 3

**Review out-of-hospital**

| First author      | Study design                  | Number of participants | Inclusion                                                                 | Conditions                                                                 | Survival to discharge                          | Quality of life |
|-------------------|-------------------------------|------------------------|---------------------------------------------------------------------------|----------------------------------------------------------------------------|-----------------------------------------------|-----------------|
| Van de Glind, E. M. et al | Systematic review               | 44,582                | ExclusionAge below 70 or no separate subgroup with participants > 70 years | Most studies include arrest factors such as: Witnessed arrest                | Pooled survival to discharge                  | Functional status |
| Year              | 1980–2011                      |                        | The examination of In-hospital CPR only                                   | Bystander arrest                                                             | Patients aged 70 years or older: 4.1%         | 7.5% of the patients for whom resuscitation was attempted survived neurologically intact to 1 year (2 studies) |
| Country           | All retrospective cohort studies of chart reviews and one case-control |                        |                                                                           | Shockable rhythm                                                            | Patients in a nursing home: 0–5.1%            | In patients that did not achieve ROSC in the field, only 0.6% survived to discharge neurologically intact |
|                   | 23 studies included            |                        |                                                                           |                                                                             | All studies but one reported survival to discharge                           | Other studies that included only patients over 70 years showed that although the overall survival was low, the majority of the survivors displayed moderate to good cerebral performance                                      |
|                   | Age and gender                 |                        |                                                                           |                                                                             | **Long term outcome**                                                         | The study of Pleskot et al. showed no difference between younger and older survivors in cerebral performance (but the number of survivors was insufficient to identify significant differences) |
|                   | Range 33–99 years              |                        |                                                                           |                                                                             | 7 reported long-term outcome                                                   | In the Horsted study, survivors rated two of the eight quality of life aspects of the SF-36 scale as significantly worse than the age-matched normative scores (no specification for age was made) |
|                   | Patients ≥ 70 years (4 studies) |                        |                                                                           |                                                                             | No results were mentioned                                                      |                                             |
|                   | Mean age ≥ 70 years (5 studies) |                        |                                                                           |                                                                             |                                               |                                             |
|                   | Subgroups provided (14 studies) |                        |                                                                           |                                                                             |                                               |                                             |
| **Location**      | 14 USA                         |                        |                                                                           |                                                                             |                                               |                                             |
|                   | 8 Europe                       |                        |                                                                           |                                                                             |                                               |                                             |
Table 4  Primary studies out-of-hospital

| First author       | Study design | Number of participants | Inclusion Conditions | ROSC | Survival to admission | Quality of life |
|--------------------|--------------|------------------------|----------------------|------|-----------------------|-----------------|
| Abrams H. C. et al | Study design | 1156                   | Inclusion All arrests of presumed cardiac etiology where resuscitation was attempted by EMTs or paramedics EMS, or by first responders | Witnessed bystander: 46; 8% | Pre-hospital ROSC: 32% (374/1156) | Survival until hospital discharge: Among all patients: 11.1% (128/1156) in patients with pre-hospital ROSC: 32.9% (128/374) in the age group of: 60–70 years: 15% (35/234) 70–80 years: 9.2% (21/238) >80 years: 2.8% (6/215)  |
| Year               |             |                        |                      | Initial rhythm: VF/VT: 32.9% Asystole: 24% Location: Home: 53.1% Public place: 22.3% Other: 18.6% | Pre-hospital ROSC: 32% (374/1156) | Survival until hospital discharge: Among all patients: 11.1% (128/1156) in patients with pre-hospital ROSC: 32.9% (128/374) in the age group of: 60–70 years: 15% (35/234) 70–80 years: 9.2% (21/238) >80 years: 2.8% (6/215)  |
| Country            | Study design | 101,968                | Inclusion Patients with OHCA of presumed cardiac etiology | Conditions Not Available for patients ≥ 65 years | ROSC achieved: 65–69: 32.5% 70–74: 32% 75–79: 31.5% 80–84: 29% 85–89: 28.5% 90–94: 28% 95–99: 23.5% >100: 25% | Survival until hospital discharge: Good neurological state (CPC 1–2) at discharge: 65–69: 9% 70–74: 7% 75–79: 6% 80–84: 4% 85–89: 3% 90–94: 2% 95–99: 1% >100: 2% |
| Abrams H. C. et al | Study design | 101,968                | Exclusion Patients aged 16 or younger Patients where no CPR was attempted in the prehospital setting Patients where resuscitation efforts were terminated based on a DNR designation Patients with missing data on the exposure (age), covariates or outcomes | Conditions Not Available for patients ≥ 65 years | ROSC achieved: 65–69: 32.5% 70–74: 32% 75–79: 31.5% 80–84: 29% 85–89: 28.5% 90–94: 28% 95–99: 23.5% >100: 25% | Survival until hospital discharge: Good neurological state (CPC 1–2) at discharge: 65–69: 9% 70–74: 7% 75–79: 6% 80–84: 4% 85–89: 3% 90–94: 2% 95–99: 1% >100: 2% |
| Year               | Study design | 101,968                | Conditions: | ROSC achieved: 65–69: 32.5% 70–74: 32% 75–79: 31.5% 80–84: 29% 85–89: 28.5% 90–94: 28% 95–99: 23.5% >100: 25% | Survival until hospital discharge: Good neurological state (CPC 1–2) at discharge: 65–69: 9% 70–74: 7% 75–79: 6% 80–84: 4% 85–89: 3% 90–94: 2% 95–99: 1% >100: 2% |
| Country            | Study design | 101,968                | Conditions Not Available for patients ≥ 65 years | ROSC achieved: 65–69: 32.5% 70–74: 32% 75–79: 31.5% 80–84: 29% 85–89: 28.5% 90–94: 28% 95–99: 23.5% >100: 25% | Survival until hospital discharge: Good neurological state (CPC 1–2) at discharge: 65–69: 9% 70–74: 7% 75–79: 6% 80–84: 4% 85–89: 3% 90–94: 2% 95–99: 1% >100: 2% |
| Abrams H. C. et al | Study design | 101,968                | Conditions: | ROSC achieved: 65–69: 32.5% 70–74: 32% 75–79: 31.5% 80–84: 29% 85–89: 28.5% 90–94: 28% 95–99: 23.5% >100: 25% | Survival until hospital discharge: Good neurological state (CPC 1–2) at discharge: 65–69: 9% 70–74: 7% 75–79: 6% 80–84: 4% 85–89: 3% 90–94: 2% 95–99: 1% >100: 2% |
| Year               | Study design | 101,968                | Conditions: | ROSC achieved: 65–69: 32.5% 70–74: 32% 75–79: 31.5% 80–84: 29% 85–89: 28.5% 90–94: 28% 95–99: 23.5% >100: 25% | Survival until hospital discharge: Good neurological state (CPC 1–2) at discharge: 65–69: 9% 70–74: 7% 75–79: 6% 80–84: 4% 85–89: 3% 90–94: 2% 95–99: 1% >100: 2% |
| Country            | Study design | 101,968                | Conditions: | ROSC achieved: 65–69: 32.5% 70–74: 32% 75–79: 31.5% 80–84: 29% 85–89: 28.5% 90–94: 28% 95–99: 23.5% >100: 25% | Survival until hospital discharge: Good neurological state (CPC 1–2) at discharge: 65–69: 9% 70–74: 7% 75–79: 6% 80–84: 4% 85–89: 3% 90–94: 2% 95–99: 1% >100: 2% |
| Abrams H. C. et al | Study design | 101,968                | Conditions: | ROSC achieved: 65–69: 32.5% 70–74: 32% 75–79: 31.5% 80–84: 29% 85–89: 28.5% 90–94: 28% 95–99: 23.5% >100: 25% | Survival until hospital discharge: Good neurological state (CPC 1–2) at discharge: 65–69: 9% 70–74: 7% 75–79: 6% 80–84: 4% 85–89: 3% 90–94: 2% 95–99: 1% >100: 2% |
| Year               | Study design | 101,968                | Conditions: | ROSC achieved: 65–69: 32.5% 70–74: 32% 75–79: 31.5% 80–84: 29% 85–89: 28.5% 90–94: 28% 95–99: 23.5% >100: 25% | Survival until hospital discharge: Good neurological state (CPC 1–2) at discharge: 65–69: 9% 70–74: 7% 75–79: 6% 80–84: 4% 85–89: 3% 90–94: 2% 95–99: 1% >100: 2% |
| First author | Study design | Number of participants | Inclusion Conditions | ROSC | Survival to admission | Quality of life |
|--------------|--------------|------------------------|---------------------|------|-----------------------|----------------|
| Andrew, E. et al. | 2018 | 20,103 | Survivors to hospital discharge aged ≥65 years after OHCA | – | Survival until hospital discharge | GOSE |
| Austria [27] | Study design | 20,103 | Inclusion: Survivors to hospital discharge aged ≥65 years after OHCA | Location | Alive | Good upper and lower recovery: |
| | Retrospective | | | | All patients: 9.7% (876/9016) | 65–74: 72.4% (262/363) |
| | analysis of Victorian Ambulance cardiac arrest registry data | | | | 75–84: 63.3% (143/227) | ≥ 85: 41.4% (25/61) |
| | 2010–2016 | | | | Moderate upper and lower recovery: | 65–74: 16.6% (46/277) |
| | Mean age (years) | | | | 75–84: 13.3% (30/227) | ≥ 85: 14.8% (9/61) |
| | 75.0 (SD 7.4) | | | | Severe upper and lower disability: | 65–74: 10.8% (39/363) |
| | Age category | | | | 75–84: 23.4% (53/227) | ≥ 85: 44.3% (27/61) |
| | 65–74: 51.8% | | | | Vegetative state: | 65–74: 0.3% (1/363) |
| | 75–84: 35.6% | | | | 75–84: 0% (0/227) | ≥ 85: 0% (0/61) |
| | ≥ 85: 12.6% | | | | In an aged care facility: | In 1/8 patients were in a vegetative state |
| | Men (%) | | | | 7/8 had a lower severe disability | 7/8 had a lower severe disability |
| | 75.7 | | | | | |

**Table 4 (continued)**

| First author | Study design | Number of participants | Inclusion Conditions | ROSC | Survival to admission | Quality of life |
|--------------|--------------|------------------------|---------------------|------|-----------------------|----------------|
| Andrew, E. et al. | 2018 | 20,103 | Survivors to hospital discharge aged ≥65 years after OHCA | – | Survival until hospital discharge | GOSE |
| Austria [27] | Study design | 20,103 | Inclusion: Survivors to hospital discharge aged ≥65 years after OHCA | Location | Alive | Good upper and lower recovery: |
| | Retrospective | | | | All patients: 9.7% (876/9016) | 65–74: 72.4% (262/363) |
| | analysis of Victorian Ambulance cardiac arrest registry data | | | | 75–84: 63.3% (143/227) | ≥ 85: 41.4% (25/61) |
| | 2010–2016 | | | | Moderate upper and lower recovery: | 65–74: 16.6% (46/277) |
| | Mean age (years) | | | | 75–84: 13.3% (30/227) | ≥ 85: 14.8% (9/61) |
| | 75.0 (SD 7.4) | | | | Severe upper and lower disability: | 65–74: 10.8% (39/363) |
| | Age category | | | | 75–84: 23.4% (53/227) | ≥ 85: 44.3% (27/61) |
| | 65–74: 51.8% | | | | Vegetative state: | 65–74: 0.3% (1/363) |
| | 75–84: 35.6% | | | | 75–84: 0% (0/227) | ≥ 85: 0% (0/61) |
| | ≥ 85: 12.6% | | | | In an aged care facility: | In 1/8 patients were in a vegetative state |
| | Men (%) | | | | 7/8 had a lower severe disability | 7/8 had a lower severe disability |
| | 75.7 | | | | | |

**Table 4 (continued)**

| First author | Study design | Number of participants | Inclusion Conditions | ROSC | Survival to admission | Quality of life |
|--------------|--------------|------------------------|---------------------|------|-----------------------|----------------|
| Andrew, E. et al. | 2018 | 20,103 | Survivors to hospital discharge aged ≥65 years after OHCA | – | Survival until hospital discharge | GOSE |
| Austria [27] | Study design | 20,103 | Inclusion: Survivors to hospital discharge aged ≥65 years after OHCA | Location | Alive | Good upper and lower recovery: |
| | Retrospective | | | | All patients: 9.7% (876/9016) | 65–74: 72.4% (262/363) |
| | analysis of Victorian Ambulance cardiac arrest registry data | | | | 75–84: 63.3% (143/227) | ≥ 85: 41.4% (25/61) |
| | 2010–2016 | | | | Moderate upper and lower recovery: | 65–74: 16.6% (46/277) |
| | Mean age (years) | | | | 75–84: 13.3% (30/227) | ≥ 85: 14.8% (9/61) |
| | 75.0 (SD 7.4) | | | | Severe upper and lower disability: | 65–74: 10.8% (39/363) |
| | Age category | | | | 75–84: 23.4% (53/227) | ≥ 85: 44.3% (27/61) |
| | 65–74: 51.8% | | | | Vegetative state: | 65–74: 0.3% (1/363) |
| | 75–84: 35.6% | | | | 75–84: 0% (0/227) | ≥ 85: 0% (0/61) |
| | ≥ 85: 12.6% | | | | In an aged care facility: | In 1/8 patients were in a vegetative state |
| | Men (%) | | | | 7/8 had a lower severe disability | 7/8 had a lower severe disability |
| | 75.7 | | | | | |
### Table 4 (continued)

| First author | Year | Country | Study design | Methods | Population Setting | Number of participants | Inclusion | Conditions | ROSC | Survival to admission | Survival to ICU/hospital discharge | Long-term survival | Quality of life |
|---------------|------|---------|--------------|---------|---------------------|-----------------------|-----------|------------|------|----------------------|-------------------------------|------------------|----------------|
| Beesems, S. G. et al | 2015 | The Netherlands | Study design: Prospective community-based cohort study with retrospective collection of comorbidity information | 2009–2011 | Age categories: ≥ 70 years: 100%; 70–79 years: 52.5%; ≥ 80 years: 47.5% | 1332 | All nontraumatic OHCA patients of ≥ 70 years in whom CPR was attempted by EMS personnel were included in the survival analysis | Initial rhythm: Shockable: 36%; Not shockable: 64% | Survival to ER: 70 years: 55% (736/1332); 70–79 years: 59% (410/699); ≥ 80 years: 30% (191/633) | Survival until hospital discharge: 70 years: 12% (156/1332); 70–79 years: 16% (108/699); ≥ 80 years: 8% (48/633) | 1-year survival: 70 years: 10% (137/1332); 70–79 years: 14% (96/699); ≥ 80 years: 6% (41/633) | 1-year mortality of patients discharged alive: 88% | Good neurological state (CPC 1–2): CPC1: 9% (9/100); CPC2: 15% (6/41); CPC3: 36% (4/11) | Cerebral Performance Category (CPC) 1–2 at discharge: 1-year mortality rate among those with CPC 1 or 2 at discharge: 21.4% | Discharge location: Home (most without requirement for home health care): 52.6% (592/1127) | An inpatient skilled nursing or rehabilitation facility: 38.3% (431/1127) | Hospice or another facility: 8.0% (90/1127) | Non-home facilities: 1.2% (14/1127) | Readmissions: 638 (56.6%) patients were readmitted during the first year, and 279 (24.8%) were readmitted≥ 3 times |
| Chan P. S | 2016 | USA | Study design: Prospective clinical registry study using the National CARES registry | 2005–2010 | Age category (year): 65+ | 1127 | Adults 65 years or older with an OHCA not occurring in the presence of EMS personnel and enrolled within CARES | Conditions: Witnessed: 70.6%; Bystander CPR: 34.3%; First responder CPR: 29.5%; EMS CPR: 36.1% | Survival until hospital admission: 24.2% (393/16208) | Survival until hospital discharge: 6.9% (1172/16208) | Mortality: At 30 days: 12.7%; At 1 year: 31.8%; At 3 years: 47.2% | Good neurological state (CPC 1–2): Of patients who survived to discharge: CPC 1: 52.8% (555/1127); CPC 2: 25.2% (265/1127); CPC 3: 17.8% (197/1127) | Discharge location: Home (most without requirement for home health care): 52.6% (592/1127) | An inpatient skilled nursing or rehabilitation facility: 38.3% (431/1127) | Hospice or another facility: 8.0% (90/1127) | Non-home facilities: 1.2% (14/1127) | Readmissions: 638 (56.6%) patients were readmitted during the first year, and 279 (24.8%) were readmitted≥ 3 times |
Table 4 (continued)

| First author | Year | Country | Study design | Methods | Number of participants | Inclusion | Conditions | ROSC | Survival to admission | Quality of life |
|--------------|------|---------|--------------|---------|------------------------|-----------|------------|------|-----------------------|----------------|
| Deasy, C. et al 2012 Austria [40] | Study design | A retrospective study of The Victorian Ambulance Cardiac Arrest Registry (VACAR) 2000–2009 | Mean age (years) 70 (52–80) | Men (%) 66 | 30,006 | Inclusion | All OHCA's occurring in residential aged care facilities, which were unwitnessed by EMS | Initial rhythm > 70 years At a residential aged care facility (RACF): Shockable: 7.6% (179/2350) Asystole: 72% (2171/2350) PEA: 20% At home: Shockable: 11% Asystole: 77% PEA: 13% Witnessed for patients > 70 years At RACF: 36% At home: 31% EMS response time for patients > 70 years (min) At RACF: 7 (6–9) At home: 7.9 (6–10) Location 7.8% in a residential aged care facility | ROSC achieved | OHCA at RACF > 70 years: 24% OHCA at home > 70 years: 32% | Survived event | Patients > 70 years: At RACF: 20% (163/815) At home: 26% (1206/4631) Survival until hospital discharge All patients > 70 years: 4.3% (22/5389) OHCA's at RACF > 70 years: All rhythms: 2.1% (17/810) Shockable: 8.2% (12/146) Non-shockable: 0.9% (6/674) OHCA's at home > 70 years: All rhythms: 4.7% (215/4755) Shockable: 9.9% (125/1265) Non-shockable: 2.7% (90/3304) | Discharge location | A rehabilitation facility: 12% (3/25) Survivors returning to the same level of facility from which they originated: 88% (22/25) |
| Fan et al 2017 China [32] | Study design | Retrospective analysis of the prospectively collected data 2012–2013 | Mean age (years) 80 (66–87) | Age categories (years) ≥65 years: 76.4% Men (%) 56 | 5154 | Inclusion | Patients of all ages were who experienced an OHCA Exclusion OHCA's caused by trauma Victims directly transferred to the public mortuary from scene by EMS personnel Patients not using a ground ambulance | Cases attended by EMS Home: 51.7% Public place: 10.5% Street: 3.0% HFA: 30.4% On-route to hospital: 4.3% Others: <0.02% Witnessed arrest: 39.5% Bystander CPR: 28.8% Initial rhythm: VF/VT: 8.7% Asystole: 81.1% PEA: 9.9% Unknown/other: 0.2% EMS response time (min): 10 (8–15) | ROSC on hospital arrival 3.1% (162/5154) | Survived to hospital admission 15.3% (788/5154) Survival until hospital discharge or 30-day survival 2.3% (121/5154) | Good neurological state (CPC 1–2) Of all patients at discharge or at 30 days: 1.5% (78/5154) |
### Table 4 (continued)

| First author         | Year   | Country | Study design | Methods                                   | Number of participants | Inclusion                                                                 | Conditions | ROSC | Survival to admission | Quality of life |
|----------------------|--------|---------|--------------|-------------------------------------------|------------------------|---------------------------------------------------------------------------|------------|------|-----------------------|-----------------|
| Fukuda, T. et al     | 2015   | Japan   | Study design | Prospective, population-based clinical registry study using the All-Japan Utstein Registry of the Fire and Disaster Management Agency 2005–2010 | 605,505                | All patients with a confirmed OHCA of all causes and for whom resuscitation is attempted are identified and followed, including those with DNR orders Data collected from 3 sources: 119 dispatch centers, EMS agencies, and receiving hospitals | Not available for patients ≥65 years | Prehospital ROSC 2005–2006: 4.5% (8696/191,325) 2007–2008: 5.6% (10,928/194,688) 2009–2010: 6.6% (14,521/219,492) | 30-day survival 2005–2006: 3.8% (7230/191,325) 2007–2008: 4.2% (8091/194,688) 2009–2010: 4.6% (10,034/219,492) | Good neurological state (CPC 1–2) Of all patients at 1 month: 1.8% 2005–2006: 1.4% (2627/191,325) 2007–2008: 1.9% (3607/194,688) 2009–2010: 2.1% (4572/219,492) |
| et al                | 2014   | France  | Study design | A retrospective cohort study 2000–2009 | 225                    | Survivors to ICU admission after OHCA aged 75 years and older | Initial rhythm VT/VF: 5% Location Home: 51% Public place: 28% Other: 21% | – | Survival of ICU-admitted patients To discharge: 21.8% (49/225) To 6 months: 19.5% (44/225) To 1 year: 18.5% (42/225) To 5 years: 7.6% (18/225) Survival of ICU-discharged patients 1 year: 69.3% (42/60) 28.4 months: 38% (23/60) 5 years: 32.1% (18/60) | Good neurological state (CPC 1–2) At ICU discharge: 25.3% (57/225) In long-term survivors (28.4 months): CPC1: 91% (21/23) CPC2: 9% (2/23) In patients who died (35/60) or were lost (2/60) during follow-up: 75.6% (28/37) Overall performance category In long-term survivors (28.4 months): OPC1: 74% (17/23) OPC2: 22% (5/23) OPC3: 4% (1/23) 15% (9/37) were institutionalized during follow-up |

#### Notes:
- ROSC: Return of spontaneous circulation
- CPC: Cerebral Performance Category
| First author  | Study design               | Number of participants | Inclusion                                                                                       | Conditions | ROSC                   | Survival to admission          | Quality of life                      |
|--------------|---------------------------|------------------------|------------------------------------------------------------------------------------------------|------------|------------------------|--------------------------------|-------------------------------------|
| Kitamura, T. | Prospective, population-based observational study | 10,876                 | Patients aged ≥ 65 years suffering bystander witnessed OHCA of presumed cardiac origin, who were resuscitated by EMS personnel or bystanders, and were transported to medical institutions | Initial rhythm: VF: 14.8% PEA: 32.5% Asystole: 51.3% Others: 1.4% | Achieved ROSC: Overall: 39% (4251/10 876) VF: 59.9% (962/1614) Non-VF: 35.7% (3289/9262) | Survived to admission: Overall: 30.5% (33 16/10 876) VF: 52.9% (854/1614) Non-VF: 26.6% (246/9262) | Good neurological state (CPC 1–2): At 1 month: 1999: 1.4% 2011: 4.8% At homes: 2.4% (186/7661) At public places: 11.6% (161/1392) At nursing homes: 1.3% (17/1358) At other locations: 5.9% (27/461) VF: 17.1% (276/1614) Non-VF: 1.2% (115/9262) |
| 2014         | Japan                     | 169,360                | All patients with OHCA of cardiac and noncardiac origins in whom resuscitation was attempted and who were then transported to medical institutions | Bystander witnessed: 100% | – | – | – |
| [34]         |                           |                        |                                                                                               |            |                        |                                |                                     |

**Table 4 (continued)**

**First author**

**Year**

**Country**

**Study design**

**Population**

**Setting**

**Number of participants**

**Inclusion**

**Conditions**

**Location**

**ROSCE**

**Survival to admission**

**Quality of life**
Table 4 (continued)

| First author | Year | Country | Study design | Methods | Number of participants | Inclusion Conditions | ROSC | Survival to admission | Quality of life |
|--------------|------|---------|--------------|---------|------------------------|----------------------|------|------------------------|----------------|
| Libungan, B. et al | 2015 | Sweden | Observational study | using the Swedish CPR Register 1990–2013 | 36,605 | Patients aged ≥ 70 years who were reported to the Swedish CPR Register were included | – | 30-day survival | Good neurological state (CPC 1–2) |
|               |      |         |              |         |                        |                      |      | 70–79: 6.7% (1301/19422) | At 30-days: |
|               |      |         |              |         |                        |                      |      | 80–89: 4.4% (647/14710) | CPC1  |
|               |      |         |              |         |                        |                      |      | ≥ 90: 2.4% (59/2473)    | ≥ 90: 86% (51/59) |
|               |      |         |              |         |                        |                      |      | 95–99: 1.7%             | CPC2  |
|               |      |         |              |         |                        |                      |      | 70–79: 79% (1027/1301)  | 70–79: 79% (1027/1301) |
|               |      |         |              |         |                        |                      |      | 80–89: 77% (498/647)    | 80–89: 77% (498/647) |
|               |      |         |              |         |                        |                      |      | ≥ 90: 86% (51/59)       | ≥ 90: 86% (51/59) |
|               |      |         |              |         |                        |                      |      | At 12 months:           | At 12 months: |
|               |      |         |              |         |                        |                      |      | In an aged care facility, no patient reported a good 12-month functional recovery | In an aged care facility, no patient reported a good 12-month functional recovery |
Table 4 (continued)

| First author | Year | Country | Study design | Methods | Population | Setting | Inclusion Conditions | ROSC | Survival to admission | Quality of life |
|--------------|------|---------|--------------|---------|------------|---------|----------------------|------|-----------------------|----------------|
| Okubo M. et al | 2017 | Japan [35] | Study design: A 10-year cohort study | Nationwide, population-based OHCA registry in Japan 2005–2014 Age category ≥75 years Median age (years) 76–80 | Inclusion: All patients aged 75 years or older with OHCA of medical origin in whom EMS attempted CPR and subsequently transported to hospitals Exclusion: OHCA with unknown age Unknown witness status Arrest witnessed by EMS personnel Unknown first documented rhythm Unknown bystander CPR status Unknown origin Unknown outcome | Mean arrival time (min) <70: 8.0 (5.5) ≥70: 8.5 (4.6) Shockable 2005: 8.8% 2006: 9.1% 2007: 9.2% 2009: 9.6% 2010: 9.9% 2011: 9.4% 2012: 9.0% 2013: 9.2% 2014: 10.4% Bystander witnessed 2005: 34.3% 2006: 35.6% 2007: 35.8% 2009: 35.8% 2010: 35.5% 2011: 36.2% 2012: 35.8% 2013: 36.1% 2014: 37.6% Mean arrival time (min) <70: 8 ≥70: 7 Bystander CPR 2005: 34.9% 2006: 38.1% 2007: 42.5% 2009: 43.9% 2010: 46.9% 2011: 47.0% 2012: 47.1% 2013: 46.8% 2014: 50.6% Median EMS response time (min. IQR) 2005: 8 (6–10) 2006: 8 (6–10) 2007: 8 (6–10) 2009: 8 (6–10) 2010: 8 (6–10) 2011: 8 (7–10) 2012: 8 (7–10) 2013: 8 (7–10) 2014: 8 (7–11) | 6.4% (55,152/861,756) 30-day survival: 4.3% (37,055/861,756) | Good neurological state (CPC 1–2) At 1 month: 2.0% (17,235/861,756) |
| First author       | Year | Country     | Study design                                                                 | Number of participants | Inclusion                                                                 | Conditions                                                                 | ROSC | Survival to admission                                                                 | Quality of life |
|--------------------|------|-------------|-------------------------------------------------------------------------------|------------------------|---------------------------------------------------------------------------|-----------------------------------------------------------------------------|------|----------------------------------------------------------------------------------------|------------------|
| Pape, M. et al     | 2017 | Denmark     | A register-based, nationwide, follow-up study using the Danish Cardiac Arrest Register 2001–2014 | 26,999                 | Patients with OHCA in nursing homes and private homes                     | Witnessed arrests, Nursing home: 55.4%, Private home: 43.4% Bystander CPR, Nursing home: 49.7%, Private home: 35.3% | –   | 30-day survival: ≥ 65 years: 3.0% (560/18,956) ≥ 80 years: 1.3% (1058/228) Nursing homes: 1.7% (42/2516) Private homes: 4.9% (1201/24,483) ≥ 65 years Nursing homes: 1.4% (33/2285) Private homes: 3.2% (527/16,671) | –                |
| Pleskot            | 2011 | Czech Republic | Prospective multicenter cohort study 2002–2004                                   | 718                    | Patients aged between 16 and 97 years with suspected OHCA reported to the dispatch center in whom resuscitation was considered | Initial rhythm, Patients ≥ 70 years: VF: 37%, VT: 3%, AV block: 3%, Asystole: 49%, PEA: 8% | –   | 30-day survival: ≥ 65 years: 2.4% (452/18,956) ≥ 80 years: 0.8% (60/828) Nursing homes: 1.2% (29/2516) Private homes: 4.3% (1053/24,483) ≥ 65 years Nursing homes: 0.9% (20/2285) Private homes: 2.6% (432/16,671) | –                |

In the age group 70–79 years
- 2-year survival: 4% (7/175)
- 3-year survival: 4% (7/175)
- 4-year survival: 3% (6/175)
- 5-year survival: 2% (4/175)

None of the patients aged 80 years and over survived 1 year
In the subgroup aged 70 years
- 5-year survival: 2%
| First author | Year | Country | Study design | Population Setting | Number of participants | Inclusion | Conditions | ROSC | Survival to admission | Quality of life |
|--------------|------|---------|--------------|-------------------|-----------------------|----------|-----------|------|----------------------|----------------|
| Segal, N. et al | 2017 | France | Retrospective cohort study using the French National CA registry (RéAC) 2011–2015 | Median age (years) 79 (72–85) | 18,249 | All people > 65 years old with nontraumatic CA on whom at least a resuscitation attempt (i.e., BLS, ACLS, or both) was performed | Bystander CPR: 71.8% Initial rhythm Asystole: 82.4% PE/A: 5.6% VF/VT: 6.6% BLS response time (min) 10 (13.27) Location: Home: 78.4% Public or workplace: 9.9% Institution: 11.6% | ROSC achieved 65–69: 27.9% (836/2999) 70–74: 25.6% (711/2777) 75–79: 23.4% (818/3497) 80–84: 18.6% (719/3864) ≥ 95: 7.7% (18/234) Survival until hospital admission 65–69: 22.0% (660/2999) 70–74: 18.9% (525/2777) 75–79: 16.8% (587/3497) 80–84: 12.7% (491/3864) ≥ 95: 7.3% (17/234) 30-day survival: 65–69: 6.6% (198/2999) 70–74: 3.9% (108/2777) 75–79: 3.2% (587/3497) 80–84: 2.3% (89/3864) ≥ 95: 0.9% (15/234) | Good neurological state (CPC 1–2) 1 month survivors: 65–69: 84.2% (1671/1980) 70–74: 80.0% (861/1082) 75–79: 80.0% (901/1128) 80–84: 91.6% (821/889) ≥ 95: 80.0% (45/56) |
| SOS-KANTO 2012 Study Group | 2015 | Japan | Retrospective collection 2002–2012 | Median age (years) 77 (IQR 71–84) | 8964: 3544 (2002) 5420 (2012) | Patients aged ≥ 65 years, who experienced cardiac arrest of cardiac etiology; received CPR administered by EMS providers; and were subsequently transported to the participating institutions | Exclusion Cases with missing data regarding inclusion criteria or main outcomes (1-month survival, neurological outcome, and ROSC). Onset of cardiac arrest after the arrival of paramedics or after arrival at the hospital Only respiratory arrest at the time of EMS provider arrival Patients from Niigata prefecture from 2002 (no participation) | Witnessed 2002: 1.2% 2012: 0.0% | Pre-hospital ROSC 2002: 3.8% 2012: 5.6% | Pre-hospital CPC 1–2 2002: 72.5% 2012: 74.6% | 30-day survival: 2002: 3.4% 2012: 4.2% | Good neurological state (CPC 1–2) As 1-month: 2002: 1.6% 2012: 2.7% |
| First author | Year | Country | Study design | Methods | Population | Setting | Inclusion | Conditions | ROSC | Survival to admission | Quality of life |
|--------------|------|---------|--------------|---------|------------|---------|-----------|------------|------|-----------------------|-----------------|
| Tsurukiri J  | 2017 | Japan   | Prospective study | 2010–2011 | Men (%): 65 | 31      | Patients aged ≥ 65 years with OHCA who received BLS and did not achieve ROSC until arrival at the emergency center | Location | ROSC achieved: 25.8% (8/31) | Survival until hospital discharge: | – |
|              |      |         |              |         |            |         |           | ROSC       | Octogenarians: 30% (166/588) | Among patients with ROSC: 10% | Quality of life |
| Winther-     | 2015 | Denmark | Retrospective study | 2007–2011 | Mean age (years): 67 (57–79), Men (%): 67 | 2509    | OHCA of all causes with attempted CPR and/or more advanced resuscitative efforts (intubation, medication with dispatch by the EMS) | Inclusion | Octogenarians: 30% (166/588) | 30-day mortality: | Good neurological state (CPC 1–2) |
| Jensen, M   |      |         |              |         |            |         | Patients < 18 years | Exclusion | Octogenarians: 89% | Octogenarians: 9% | Prior to OHCA: |
| et al        |      |         |              |         |            |         | Patients who were found with obvious signs of death (rigor mortis, decapitation, maceration) with no attempted CPR | Successful resuscitated octogenarians | EMS-witnessed OHCA: 7% | EMS-witnessed OHCA: 7% | Octogenarians: 7% (26/33) |
|              |      |         |              |         |            |         | VF/VT: 40% | PEA: 24% | Asystole: 24% | Other/unknown: 12% | 30-day mortality: |
|              |      |         |              |         |            |         | Bystander witnessed: 87% | Bystander CPR: 48% | EMS-witnessed OHCA: 7% | EMS response time (min): 7 (5–10) | Octogenarians: 89% |
|              |      |         |              |         |            |         | Unsuccessfully resuscitated octogenarians | Other/unknown: 11% | Bystander witnessed: 57% | EMS: 5% | CPC 3: 19% (8/43) |
|              |      |         |              |         |            |         | VF/VT: 14% | PEA: 21% | Asystole: 54% | Other/unknown: 5% | CPC 4: 0% | In successful or ongoing CPR: |
|              |      |         |              |         |            |         | Bystander CPR: 26% | EMS-witnessed OHCA: 5% | EMS response time (min): 7 (5–10) | Octogenarians: 79% (26/33) |
from 16 to 28.5% [28, 29]. Five studies registered an overall 1-month survival ranging from 13.5 to 28% [16, 18, 23, 24, 26]. Three studies found an overall 1-year survival between 9.4 and 25% [23, 24, 26].

The systematic review concerning OHCAs consisted of 23 studies. Four of these studies featured patients of 70 years and up exclusively, while five had a mean age of at least 70 years and the remaining studies provided various age categories. A meta-analysis for survival was performed on 14 studies. In patients aged 70 years or older, the overall survival until discharge was 4.1% (range 0–9%). The probability of survival significantly decreased as age increased, both in univariate and multivariate analyses.

Survival until hospital admission registered in five primary studies was 15.3–30.5% [31, 32, 34, 44, 45]. The survival until hospital discharge was registered in nine additional studies was also slightly higher than the previously published review and varied from 6.9 to 11.1% [32, 35–37, 42, 44, 45, 47, 50]. Twelve studies registered the 1-month survival rate, ranging from 3.8 to 7.8% of all patients [28, 29, 31–36, 38, 41, 43, 44]. Of those who survived until hospital discharge, 1-year survival reached 88% [45]. Two studies found a 3-year survival rate ranging from 6.8 to 52.8% [31, 36]. Survival up to 5 years was also registered in two studies and ranged from 2 to 32.1% [36, 39].

Neurological assessment

The results of both the IHCA and OHCA reviews on quality of life following CPR were scarce and contradictory [14, 15].

In the primary IHCA studies exploring CPC as an outcome, a favorable outcome (CPC 1–2) was found in a mean of 20.1–23.6% of all resuscitated patients [16, 23]. This proved to be 82.4–93.1% of the patients surviving until hospital discharge [16, 23, 26]. In the primary OHCA studies, a CPC 1–2 at discharge or at 1 month was registered in only 1–4.8% of all resuscitated patients [28, 29, 32, 34, 35]. On the other hand, one study saw that of all survivors until hospital discharge aged 90 years or older, a favorable outcome at 1 month (CPC 1 or 2) was found in all patients (100%) [43].

Discharge location

In the IHCA review, the discharge location was registered in only one of the included studies. Out of 50 patients who survived until hospital discharge, 38% were discharged to their homes, 24% were admitted to a rehabilitation or psychiatric facility, 18% to a nursing home and 20% were transferred to a chronic care hospital with ventilator capabilities [14]. The proportion of patients who returned home after hospital discharge was registered in three primary IHCA studies and three OHCA studies, ranging from 4.8 to 40% and 52.6–77.9%, respectively [17, 19, 26, 27, 31, 39]. Concerning one OHCA study, 88% returned to the same type of facility from which they originated [40].

Functional recovery

Furthermore, one study concerning IHCA found that although 74.9% of the survivors were functionally independent at hospital admission only 20.1% remained so after the event. In total, 63.4% of survivors were less functional upon hospital discharge compared to their state at the time of admission [17].

With regard to the OHCA cases, two studies used additional QoL measures such as the Overall Performance Category, SF-12 score, GOSE score, and the EQ-5D score [27, 39]. The mean SF-12 mental component summary was 56.5 (SD 6.5). In contrast, the mean SF-12 physical component summary was 44.8 (SD 11.2), and this decreased with increasing age (p < 0.001). They found an upper and lower severe disability in 18.4% of the survivors, with the highest proportion in the age category 85 years and older (44.3%) [27].

Age categories

See Table 5.

Risk factors

Nineteen studies analyzed risk factors associated with short-term and long-term survivals following IHCA and OHCA [17–23, 26, 30–32, 36, 38–41, 43–45].

Patient-related factors associated with worse survival rates were increasing age, a previous history of heart failure or chronic obstructive pulmonary disease, malignancy, renal dysfunction, and multiorgan failure and/or septicemia after CPR. Pertaining OHCA, several studies found that increasing age was associated with worse survival outcomes, but a high Charlson Comorbidity Index (CCI ≥ 4) was not significantly associated with survival.

Arrest characteristics repeatedly associated with increased survival included: initial shockable rhythm (ventricular fibrillation and pulseless ventricular tachycardia), witnessed or ECG monitored arrests, cardiac etiology of arrest, monitored hospital location and time of arrest (during working hours on weekdays). The same risk factors were found concerning OHCA. In addition, arrests at public places were associated with increased survival rates, while arrests that occurred in nursing homes and multiple CPR events resulted in lower chances of survival.
Finally, rescue characteristics such as bystander CPR/defibrillation and shorter time to EMS response, defibrillation and ROSC were also associated with better survival outcomes following both IHCA and OHCA.

Eight studies analyzed risk factors associated with neurological and functional outcome following IHCA or OHCA. Increasing age was associated with worse functional outcomes, whereas initial shockable rhythm, cardiac etiology, public location of the arrest or witnessed arrest, and resuscitation factors such as bystander CPR, early EMS response and early use of automated external defibrillator were associated with a favorable neurological outcome [27, 28, 33, 34, 42, 45]. In addition, being functionally dependent before hospital admission and an admission diagnosis of trauma were associated with less optimal functional outcomes [17, 18].

**Discussion**

This scoping review presents an overview of the survival and quality of life of older patients following IHCA or OHCA. Data regarding the last decennium indicate a slight improvement in the survival until hospital discharge rates at ages 70 years and older following IHCA. Van Gijn et al. (including articles from 1968 to 2012) found an overall survival until hospital discharge of 18.7% for patients between 70 and 79 years old, 15.4% for patients between 80 and 89 years old, and 11.6% for patients of 90 years and older, whereas in more recent primary studies (including articles from 2012 to 2018), these rates were consistently higher (19–28%, 11.3–19% and 11–15%, respectively). The same trend was noted for OHCA with an overall survival rate of 4.1% in the systematic review from 1980 to 2011 versus a survival rate of 4.3–12% in the primary studies from 2011 to 2018, for patients aged 70 years or older.

Neurological outcome of resuscitated patients following IHCA or OHCA was only evaluated in a limited number of studies. Considering all resuscitated patients, the proportion that survived until hospital discharge with a favorable neurological outcome never exceeded 25%. However, considering the subgroup of patients surviving until hospital discharge or 30 days, the proportion with a good neurological outcome was eminently high, namely 82–100% regardless of the age.

**Considerations**

Possibly partially responsible for these improved survival rates is the increased initiation of CPR and/or defibrillation by bystanders out-of-hospital. Better management of complications and post-resuscitation care in-hospital, a specific task of the geriatrician, could also be an important factor contributing to the improved outcomes [48]. However, favorable results are more often seen following cardiac arrests with shockable rhythms which are only present in a minority of the older population. Consequently, overall survival rates remain low.

The effect of age on outcome remains controversial. While the included systematic reviews found that old age was associated with worsened survival outcomes for both IHCA and OHCA, other previously published studies could not find any association [49–51]. These inconsistent results may partially be explained by differences in patient characteristics, circumstances of the cardiac arrest, post-resuscitation care, cultural practices, do-not-attempt resuscitation policies, and withdrawal of life-sustaining treatment practice [52]. Moreover, the older population is particularly heterogeneous. The prevalence of multi-morbidity is increasing from 35 to 65% in patients aged 60–69 years to 80–99% in octogenarians [53]. In addition, the reduction of the physiological reserve of multiple organ systems with aging, called frailty, results in an increased inability to maintain homeostasis when faced with disease or injury. As such, not chronological age, but the level of frailty, which results in the reduced ability to withstand acute stress situations such as cardiac arrests, may be an important contributing factor for worse

| Table 5 | Results categorized by age |
|---------|--------------------------|
|         | 70–79 years | 80–89 years | ≥ 90 years |
| IHCA    |             |             |            |
| Survival until discharge | 20.1–27.9% [18, 19, 26] | 15.3–21.5% [18, 19, 26] | 11–15.1% [18, 19] |
| One-month survival | 27.9% [18] | 20% [18] | 14% [18] |
| CPC 1–2 at discharge | 22.7% [18] | 16.5% [18] | 11.5% [18] |
| ≥ 70 years | ≥ 80 years | ≥ 90 years |
| OHCA    |             |             |            |
| Survival until discharge | 4.3–12.0% [30, 40, 45] | 2.8–8% [30, 45] | 1.7–3.9% [42] |
| One-month survival | 5.4–5.7% [36, 43, 44] | 0.9–7% [36, 38, 41, 43, 44] | 0–2.4% [36, 43, 44] |
| CPC 1–2 at discharge/1-month | 10.5% [44] | 0.9% [33] | 0.5–1.8% [28, 33] |
| One-year survival | 3.2–10% [36, 45] | 0–6% [36, 38, 45] | 0% [36] |
survival outcomes [3]. This was confirmed by a recent study published after this review [54]. These results may facilitate clinical decision making regarding whether CPR may be considered futile.

In conclusion, age alone should not be used as the sole criterion to decide whether CPR is a medically appropriate treatment for the older patient. Patient-related factors (age, medical history and frailty), arrest characteristics (initial rhythm, witnessed of monitored, etiology, location and time) and rescue characteristics (bystander CPR/defibrillation and shorter time to EMS response, defibrillation and ROSC) should also be taken into account.

**Strengths and limitations**

Strengths of this study include giving a comprehensive overview of the most recent available data on outcomes concerning survival, neurological state and quality of life of both in-hospital and out-of-hospital CPR in older patients, by systematically including return of spontaneous circulation (ROSC), survival until hospital discharge, long-term survival (≥ 1 year following the event), discharge location and other quality of life measurements as outcome variables.

This review has several limitations, due to the heterogeneity of classification in the individual studies we were not able to compare outcomes of specific age categories. The age categories were randomly selected, making comparison of outcomes between studies impractical. As a result, no meta-analysis was performed. However, no tools were used to measure the heterogeneity in this review. Furthermore, the pooled odds ratios concerning the risk factors were also not calculated in this study.

In addition, as a result of the inclusion of studies from various regions, different views and regulations concerning CPR performance have been adopted. For example, EMS providers in Japan are not permitted to terminate resuscitation in the field (except in case of decapitation or dissolution), and Do-Not-Resuscitate (DNR) orders are not generally accepted. Therefore, the generalisability of these study results is restricted.

Moreover, the term ‘frailty’ was only mentioned in one study concerning IHCAs [20]. Four OHCA studies mentioned frailty, but did not include this variable in their analysis. This would, however, allow healthcare providers to better differentiate older patients with poor prognosis from those with a good chance of survival. A multidimensional interdisciplinary diagnostic process is required to determine an older person’s medical, psychological and functional capability, such as a comprehensive geriatric assessment. The Clinical Frailty Scale is also a simple bedside assessment that can provide invaluable information when considering treatment escalation plans [54].

Finally, it is also possible that some eligible studies were missed because they did not specifically refer to older patients in the title or abstract. However, by performing an elaborate search and thorough cross-referencing, this risk was reduced to a minimum.

**Implication for practice**

The review provides an overview of the recent evidence on outcome regarding survival and quality of life after CPR following both IHCA and OHCA in the older population. CPR for patients of advanced age should be seen as a conditional therapy that may be worthwhile in some older patients, but may cause significant harm and suffering when applied in an undifferentiated way [55]. This knowledge can contribute to end-of-life conversations between health care practitioner and patient to make well-informed decisions and promote advance care planning (ACP). In hospitalized, frail or elderly patients, the etiology of the arrests is more likely to be complex due to other pathologies and complications [56]. These patients should be well informed about the overall low chance of survival and a significant possibility of neurological deficits, especially for nursing home residents. On the other hand, all patients with a limited risk profile should be informed of their chances of survival with a good neurological outcome following CPR [57].

Advance care planning in the hospital and in long-term-care facilities such as nursing homes can help avoid unwanted or ill-advised CPR. Results show that the implementation of ACP possibly decreases potentially inappropriate life-sustaining treatment, increases the use of hospice and palliative care and prevents hospitalization. It has also proven useful to include end-of-life choices such as Do-Not-Resuscitate decisions [55, 58].

When cardiac arrests happen outside the hospital, information about possible advance care planning is generally unavailable. Validated rules for prehospital termination of resuscitation (TOR) could be highly valuable in such cases to avoid futile transport and escalation of care. Until now, there is no international agreement on TOR rules neither on how to apply them. Verbeek et al. and Morrison LJ et al. propose the following criteria: arrest unwitnessed by EMS provider, no shock delivered, no prehospital ROSC, unwitnessed by bystander or no bystander CPR in an Advanced Life Support setting [59, 60]. Shibahashi et al. propose the following three criteria: non-shockable initial rhythm, unwitnessed by bystanders, and age ≥ 73 years; this TOR rule provided an excellent positive predictive value (> 99%) for unfavorable 1-month neurological outcome after OHCA [61]. These criteria were validated in North America by Grunau and Glober [62, 63].
Future research

None of the included studies was able to capture a good image of the patients' quality of life broader than the neurological outcome. Most of the studies merely used the CPC scale which is insufficiently attuned to identifying all the impairments of cardiac arrest survivors [46]. In addition, this score excludes return to private homes, participation in society or other aspects of life greatly valued by this category of patients such as the desire to avoid being a burden to their family, suffering pain, the loss of speech, the loss of dignity and the incapacity to think clearly [64]. Only two studies incorporated multiple measurement tools to assess the quality of life, namely the Extended Glasgow Outcome Score (or GOSE), the Overall Performance Category (OPC), the SF-12 score, and the EQ-5D score [27, 29]. More extensive research into quality of life after resuscitation will allow patients to make better-informed decisions and facilitate decision making adopted to the patient's clinical situation.

A core outcome set for cardiac arrest (COSCA) was recently developed for adults that identified survival, neurological function, and health-related quality of life as essential outcomes in cardiac arrest effectiveness trials. They stated that survival until hospital discharge, at 30 days, or both should be reported, accompanied by neurological state. Health-related quality of life should be measured with ≥1 tools from the Health Utilities Index-3 questionnaires, Short Form Health survey 36 version 2 or the five-level EQ-5D instruments at 90 days and at periodic intervals up to 1 year after cardiac arrest, if resources allow [65, 66]. Further research should implement this assessment method and determine if it is also optimal for evaluation of the older population. Prospective study designs are preferred, because many potentially relevant prearrest factors or outcome measures cannot be retrieved retrospectively.

Conclusion

Hospital survival rates following IHCA and OHCA in the older population improved in the recent decade, though do not exceed 28.5% and 11.1%, respectively. Several risk factors were identified, among which increasing age and nursing home residency. However, the effect of age on outcome remains controversial and age should not be used as the sole decision criterion whether to initiate CPR. Future research should analyze frailty as an independent variable regardless of age and include more extensive quality of life measures as outcome variables.

Supplementary Information The online version contains supplementary material available at https://doi.org/10.1007/s41999-021-00454-y.

Compliance with ethical standards

Conflict of interest On behalf of all the authors, the corresponding author states that there is no conflict of interest.

References

1. Jacobs I, Nadkarni V, Bahr J, Berg RA, Billi JE, Bossaert L et al (2004) Cardiac arrest and cardiopulmonary resuscitation outcome reports: update and simplification of the Utstein templates for resuscitation registries. A statement for healthcare professionals from a task force of the international liaison committee on resuscitation (American Heart Association, European Resuscitation Council, Australian Resuscitation Council, New Zealand Resuscitation Council, Heart and Stroke Foundation of Canada, InterAmerican Heart Foundation, Resuscitation Council of Southern Africa). Resuscitation 63(3):233–249 (PubMed PMID: 15582757. Epub 2004/12/08. eng)
2. Matsuyma T, Kitamura T, Kiyohara K, Kiguchi T, Kobayashi D, Nishiyama C et al (2018) Assessment of the 11-year nationwide trend of out-of-hospital cardiac arrest cases among elderly patients in Japan (2005–2015). Resuscitation 131:83–90 (PubMed PMID: 30099119. Epub 2018/08/14. eng)
3. Tarras SL, Napolitano LM (2017) Critical Care Epidemiology and Outcomes/Resource Use in the Elderly. In: Luchette FA, Yelon JA (eds) Geriatric trauma and critical care. Springer International Publishing, Cham, pp 355–366
4. Neumar RW, Nolan JP, Adrie C, Aibiki M, Berg RA, Bottiger BW et al (2008) Post-cardiac arrest syndrome: epidemiology, pathophysiology, treatment, and prognostication. A consensus statement from the International Liaison Committee on Resuscitation (American Heart Association, Australian and New Zealand Council on Resuscitation, European Resuscitation Council, Heart and Stroke Foundation of Canada, InterAmerican Heart Foundation, Resuscitation Council of Asia, and the Resuscitation Council of Southern Africa); the American Heart Association Emergency Cardiovascular Care Committee; the Council on Cardiovascular Surgery and Anesthesia; the Council on Cardiopulmonary, Perioperative, and Critical Care; the Council on Clinical Cardiology; and the Stroke Council. Circulation 118(23):2452–83 (PubMed PMID: 18948368. Epub 2008/10/25. eng)
5. Kim J-H, Oh Ym, So BH, Hong TY, Lee WJ, Choi SP et al (2008) Systemic complications of comatose survivors following cardiopulmonary resuscitation. European Geriatric Medicine (2021) 12:695–723
treatments. Intensive Care Med 39(9):1565–1573 (PubMed PMID: 23765236. Epub 2013/06/15.eng)
10. Murphy DJ, Burrows D, Santilli S, Kemp AW, Tenner S, Kreling B et al (1994) The influence of the probability of survival on patients’ preferences regarding cardiopulmonary resuscitation. N Engl J Med 330(8):545–549 (PubMed PMID: 8302322. Epub 1994/02/24.eng)
11. Chang WH, Huang CH, Chien DK, Su YJ, Lin PC, Tsai CH (2009) Factors analysis of cardiopulmonary resuscitation outcomes in the elderly in Taiwan. Int J Gerontol 3(1):16–25 (English)
12. Chamberlain D (2010) Predictors of survival from out-of-hospital cardiac arrest. Heart 96(22):1785–1786 (PubMed PMID: 20965991. Epub 2010/10/23.eng)
13. Narang AT, Sikka R (2006) Resuscitation of the elderly. Emerg Med Clin North Am 24(2):261–272 (PubMed PMID: 16849547. Epub 2006/04/06.eng)
14. van Gijn MS, Frijns D, van de Glind EM, B CvM, Hamaker ME (2014) The chance of survival and the functional outcome after in-hospital cardiopulmonary resuscitation in older people: a systematic review. Age Ageing 43(4):456–463 (PubMed PMID: 24760957. Epub 2014/04/25.eng)
15. van de Glind EM, van Munster BC, van de Wetering FT, van Delden JJ, Scholten RJH, Hoof H (2013) Pre-arrest predictors of survival after resuscitation from out-of-hospital cardiac arrest in the elderly a systematic review. BMC Geriatr 13:68 (English)
16. Al-Dury N, Rawshani A, Israelsson J, Stromsoe A, Agerstrom J et al (2017) Characteristics and outcome among 14,933 adult cases of in-hospital cardiac arrest: A nationwide study with the emphasis on gender and age. Am J Emerg Med 35(12):1839–1844 (PubMed PMID: 28624147. Epub 2017/06/19.eng)
17. Gershengorn HB, Li G, Kramer A, Wunsch H (2012) Survival and functional outcomes after cardiopulmonary resuscitation in the intensive care unit. J Crit Care 27(4):421.e9–17 (PubMed PMID: 22227081. Epub 2012/01/10.eng)
18. Hirlekar G, Karlsson T, Aune S, Ravn-Fischer A, Albertsson P, Herlitz J et al (2017) Survival and neurological outcome in the elderly after in-hospital cardiac arrest. Resuscitation 118:101–106 (PubMed PMID: 28763624. Epub 2017/07/25.eng)
19. Menon PR, Ehlenbach WJ, Ford DW, Stapleton RD (2014) Multicenter in-hospital resuscitation efforts in the elderly. Critical Care Med 42(1):108–117 (PubMed PMID: 24346518. PMCID: PMC367742. Epub 2013/12/19.eng)
20. Roedl K, Jarczak D, Becker S, Fuhrmann V, Kluge S, Muller J (2018) Long-term neurological outcomes in patients aged over 90 years who are admitted to the intensive care unit following cardiac arrest. Intensive Care Med 39(9):1565–1573 (PubMed PMID: 27068632. PMCID: PMC4943267. Epub 2016/04/14.eng)
21. Chan PS, Berg RA, Spertus JA, Schwamm LH, Bhatt DL, Fonarow GC et al (2013) Risk-standardizing survival for in-hospital cardiac arrest to facilitate hospital comparisons. J Am Coll Cardiol 62(7):601–609 (PubMed PMID: 23770167. PMCID: PMC3769937. Epub 2013/06/19.eng)
22. DeVoe B, Roth A, Maurer G, Tamuz M, Lesser M, Pekmezaris R et al (2016) Correlation of the predictive ability of early warning metrics and mortality for cardiac arrest patients receiving in-hospital Advanced Cardiovascular Life Support. Heart Lung 45(6):497–502 (PubMed PMID: 27693935. Epub 2016/10/05.eng)
23. Hessulf F, Karlsson T, Lundgren P, Aune S, Strömösö A, Södersved Källstedt ML et al (2018) Factors of importance to 30-day survival after in-hospital cardiac arrest in Sweden—a population-based register study of more than 18,000 cases. Int J Cardiol 255:237–242 (English)
24. Thompson LE, Chan PS, Tang F, Nallamothu BK, Girotra S, Perman SM et al (2018) Long-term survival trends of medicare patients after in-hospital cardiac arrest: insights from get with the guidelines-resuscitation®. Resuscitation 123:58–64 (English)
25. Kazaure HS, Roman SA, Sosa JA (2013) Epidemiology and outcomes of in-hospital cardiopulmonary resuscitation in the United States, 2000–2009. Resuscitation 84(9):1255–1260 (PubMed PMID: 23470471. Epub 2013/03/09.eng)
26. Chan PS, Nallamothu BK, Krumholz HM, Spertus JA, Li Y, Hammill BG et al (2013) Long-term outcomes in elderly survivors of in-hospital cardiac arrest. N Engl J Med 368(11):1019–1026 (PubMed PMID: 23484828. PMCID: PMC3652256. Epub 2013/03/15.eng)
27. Andrew ER, Mercier E, Nehme Z, Bernard S, Smith K (2018) Long-term functional recovery and health-related quality of life of elderly out-of-hospital cardiac arrest survivors. Resuscitation 126:118–124 (PubMed PMID: 29545136. Epub 2018/03/17.eng)
28. Fukuda T, Ohashi-Fukuda N, Matsubara T, Doi K, Kitsuwa Y, Nakajima S et al (2015) Trends in Outcomes for Out-of-Hospital Cardiac Arrest by Age in Japan: An Observational Study. Medicine (Baltimore) 94(49):e2049 (PubMed PMID: 26656330. PMCID: PMC5008475. Epub 2015/12/15.eng)
29. Group S-KS (2015) Changes in treatments and outcomes among elderly patients with out-of-hospital cardiac arrest between 2002 and 2012: a post hoc analysis of the SOS-KANTO 2002 and 2012. Resuscitation 97:76–82 (PubMed PMID: 26410571. Epub 2015/09/28.eng)
30. Abrams HC, Moyer PH, Dyer KS (2011) A model of survival from out-of-hospital cardiac arrest using the Boston EMS arrest registry. Resuscitation 82(8):999–1003 (PubMed PMID: 21546147. Epub 2011/05/07.eng)
31. Chan PS, McNally B, Nallamothu BK, Tang F, Hammill BG, Spertus JA et al (2016) Long-term outcomes among elderly survivors of out-of-hospital cardiac arrest. J Am Heart Assoc 5(3):e002924 (PubMed PMID: 27068632. PMCID: PMC4943267. Epub 2016/04/14.eng)
32. Fan KL, Leung LP, Siu YC (2017) Out-of-hospital cardiac arrest in Hong Kong: a territory-wide study. Hong Kong Med J 23(1):48–53 (PubMed PMID: 28057896. Epub 2017/01/07.eng)
33. Kitamura T, Iwami T, Kawamura T, Nitta M, Nagao K, Nonogi H et al (2012) Nationwide improvements in survival from out-of-hospital cardiac arrest in Japan. Circulation 126(24):2834–2843 (PubMed PMID: 23035209. Epub 2012/10/05.eng)
34. Kitamura T, Morita S, Kiyohara K, Nishiyama C, Kajino K, Sakai T et al (2014) Trends in survival among elderly patients with out-of-hospital cardiac arrest: a prospective, population-based observation from 1999 to 2011 in Osaka. Resuscitation 85(11):1432–1438 (PubMed PMID: 25110248. Epub 2014/08/12.eng)
35. Okubo M, Kiyohara K, Iwami T, Callaway CW, Kitamura T (2017) Nationwide and regional trends in survival from out-of-hospital cardiac arrest in Japan: A 10-year cohort study from 2005 to 2014. Resuscitation 115:120–128 (PubMed PMID: 28392371. Epub 2017/04/11.eng)
36. Pleskot M, Hazukova R, Stritecka H, Cermakova E (2011) Five-year survival of patients after out-of-hospital cardiac arrest depending on age. Arch Gerontol Geriatr 53(2):e88–e92 (PubMed PMID: 20678813. Epub 2010/08/04.eng)
37. Tsurukiri J, Nagata K, Kumasaka K, Ueno K, Ueno M (2017) Mid-late latency auditory evoked potential index for prediction of post-resuscitation survival in elderly populations with out-of-hospital cardiac arrest. Signa Vitae 13(1):90–3 (English)
38. Pape M, Rajan S, Hansen SM, Mortensen RN, Riddersholt S, Folke F et al (2018) Survival after out-of-hospital cardiac arrest in nursing homes—a nationwide study. Resuscitation 125:90–98 (English)
39. Grimaldt D, Dumas F, Perier MC, Charpentier J, Varenne O, Zuber B et al (2014) Short- and long-term outcome in elderly patients after out-of-hospital cardiac arrest: a cohort study. Crit Care Med
