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Cardiopulmonary resuscitation duration and survival in out-of-hospital cardiac arrest patients☆

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ABSTRACT

Aim: Relationship between cardiopulmonary arrest and resuscitation (CPR) durations and survival after out-of-hospital cardiac arrest (OHCA) remain unclear. Our primary aim was to determine the association between survival without neurologic sequelae and cardiac arrest intervals in the setting of witnessed OHCA.

Methods: We analyzed 27,301 non-traumatic, witnessed OHCA patients in France included in the national registry from June 1, 2011 through December 1, 2015. We analyzed cardiac arrest intervals, designated as no-flow (NF; from collapse to start of CPR) and low-flow (LF; from start of CPR to cessation of resuscitation) in relation to 30-day survival without sequelae. We determined the influence of recognized prognostic factors (age, gender, initial rhythm, location of cardiac arrest) on this relation.

Results: For the entire cohort, the area delimited by a value of NF greater than 12 min (95% confidence interval: 11–13 min) and LF greater than 33 min (95% confidence interval: 29–45 min), yielded a probability of 30-day survival of less than 1%. These sets of values were greatly influenced by initial cardiac arrest rhythm, age, sex and location of cardiac arrest. Extended CPR duration (greater than 40 min) in the setting of initial shockable cardiac rhythm is associated with greater than 1% survival with NF less than 18 min. The NF interval was highly influential on the LF interval regardless of outcome, whether return of spontaneous circulation ($p < 0.001$) or death ($p < 0.001$).

Conclusion: NF duration must be considered in determining CPR duration in OHCA patients. The knowledge of (NF, LF) curves as function of age, initial rhythm, location of cardiac arrest or gender may aid in decision-making vis-à-vis the termination of CPR or employment of advanced techniques.

Introduction

Sudden cardiac arrest accounts annually for 600,000 deaths in industrialized countries. Time to treatment is recognized as a main predictor of survival.[1] Duration of resuscitation efforts is widely recognized as a major determinant of survival after out-of-hospital cardiac arrest (OHCA). Duration of resuscitation may be defined as the sum of two distinct intervals: (1) no-flow ([NF]; interval from collapse to initiation of CPR) and (2) low-flow ([LF]; interval from start of cardiopulmonary resuscitation (CPR) to return of

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Table 1
Characteristics of resuscitated OHCA patients, included in the RéAC register.

Variable[a]	(N = 27,301)
Median age—(10th–90th percentile)—year	71 (58–82)
Age ≥ 65 year—no. (%)	17,058 (62.5)
Male gender—no. (%)	17,728 (64.9)
Location	
Home—no. (%)	19,977 (73.2)
Other—no. (%)	7209 (26.4)
Sudden death characteristics	
EMS—witnessed arrest—no. (%)	2424 (8.9)
Bystander witness performed CPR—no. (%)	11,900 (43.6)
Initial cardiac rhythm—no. (%)	
Ventricular fibrillation or pulseless ventricular tachycardia	3814 (14.0)
Asystole or pulseless electrical activity	22,007 (80.6)
Time from collapse to arrival of first responders, median (10th–90th percentile)—min	14 (5–37)
Time from collapse to first defibrillation shock, median (10th–90th percentile)—min	14 (5–30)
Time from collapse to start of advanced resuscitation, median (10th–90th percentile)—min	24 (10–50)
Time from collapse to start of CPR; i.e. no-flow duration, median (10th–90th percentile)—min	10 (0–35)
Time from sta rt of CPR to the end of resuscitation efforts (ROSC or withdraw resuscitation) i.e. low flow, median (10th–90th percentile)—min	30 (10–50)
Resuscitation outcomes	
Return of spontaneous circulation—no. (%)	7312 (26.8)
Survival to hospital admission—no. (%)	5378 (19.7)
30 day—survival to hospital discharge	1482 (5.4)
30-day—survival to hospital discharge with CPC 1–2	1249 (4.5)

OHCA denotes out-of-hospital cardiac arrest; EMS denotes emergency medical system, CPR denotes cardiopulmonary resuscitation; CPC denotes Cerebral Performance Categories.
[a] All missing data are <5%.

spontaneous circulation (ROSC) or termination of resuscitation).[2] Relatively few published studies have examined the impact of low-flow and no-flow intervals on clinical outcomes.[1,3,4] However these two factors are widely recognized as the most important variables associated with long-term survival without sequelae.[5] Two recent studies pointed out this correlation, based on nationwide registries.[1,3] The first study demonstrated a very robust correlation between the no-flow (NF) interval and survival status, with a rate of survival less than one percent when duration of no-flow exceeded 14 min.[1] In the second study, the authors suggested a strong association between duration of CPR (low-flow) and rate of ROSC with significant increase in survival when institutionally-imposed duration of CPR (low-flow) exceeded 30 min.[3] The results were similar in the setting of in-hospital cardiac arrest.[5] No systematic studies, however, have evaluated the impact of both NF and LF intervals in terms of survival without sequelae and the interaction of these two time parameters. In fact, one might anticipate that prognosis should be inversely proportional to LF and NF. Clinicians often feel helpless in assessing the appropriate length of resuscitation attempts when considering termination of efforts. Unfortunately, national and international guidelines have not adequately addressed this issue. European Resuscitation Council Guidelines for Resuscitation 2015 state that asystole for more than 20 min in the absence of a reversible cause and with ongoing advanced resuscitation constitutes a reasonable ground for stopping further resuscitation attempts.[6] Other authors have opined that it is reasonable to stop resuscitation after a patient has been in asystole for more than 10 min, if there is no readily identified and reversible cause.[7] A quantitative understanding of the relation between LF, NF and survival may help emergency response teams to evaluate the chance of survival knowing two values (NF, LF), aiding in the decision to terminate cardio-pulmonary resuscitation (CPR) or to implement other strategies, such as extracorporeal resuscitation (ECPR) and/or non-heart beating donor orientation (NHBD).[8,9]

In the current study, our primary aim was to determine the association between survival without neurologic sequelae and values of NF and LF in the setting of witnessed OHCA of medical (non-traumatic) origin. A secondary aim was to determine the set of values of NF and LF in which CPR may be considered as futile.

Methods

Participant selection

Study subjects were selected from RéAC, a large, multicenter observational registry of OHCA in France. All patients of any age who have had an OHCA, regardless of etiology, in which a prehospital medical team is involved, regardless of resuscitation attempts, are included in the RéAC register. RéAC was initiated in 2009 and officially implemented in June 2011 in two university hospitals (Lille and Lyon).[10] The RéAC register is a nonprofit organization directed by a management board.

All EMS centers in France report data to the registry in accordance with the Utstein style.[11] Patients are identified through centralized collection of cardiac arrest flow sheets (i.e., clinical records of the events and treatments administered during CPR). Currently, RéAC catalogs about 70% of all persons who have had an OHCA in France and who were managed by a prehospital medical team. Variables obtained include cardiac arrest circumstances, time delays, and characteristics of the resuscitation attempts, hospital survival and 30-day survival with neurologic assessment. This registry has been described elsewhere.[10]

For our study, we included only witnessed non-traumatic OHCA in which resuscitation was attempted and for which the time of collapse was accurately determined.

EMS organization in France

France has a two-tiered, physician-based, EMS system for responses to all medical emergencies. There are 101 regional dispatching centers (called SAMU; Service d'Aide Medical d'Urgences) to cover its 66 million citizens. Each dispatching center may be reached by calling a national emergency number, "15," and is responsible for dispatching to the scene a physician-staffed ambulance and/or a fire ambulance staffed by emergency medical