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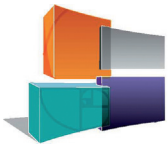

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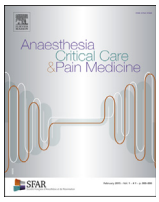

Special article

Epidemiology of out-of-hospital cardiac arrest: A French national incidence and mid-term survival rate study

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ABSTRACT

Out-of-hospital cardiac arrest (OHCA) is considered an important public health issue but its incidence has not been examined in France. The aim of this study is to define the incidence of OHCA in France and to compare this to other neighbouring countries. Data were extracted from the French OHCA registry. Only exhaustive centres during the period from January 1, 2013, to September 30, 2014 were included. All patients were included, regardless of their age and cause of OHCA. The participating centres covered about 10% of the French population. The study involved 6918 OHCA. The median age was 68 years, with 63% of males. Paediatric population (< 15 years) represented 1.8%. The global incidence of OHCA was 61.5 per 100,000 inhabitants per year in the total population corresponding to approximately 46,000 OHCA per year. In the adult population, we found an incidence of 75.3 cases per 100,000 inhabitants per year. In adults, the incidences were 100.3 and 52.7 in males and females, respectively. Most (75%) OHCA occurred at home and were due to medical causes (88%). Half of medical OHCA had cardiovascular causes. Survival rates at 30 days was 4.9% [4.4; 5.4] and increased to 10.4% [9.1; 11.7] when resuscitation was immediately performed by bystander at patient's collapse. The incidence and survival at 30 days of OHCA in France appeared similar to that reported in other European countries. Compared to other causes of deaths in France, OHCA is one of the most frequent causes, regardless of the initial pathology.

1. Introduction

Out-of-hospital cardiac arrest (OHCA) represents a considerable health issue in Europe and in the United States and remains associated with very high mortality and morbidity [1,2]. To improve the outcome of sudden cardiac arrest, measures are needed to strengthen the "chain of survival", which includes a prompt bystander cardiopulmonary resuscitation, quick arrival of the emergency services, early defibrillation, and timely advanced cardiac life support [3]. The potential impact of ongoing efforts to improve the chain of survival needs a precise OHCA incidence and survival estimation over a long period.

The number of OHCA largely varies in Europe and in different areas of the United States [4]. The number of OHCA in France was estimated between 10,000 and 60,000 per year, but these figures were obtained by extrapolation from studies performed in other countries [5]. Furthermore, immediate and long-term survival is also variable in different countries and areas inside each county. This variability seems to be due to different factors such as the aetiology of cardiac arrest, the presence of bystanders, the duration

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of cardiopulmonary resuscitation as well as different timings such as no-flow duration (time between cardiac arrest and first cardiopulmonary resuscitation) and mobile medical team response time.

The French national cardiac arrest registry "RéAC" (Registre électronique des Arrêts Cardiaques) was set up to enabled the well-organised and exhaustive identification and understanding of relevant indicators for effective OHCA care [6]. This paper aims to describe the incidence and immediate OHCA survival in France.

2. Materials and methods

2.1. Study setting

In each French county, the EMS system is a two-tiered, physician-based system with a fire department ambulance for prompt intervention, a single "SAMU" ("Service d'Aide Médicale d'Urgence" – also commonly called "15") dispatch centre and several prehospital emergency departments, which are called Mobile Emergency and Resuscitation Services ("Service Mobile d'Urgence et de Réanimation" [SMUR]). They are responsible for out-of-hospital emergencies care [7]. Each mobile emergency and resuscitation service includes one or more mobile medical teams (MMT) that operate on-scene. Each MMT is mandatorily composed of an emergency physician, a nurse and an emergency medical technician. MMT can be triggered by ground ambulance or by helicopter ambulance if needed. The dispatching physicians are responsible for determining the nature of the emergency response and can give telephone-assisted instructions for cardiopulmonary resuscitation or special care manoeuvres for bystanders. For OHCA, the response team is generally a MMT and fire department team. Generally, the first team arriving on scene is the firemen ambulance which can implement or resume basic life support. The decision to resume resuscitation or to start advance cardiac life support or not is the responsibility of the MMT emergency physician.

2.2. Time period and population

There was no exclusion criterion in this registry. Thus, infants, children and adults were included and taken into account regardless of the nature of their OHCA (traumatic or medical) in this 21-month period from January 1, 2013, to September 30, 2014. Subgroups of the cohort included all MMT-assessed OHCA and MMT-treated OHCA. All included cases were victims of cardiac arrest that occurred outside of hospital which were evaluated by MMT personnel and either received a basic life support (BLS) by lay responders and/or first aid providers (firemen) and were assessed by MMT whether or not advanced cardiac life support (ACLS) was initiated.

The study geographical area extended into 14 mobile emergency and resuscitation services areas of intervention located in different French regions (Aulnay-sous-Bois, Clichy, Bobigny, Chalons-sur Saône, Clermont-Ferrand, Créteil, Garches, Lille, Lyon, Montfermeil, Roubaix, Rouen, Saint-Denis and Villefranche-sur Saône). Mobile emergency and resuscitation services were selected according their volunteered, exhaustive and complete participation during the period noted above. The resident population covered by each mobile emergency and resuscitation service was obtained from demographic data published by INSEE (National Institute of Statistics and Economic Studies). Data were those calculated for populations in 2011. This data divided populations by gender and age regarding data from the INSEE (<15; 15–29; 30–44; 45–59; 60–79; 75–89; >90 years).

2.3. Study design and data collection

Data were extracted from the French national cardiac arrest registry (RéAC) database. The RéAC was created in 2011 and was previously described elsewhere [6]. Briefly, the RéAC is a secure, web-based data management system that was initiated in 2009 and deployed nationally in June 2012. The main goal of this registry is to monitor, analyse and compare out-of-hospital cardiac arrest circumstances, care and survival. Hence, the secondary objective based on these results is to improve care and survival rate of OHCA patients. The report form is in compliance with the requirements of French organisations and is organised designed into the following sections in accordance with the Utstein universal style [3,8]: anamnesis and BLS, MMT activation, ACLS, medical transport and outcome. The RéAC provides real-time statistical analysis and allows French EMS to assess and improve their professional OHCA care practices. All participating mobile emergency and resuscitation services use the specific recording sheet used during the intervention to collect patient data. This specific recording sheet is legally validated and can be used to replace the current MMT forms [6]. Next, the data are reported in the RéAC secured database (www.registreac.org). Then, if the patient is alive at hospital admission, a follow-up record sheet must also be completed and recorded in the database. These data are computerised by the MMT physician who can be helped by a nurse, secretary or clinical research associate.

2.4. Data quality control

Several quality controls are performed in real-time during data input to detect errors, inconsistencies or out-of-bound values. Offline tests are performed to detect other types of errors that require verification from the originating EMS. Randomly chosen records are assessed by a clinical research associate in order to identify new types of inconsistencies or errors that should be included in the automated tests (on- or off-line).

2.5. Incidence assessment

The annual incidence of OHCA was computed by dividing the total number of OHCA events by the product of the number of years of the study and the community's population, as determined by INSEE and reported as cases per 100,000 per year. Survival rates were reported as percentage [CI 95%] of the number of OHCA patients. As INSEE recently published in 15 years intervals, the incidence is calculated in the total population and by these intervals (0–14, 15–29, 30–44, 45–59, 60–74, 75–89 and >90 years).

2.6. Ethical aspects

The study was approved by the French advisory committee on information processing in health research (CCTIRS) and by the French National Data Protection Commission (CNIL, authorisation number 910946). This study was approved as a medical assessment registry without the requirement for patient consent.

3. Results

We included 6918 OHCA in this study. Their characteristics are showed in Table 1. The median age was 68 years old. The median of age for the adult population (> = 15 years) was 69, as OHCA remains rare in people under 15 (n = 115). Overall, 63% of OHCA were males and 37% were females. Among OHCA, 75% occurred at home and 12% in public locations. About half occurred in the

Table 1
Characteristics of the population and OHCA in this population.

Age	
Median (years)	68
Q1–Q3 (years)	53–82
Gender	
Male, *n* (%)	4308 (63.2)
Female, *n* (%)	2510 (36.8)
Cardiac arrest location	
Home, *n* (%)	4126 (75)
Public place, *n* (%)	6 58 (12)
Work place, *n* (%)	83 (2)
Other, *n* (%)	598 (11)
Witness status	
Bystander, *n* (%)	3338 (49)
MMT or first aid professional, *n* (%)	559 (8)
Unwitnessed CA, *n* (%)	2921 (43)
Cardiac arrest aetiology	
Medical, *n* (%)	5988 (87.8)
Traumatic, *n* (%)	830 (12.2)
Presumed medical cause	
Cardiac, *n* (%)	2526 (42)
Respiratory, *n* (%)	768 (13)
Other, *n* (%)	2694 (45)
Diabetes history, *n* (%)	755 (17)
Timings, median [Q1; Q3] min	
No-flow	7 [1–13]
MMT response time	18 [12: 25]
Initial rhythm at MMT arrival	
Asystole, *n* (%)	5555 (80.3)
Pulseless VF/VT, *n* (%)	408 (5.9)
Pulseless electrical activity, *n* (%)	415 (6.0)
Spontaneous activity, *n* (%)	540 (7.8)

Q1: first quartile; Q3: third quartile; MMT: mobile medical team; CA: cardiac arrest; VF: ventricular fibrillation; VT: ventricular tachycardia.

presence of a bystander and only 8% in the presence of a mobile medical team.

Among the known medical OHCA (n = 5988; 88%), a history of cardiac pathology was reported in 42% and diabetes in 17%. The initial rhythm at mobile medical team arrival was mainly asystole (80.3%), ventricular fibrillation or tachycardia was observed in 5.9%, pulseless electrical activity in 6.0% and a spontaneous activity was recorded in 7.8%.

The global incidence of OHCA was 61.5 per 100,000 inhabitants per year in the total population corresponding to approximately 46,000 OHCA per year. In the adult population (> = 15 years old) we found an incidence of 75.3 cases per 100,000 inhabitants per year. The total incidence was 80.7 in males and 43.7 in females per 100,000 inhabitants per year, respectively. In adults (> = 15 years old) we found a total incidence of 100.3 and 52.7, respectively, in males and females. As shown in Fig. 1, the incidence was clearly higher in males than in females in each age interval. The incidence of OHCA of medical aetiology was 69.3 and 39.8 per 100,000 inhabitants per year in males and females. Traumatic aetiology incidence was lower with a global incidence of 11 in adult males and 4 in females, respectively (Table 2).

Among OHCA of medical causes, the aetiology was deduced from the history of the patient. A cardiovascular disease was known in 43% of subjects, pulmonary disease in 13%, diabetes in 13% and end of life expected (essentially to cancer) in 5%. The main cause of OHCA appeared therefore from cardiac aetiology knowing that a large part of diabetic patients died of cardiac disease.

On general population, 4.9% [4.4; 5.4] of OHCA patients were still alive at 30 days or hospital discharge. It corresponds to 5.4% [4.8; 6.0] of medical OHCA victims and 1.7% [0.8; 2.6] of traumatic OHCA victims ($P < 0.001$; OR: 3.32 [1.94; 5.70]). When patients benefited from a bystander BLS, survival rates increased leading to 9.0% [7.9; 10.1] of patients surviving at day 30 with respectively 9.5% [8.4; 10.6] for medical OHCA victims and 3.7% [1.3; 6.1] for traumatic OHCA victims ($P = 0.002$; OR: 2.77 [1.40; 5.45]). Furthermore, when this BLS was implemented immediately at patient's collapse, the survival rate was even higher with 10.4% [9.1; 11.7] at day 30 or hospital discharge (11.1% [9.7; 12.5] in medical OHCA and 3.7% [1.0; 6.4] in traumatic OHCA; $P = 0.001$; OR: 3.25 [1.51; 7.01]). However, when only MMT cared patients, survival rates decreased to 4.3% [3.4; 5.2] with respectively 4.7% [3.7; 5.7] in medical OHCA and 1.7% [0.1; 3.3] in traumatic ($P = 0.029$; OR: 2.94 [1.07; 8.09]) (Fig. 2). ACLS was not attempted by MMT in 2324 of the 5988 patients presenting OHCA of medical origin (38.8%) and 388 patients of 830 presenting a traumatic OHCA (46.7%).

4. Discussion

In a systematic review of global incidences of OHCA carried out in 2010, Berdowski et al. [4] noted that the incidence of OHCA in

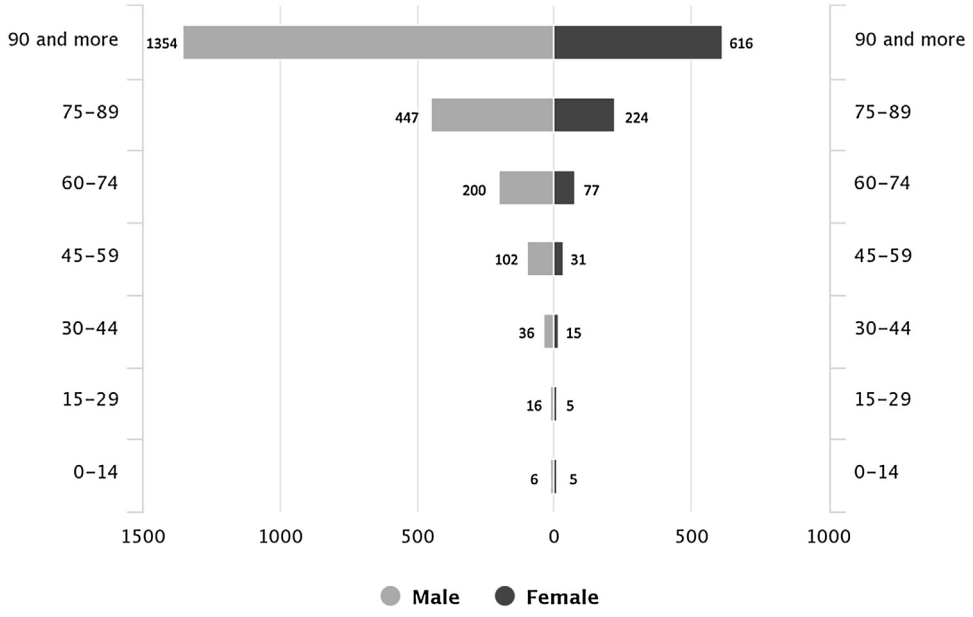

Fig. 1. Incidence of OHCA by gender and age class (number for 100,000 persons per year).

Table 2
Medical and traumatic OHCA incidence per gender and age class (number for 100,000 persons per year).

Age (years)	Medical OHCA		Traumatic OHCA	
	Males	Females	Males	Females
<15	4	4	2	1
15–29	7	3	9	2
30–44	21	10	15	5
45–59	86	29	16	2
60–74	186	71	14	6
75–89	426	216	20	9
>90	1261	604	92	14

OHCA: out-of-hospital cardiac arrest.

which mobile medical team was triggered largely varied between 24 and 186 per 100,000 persons per year with a mean of 100 and 86.4 in Europe. The French incidence in adults (75.3) belongs to the large interval found in Europe [4,9–11], but is moderately lower than in the mean calculated in the above review (95.9). However, the above review was published in 2010, including populations analysed during the 1990s and 2000s, while our study was performed in 2013 and 2014. This difference could be partially explained by the decrease in the coronary heart disease incidence measured for a few years [12], with part of OHCA having a cardiac origin.

The origins of OHCA, particularly cardiac causes, are difficult to report in out-of-hospital vital emergency situations. Furthermore, their incidence varies widely between studies. In our study, we have taken into account the history of the patient. In other studies, the diagnosis was established by exclusion (absence of another cause of OHCA) [4,8,10] or by all available information including death certificates and necropsy reports [13]. In a literature review centred on cardiac origin OHCA in European communities [9], we observed that the incidence largely varies between 5 and 119 per 100,000 persons per year with a mean of 38. As OHCA in diabetic patients was very often of cardiac origin, it can be supposed that between 45 and 50% of medical OHCA was of cardiac pathology. The mean OHCA observed in our study is in agreement with the literature.

Although the number of OHCA was small, we were able to calculate the global incidence of OHCA in this population with regard to the large population covered. Furthermore, as recorded by Berdowski et al. [4], the inclusion of paediatric OHCA to the global OHCA did not change the results, which show incidences of 96 and 84 per 100,000 persons per year in adult only and total populations, respectively.

Taking into account the distribution of OHCA per age interval observed in this study and assuming our sample of 10% of the metropolitan French population, we have calculated that the OHCA would be about 46,000 cases per year, of which 40,000 would be of medical origin. These results are close to the historical incidence estimation (50,000) used for several decades. However, this estimation is not perfect because the centres that participated in this study could not be considered perfectly representative of the total metropolitan French population. However, this result in in compliance with another recent study, EuReCA-One, which also deals with French OHCA incidence results [14]. This number is also compared to cardiovascular disease-related deaths in France (about 140,000/year), ischaemic cardiopathy (35,000/year), cardiovascular disease incidence, cancer of the lung (32,000/year), or breast cancer in females (12,000/year) (http://www.cepidc.inserm.fr). Thus, OHCA, whatever the cause, appeared as a frequent pathology and yet survival rates remain relatively low.

The global survival at 30 days was similar to the mean observed in a number of studies, which was between 5.6 and 7.1% at discharge, and sometimes higher in other studies [6,11,15,16] or clearly lower [1]. This variability is likely to depend on populations and the percentage of subjects immediately cared for by a bystander or/and MMT. In our study, the survival slightly increased when a bystander began cardiopulmonary resuscitation or MMT started or resumed cardiopulmonary resuscitation. The same effect is observed, even though it appeared more important in the study of Nichol [1], in whom the survival increased from 3.3% for the global population to 8.4% when MMT attempted ACLS in victims of OHCA. However, this increase, more important in Nichol's study than in ours, can also be explained by the promptness of ACLS initiation. Indeed the median time to ACLS was 7 minutes vs. 20 minutes in France in a previous study [6] vs. 18 minutes in our population.

We shall also highlight the fact that most OHCA are localised at home. Indeed, in these cases, public external defibrillators are not available. As the high percentage of OHCA localised at home was observed in other countries [1] as in France, that means that the reduction in mortality could also be obtained by a better training of bystanders for immediate cardiopulmonary resuscitation and/or the presence and use of external defibrillators at home in patients at high risk such as those with cardiac diseases. As the global

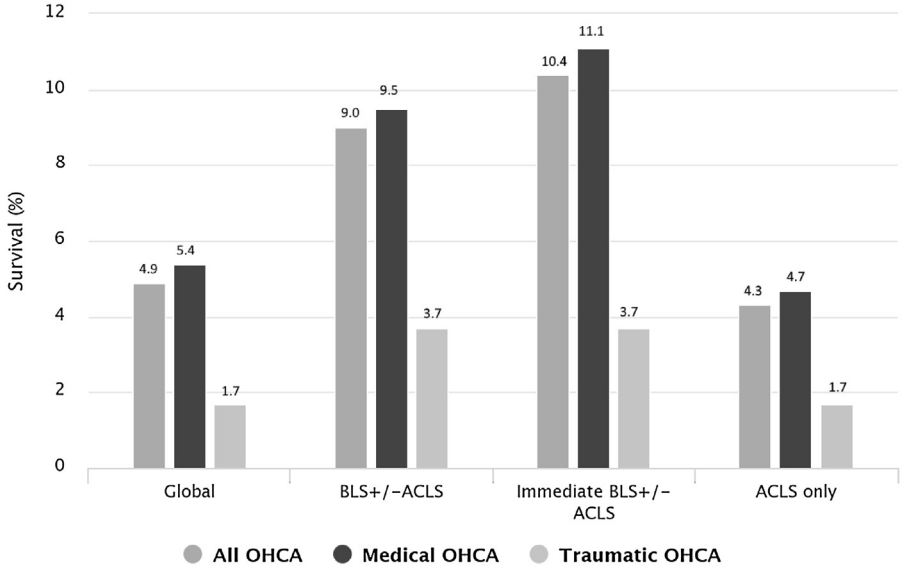

Fig. 2. Global, traumatic and medical survival rates by type of resuscitation.

survival was relatively low, we should also set up procedures to improve this survival. The training of bystanders [17,18], essentially when training was recent (< 2 years) [19] and the type of training (chest compression only vs. chest compression and mouth-to-mouth) has to be precisely analysed [20,21]. An improvement in survival with a good neurological survival could be obtained by checking other procedures such as extracorporeal cardiopulmonary support [22] or drugs. Furthermore, even if the subjects' characteristics such as the presence of diabetes or immediate bad neurological conditions (within 72 hours), this leads to poor neurological prognosis 30 days after the hospital admission [23,24].

5. Conclusions

In conclusion, the incidence of OHCA is as high as in other neighbouring countries and the survival was relatively low. As OHCA remains a main issue in terms of public health, the improvement of survival with a good neurological prognosis is essential. However, if observational studies showed potentially differences between procedures or therapeutics, only a few studies using rigorous scientific criteria such as that used a few years ago [25,26], were performed to check different procedures.

Ethical statement

The study was approved by the French advisory committee on information processing in health research (CCTIRS) and by the French National Data Protection Commission (CNIL, authorisation number 910946). This study was approved as a medical assessment registry without the requirement for patient consent.

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Disclosure of interest

The authors declare that they have no competing interest.

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