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1 **ReACanROC: Towards the Creation of a France-Canada Research** 2 **Network for Out-of-Hospital Cardiac Arrest**

3
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1 **ABSTRACT**

2 **Aims:** There are large differences between emergency medical systems, which may account for
3 variability in outcomes. We seek to compare prehospital organizations, response modes, patient
4 characteristics and outcomes after out-of-hospital cardiac arrest, between France and Canada,
5 and discuss the need for the first European-North American prehospital research network on out-
6 of-hospital cardiac arrest.

7 **Methods:** Preliminary comparative description of data drawn from two nation-wide, population-
8 based, Utstein-style prospectively implemented registries for out-of-hospital cardiac arrest in
9 France and Canada (France: RéAC, Canada: CanROC), covering approximately 80 million
10 people, and soon to be participating in an international research network in 2020.

11 **Results:** Since creation, 103,722 cases were included in France and approximately 99,317 in
12 Canada. Data used in this work were drawn from 2011 to 2016, and comprised around 33,688
13 adult, non-traumatic, treated cases in Canada, and 55,358 in France, leading to estimated
14 incidence rates of 75,3/100,000 inhabitants in France and 83/100,000 in Canada. In both
15 countries, out-of-hospital cardiac arrest predominantly occurred in male patients, in their late
16 sixties, at home, of presumed cardiac aetiology. Bystander cardiopulmonary resuscitation was
17 provided in half of the cases. First assessed cardiac rhythm was shockable in 16% (France) vs.
18 22% (Canada). Professional resuscitation was attempted in 82% (France) and 60% (Canada).
19 Prehospital organizations and response modes differed in the constitution of responding teams
20 (France: physician-led advanced life support, Canada: trained paramedics), in response time
21 intervals (call to first professional responders' arrival at scene 6.5 min (interquartile range IQR
22 [5.2-8.3]) (Canada) vs. 10 min [7-15] (France)), in on-scene interventions, type of referral at
23 hospital (France: systematic bypass of emergency department, tertiary hospital first, Canada:

1 occasional bypass, mainly closest hospital first), and in outcomes (overall survival at hospital
2 discharge in France: 5%, vs. Canada: 11%).

3 **Conclusion:** Despite similarities in some out-of-hospital cardiac arrest Utstein variables, several
4 differences exist between French and Canadian prehospital systems, and ultimately, between
5 outcomes. The creation of the ReACanROC research network will facilitate the conduction of
6 further analyses to better understand predictors of this variability.

1 INTRODUCTION

2 Outcomes after out-of-hospital cardiac arrest (OHCA) greatly vary upon countries, territories and
3 communities, with overall survival at hospital discharge, in emergency medical system (EMS)-
4 treated cases, ranging from 0% to 31% (aggregate 6,7% to 8,4%) (1). While these differences
5 can be in part accounted for by Utstein variables within the chain-of-survival, additional
6 variability remains (1,2).

7 Emergency medical services (EMS) systems in Canada and France demonstrate significant
8 differences in terms of organizations and practices (3,4). Response modes range from: physician-
9 led ambulances, critical care or advanced life support-trained paramedics, basic life support-
10 trained paramedics, fire fighter first responders, or emergency medical responders/technicians.
11 The EMS fleet composition, response times, access to bystander cardiopulmonary resuscitation
12 (CPR), external defibrillation, airway control, and drug administration of these different units
13 may affect outcomes (5–7). Further variation exists within other countries based on population
14 density and geography (8), resulting in decreased access to advanced prehospital care and
15 prolonged response times in rural and remote locations (9), therefore leading to possible
16 inequities in access to urgent and critical care (10).

17 Access to prehospital care does not only vary on a large geographic scale, it varies at
18 community- and facility levels as well. While response times are logically longer in high-rise
19 buildings (11) or in large/complex facilities (such as train stations) (12–14), leading to poorer
20 outcomes after OHCA, they also appear to be delayed in rural areas (15), socioeconomically
21 deprived areas (16), or in areas with predominantly non-white populations (17). The association
22 between low socioeconomic status, access to critical interventions, and patient outcomes remains
23 poorly understood. Some authors have suggested that poorer outcomes may be the result of

1 lower bystander presence and participation (18), lower availability of automatic external
2 defibrillators (19), more frequent accessibility constraints to EMS providers (20), or population
3 growth and urbanization rates (21). Further, as the socioeconomic status of a given territory is a
4 dynamic process that evolves with time, the ability of EMS to evolve in a corresponding time
5 and space is unclear.

6 The dynamic associations between prehospital organizations, response modes, geographic and
7 socioeconomic predictors of incidence and survival after OHCA therefore need to be further
8 explored (22). Because in-depth comparisons between service delivery and outcomes of systems
9 with differing prehospital configurations and geo-socio-economic landscape will help to identify
10 areas for care improvement, we sought to describe and compare available, preliminary, aggregate
11 data between OHCA registries in France and Canada, to illustrate the need for the creation of the
12 first international Europe-North America research network on OHCA.

13

14 **METHODS**

15 *Settings*

16 We are creating ReACanROC, an international research network between two nation-wide,
17 population-based, Utstein-style prospectively implemented registries for EMS-assessed OHCA
18 in France and Canada: RéAC (*Registre électronique des Arrêts Cardiaques*, data from 2011,
19 France), and CanROC (*Canadian Resuscitation Outcomes Consortium*, previously ROC Epistry,
20 data from 2005 in Ontario (the OPALS communities organized from Ottawa; the former Rescu
21 (now R3) communities organized from Toronto) and in British Columbia urban communities)),
22 covering approximately 80 million people (fig.1). CanROC was created in 2016 after the ROC
23 funding was discontinued. CanROC is currently expanding to include all provinces in Canada.

1 Over 87% of the 350 French prehospital mobile medical teams (MMT) participate in the RéAC
2 registry (n=305), covering a total population of 60 million inhabitants in 82 out of 96 regions on
3 mainland. MMT provide advanced life support (ALS), while first responders (firefighters)
4 provide basic life support (BLS). Nation-wide, MMT's density is 0.7/100.000 inhabitants (min.
5 0.2, max. 2.4) (23), and firefighters units' density is 10 (min. 8, max. 20) (24). National response
6 time goal metrics recommend MMT to arrive at scene within 30 minutes after receiving the call.
7 There are no such nation-wide objectives for firefighters' units. Every OHCA case included in
8 RéAC is a case for which an MMT is dispatched for assessment.

9 Of 40 EMS agencies (Ontario: 39, British Columbia (BC): 1) involved in CanROC, 150 EMS
10 units currently participate in the OPALS site, and 98 in the Toronto site. BC has a single
11 province-wide EMS system, which includes dispatch, ground response and interfacility
12 transfer/critical care primarily staffed by paramedics. Out of the 746 EMS units in BC, 172 BLS
13 and 36 ALS ambulances participate in CanROC. The total population covered by CanROC
14 registry is 20 million people. Every caregiver that participates in the chain-of-care of OHCA
15 patients can implement the CanROC registry. In Ontario and British Columbia, goal metrics for
16 EMS response times in urban areas are 6-9 minutes for OHCA. Every OHCA patient who is
17 treated by an EMS team is eligible for inclusion in CanROC.

18 Detailed rationales and implementations of both ReAC and CanROC, and other epidemiology
19 results, can be found in previously published articles (2,25–27).

20

21

1 *Data*

2 We used preliminary, available, aggregate data drawn from the RéAC (nation-wide) and
3 CanROC historical sites (ex-ROC Epistry: British Columbia and Ontario) registries. Both RéAC
4 and CanROC are Utstein-style based. They record a broad range of variables, of which core
5 elements and time events are synthesized in table 1.

6 In Canada, data from 2011 to 2016 were drawn from the Canadian sites of the North-American
7 ROC Epistry, comprising 8 sites in United States of America and 3 in Canada. CanROC now
8 aggregates data from its former ROC sites and data drawn by its current sites from 2016 to date.
9 Because ReACanROC will only use French and Canadian datasets, and in order to ensure
10 comparability between the two countries, no data that were drawn from the previous ROC
11 American sites were used in this article.

12 For standardization and comparability purposes, and due to ongoing regulatory processes, we
13 used data drawn between 2011 and 2016, for all cases recorded in RéAC and Canadian sites of
14 ex-ROC/CanROC.

15 Categorical variables are reported as numbers and percentages, and continuous variable are
16 reported as median with interquartile range ([Q1-Q3]).

17

18 **RESULTS**

19 Since creation, 103,722 patients were included in RéAC, and 99,317 in CanROC sites. The
20 number of patients analyzed in this article (adult, non-traumatic, EMS-treated) was 55,358

1 (France) and 33,688 (Canada), leading to estimated incidence rates of 75,3/100,000 (France) and
2 83/100,000 (Canada).

3 France and Canada have globally comparable populations of patients suffering OHCA (male
4 patients, median age in the mid-sixties, suffering at-home OHCA, mostly from presumed cardiac
5 aetiology, often witnessed by a non-professional bystander, with a non-shockable initial rhythm).
6 In contrast, France and Canada present with different geography, EMS systems, practices and
7 outcomes (table 2). Notable differences include: the proportion with professionally attempted
8 resuscitation varied from 60% (Canada) to 82% (France); response time intervals (from call to
9 arrival at scene) for BLS and ALS varied from 6.5 min [5-8.5] and 7 min [5-10] (Canada) to 10
10 min [7-15] and 20 min [20-28] (France); initially attempted resuscitation was discontinued prior
11 to transportation to hospital in 79% (France) and 45% (Canada) of the cases; and both overall
12 survival rates and neurological status in survivors at hospital discharge varied within wide ranges
13 (survival 5% (France) vs. 11% (Canada), favourable neurological status (cerebral performance
14 category (CPC) ≤ 2) 84% (France) vs. 92% (Canada).

15 The definitions of the Utstein core elements were very similar between the two registries, except
16 for the definition of presumed cardiac aetiology, hence ensuring good comparability of data used
17 for the present work (table 1).

18

19 **DISCUSSION**

20 *Main results*

21 Preliminary comparison of data drawn from RéAC and CanROC highlighted several differences
22 in prehospital system organizations, care delivery, practices and outcomes. Detailed analyses,

1 conducted on full and merged datasets from creation to date, are required in order to identify
2 possible reasons to explain differences in outcomes, and to gain further insight into the optimal
3 EMS configuration for OHCA management. One of the core questions that needs to be explored
4 is why a system with physician-led triage and advanced life support, and systematic emergency
5 department (ED) bypass towards catheterization laboratory and intensive care unit, presents with
6 overall survival apparently over two times poorer than a system without prehospital physicians
7 (5% vs. 11%), and in which ED bypass is inconsistent. Another question is to what extent
8 regional variations occur within, and between, each country. Higher rates of attempted
9 resuscitation, exploration of the definitions of presumed cardiac causes or other systematic
10 differences in aetiology, longer EMS response times, lower socioeconomic status, or higher
11 variability in geographic and temporal OHCA incidence rates may account for such inequities,
12 and represent key objectives for the future ReACanROC network.

13

14 *Implications for future work*

15 The ReACanROC network will be set during 2020. Once the datasets are merged and fully
16 explorable, ReACanROC will be the first Europe-North America research network on OHCA. It
17 will help to better understand the differences in outcomes between the countries and territories,
18 and their associations with geographic, socioeconomic and EMS system-related factors. Because
19 we suspect that several of the differences between France and Canada, and *in extenso* between
20 systems of either type (e.g. physician- or paramedic-led), will rely on predictors that are not
21 purely technical, we seek to perform observational studies (including propensity matched
22 analyses), comparative effectiveness analyses (including simulation modeling), and subsequently
23 international randomized clinical trials focusing on new practices and organizations.

1 *Limitations*

2 This preliminary work has limitations. First, because the ReACanROC network is not created
3 yet, and because the present work was aiming at discussing the need for its creation, we did not
4 have full access to merged and homogenized datasets, but only to aggregate data; hence we were
5 neither able to perform statistical tests of hypothesis, nor to describe, quantify, or address
6 missing data between the two datasets. Nevertheless, every core Utstein elements and time
7 events are mandatory for each registry, in order to reduce the amount of missing data, and to
8 ensure sufficient data quality.

9 Second, as depicted in previous works, the variability we are discussing may be related to the
10 quality, exactitude or definition of the variables recorded in each of the registries (28). Despite
11 using the Utstein template, each of the registries sometimes uses some specific categories for
12 core elements, and also different optional variables. Such differences warrant systematic
13 comparison of both datasets, which will be provided in future works.

14 Finally, comparing health systems is complex and must take into account a broad range of
15 variables that do not appear here, or are not collected by any of our registries (29).

1 **CONCLUSION**

2 France and Canada present with differences in EMS systems organization and care delivery, and
3 ultimately in outcomes after OHCA. The creation of ReACanROC, the first Europe-North
4 America research network on OHCA, will aim, first, at comparing the structure of each dataset,
5 and second, at further exploring structural, demographic, geographic, and socioeconomic
6 predictors of survival.

1 **Conflicts of interest**

2 The Authors declare none.

3

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- 19
- 20

1 **Legends to figures**

2 Figure 1. Sites participating in ReAC (France, A) and CanROC (Canada, B) registries

3 Table 1. Recommended Utstein core variables and time events recorded in RéAC and CanROC
4 registries: matching definitions

5 Table 2. Characteristics of EMS systems, OHCA patients and outcomes between France and
6 Canada (preliminary data)

Figure 1. Sites participating in ReAC (France, A) and CanROC (Canada, B) registries

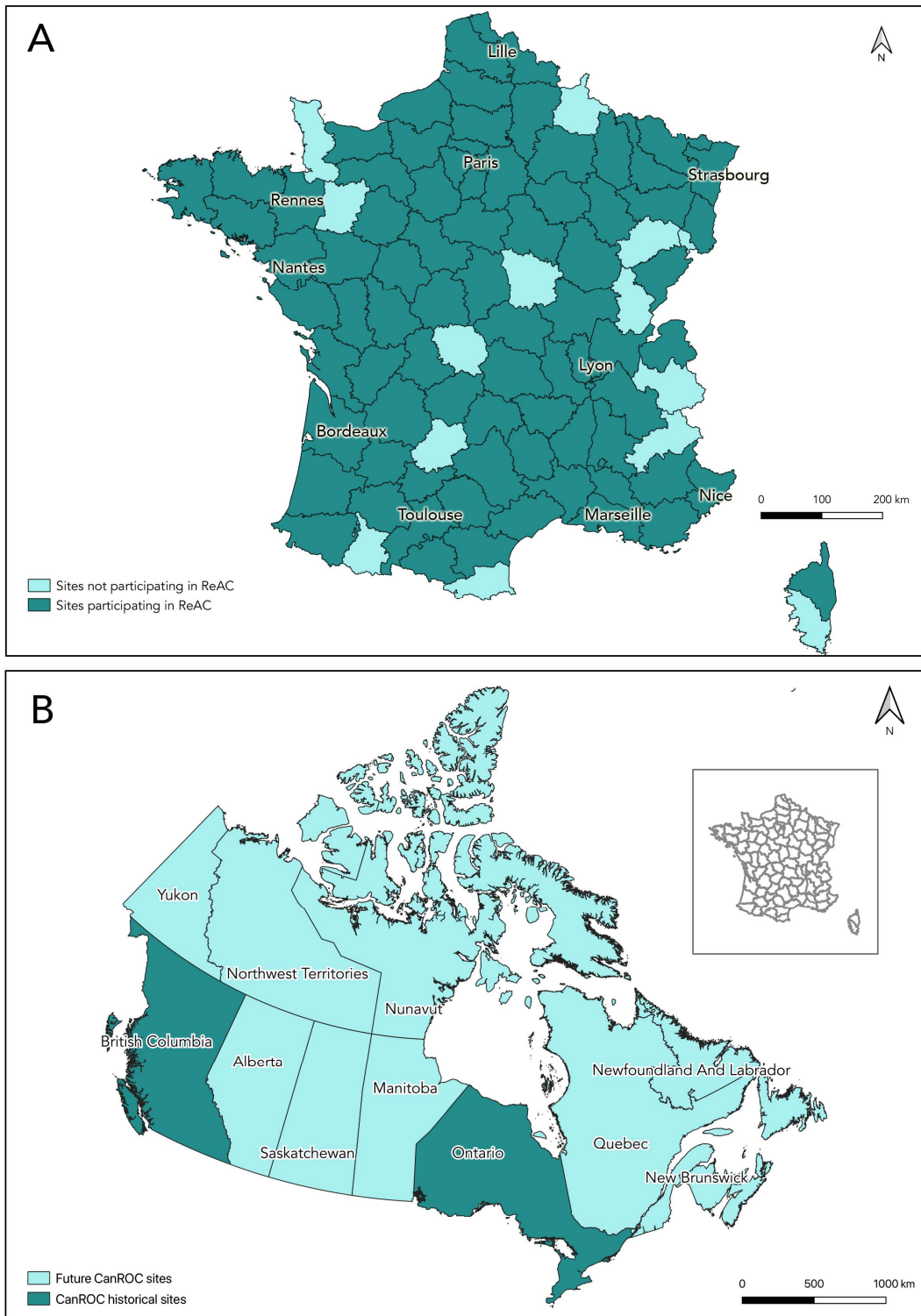


Table 1. Recommended Utstein core variables and time events recorded in RéAC and CanROC registries: matching definitions

	RéAC	CanROC	Matching definitions
CORE UTSTEIN VARIABLES			
Resuscitation not attempted			
All cases	Yes	Yes	No
DNAR	Yes	Yes	Yes
Considered futile	No	Yes	No
Resuscitation attempted			
All cases	Yes	Yes	Yes
Any defibrillation attempted	Yes	Yes	Yes
Chest compressions	Yes	Yes	Yes
Assisted ventilation	Yes	Yes	Yes
Location of arrest			
Out-of-hospital			
<i>Home</i>	Yes	Yes	Yes
<i>Public place</i>	Yes	Yes	Yes
<i>Other</i>	Yes	Yes	Yes
In-hospital			
<i>Ward</i>	Yes	Yes	Yes
<i>Emergency department</i>	Yes	No	No
<i>Operating room</i>	No	No	No
<i>CCU/ICU</i>	No	No	No
<i>Other</i>	Yes	Yes	Yes
First monitored rhythm			
Shockable			
<i>VF</i>	Yes	Yes	Yes
<i>VT</i>	Yes	Yes	Yes
Non-shockable			
<i>Asystole</i>	Yes	Yes	Yes
<i>PEA</i>	Yes	Yes	Yes
Unknown	Yes	Yes	Yes
Arrest witnessed/monitored			
By layperson/bystander	Yes	Yes	Yes
By healthcare personnel	Yes	Yes	Yes
Arrest not witnessed	Yes	Yes	Yes
CPR before EMS arrival	Yes	Yes	Yes
Aetiology			

Presumed cardiac	Yes	Yes	No
Trauma	Yes	Yes	Yes
Submersion	Yes	Yes	Yes
Respiratory	Yes	Yes	Yes
Other noncardiac	Yes	Yes	No
Unknown	Yes	Yes	Yes

Outcome

Any ROSC	Yes	Yes	Yes
<i>Yes</i>	Yes	Yes	Yes
<i>No</i>	Yes	Yes	Yes
<i>Unknown</i>	Yes	Yes	Yes
Survived event	Yes	Yes	Yes
Discharged alive	Yes	Yes	Yes
Neurologic outcome at discharge	Yes	Yes	Yes
<i>CPC 1 or 2</i>	Yes	Yes	Yes
<i>CPC 3 or 4</i>	Yes	Yes	Yes
<i>CPC 5</i>	Yes	Yes	Yes

CORE UTSTEIN TIME EVENTS

Date of death	Yes	Yes	Yes
Time of witnessed/monitored arrest	Yes	Yes	Yes
Time when call received	Yes	Yes	Yes
Time of first rhythm analysis	Yes	Yes	Yes
Time of first CPR attempts	Yes	Yes	Yes
Time of first defibrillation attempted	Yes	Yes	Yes

CCU: Critical care unit; CPC: Cerebral performance category; CPR: Cardiopulmonary resuscitation; DNAR: Do not attempt resuscitation; EMS: Emergency medical services; ICU: Intensive care unit; PEA: Pulseless electric activity; ROSC: Return of spontaneous circulation; VF: Ventricular fibrillation; VT: Ventricular tachycardia.

Table 2. Characteristics of EMS systems, OHCA patients and outcomes between France and Canada (preliminary data)

	France	Canada
Country		
Size (km ²)	551,695	9,984,670
Density (inh./km ² , mean[<i>min-max</i>])	122 [0-42,253]	4 [0-5,492]
Population (n)	66,992,699	37,589,262
Urban population (%)	80	80
Registry		
Name	RéAC	CanROC
Year of creation	2011	2005
Patients included since creation (n)	103,722	99,317
<i>Study population (2011-2016)</i> [†]	55,358	33,688
Estimated incidence rate (adults)	75,3/100,000	83/100,000
EMS systems		
Type	Stay-and-stabilize	Stay-and-stabilize or scoop-and-run
Guidelines	National	National
Emergency call centre	One per district*	Depending on region
EMS agencies (n)	96	40
Units, n (density/100.000 inh. [<i>min-max</i>])	BLS: 6,301 (10 [8-20]) ALS: 466 (0.7 [0.2-2.4])	BLS or ALS: 791 (8.42 [2.5-11.5])
Triage and dispatch	Clinically-driven (physicians)	Primarily non-physician, dispatch trained
Response mode (no. of rescuers)		
<i>BLS</i>	Firefighters (4-6)	Firefighters or primary care paramedics (2-4)
<i>ALS</i>	Physician-led MMT (3)	Advanced paramedics (2)
<i>Critical care</i>	Physician-led MMT (3)	Rarely for OHCA (air ambulance, ON)
Response time objectives	Firefighters < 10 min Physician-led MMT < 30 min (national)	First responders < 6-8 min (urban) Advanced paramedics: no goal metrics
Choice of destination	Upon agreement between the triaging physician at the emergency call center and the in-hospital physician	<u>British Columbia</u> : choice made by paramedics on scene (sometimes upon approval of specialist paramedics at the emergency call centre); information given directly to the in-hospital physician <u>Ontario</u> : dictated by dispatch unless special circumstances with bypass agreements
ER bypass	Always	Inconstant, depending on region
Population (overall)[†]		
Age, years (median [IQR])	68 [53-82]	67 [54-80]
Sex (%)	Male (63)	Male (60)
Aetiology (%)	Presumed cardiac (64)	Presumed cardiac (90)
Location (%)	Home (75)	Home (83)
Bystanders (%)		
<i>Non-EMS witnessed OHCA</i>	49	40
<i>CPR</i>	42	46
<i>Defibrillation before EMS arrival</i>	2	4
Initial rhythm (%)		
<i>Shockable* (VF/VT)</i>	16	22
<i>Not shockable (Asystole, PEA, other)</i>	84	78
EMS procedures		
EMS-RT, minutes (median, IQR)		
Call-arrival at scene		
<i>BLS/first responders</i>	10 [7-15]	6.5 [5-8.5]

ALS/MMT	20 [14-28]	7 [5-10]
Call-1 st rhythm analysis	13 [9-18]	9 [7-12]
Call-1 st injection of adrenaline	25 [18-34]	20 [16-25]
Attempted resuscitation by EMS (%)	82	60
Discontinued prior to transport	79	45
Defibrillation by EMS (%)	14	11
Infusion access	IV > IO	IV > IO
Airway management	Intubation	Intubation/SGA
Chest compression	Manual > mechanical	Manual > mechanical
ECMO	In-hospital > prehospital	Rarely in-hospital
Outcomes[†] (%)		
ROSC	24	48
Transportation to hospital	21	50
Survival at hospital discharge (overall)	5	11
Good neurological status [°] (survivors)	84	92

[†]: Population-based data are drawn from the British Columbia and Ontario CanROC sites (Canada) and from the overall ReAC population (France), in adult, non-traumatic, EMS-treated OHCA cases

^x: patients shocked either prior to EMS arrival or by EMS teams

[°]: Cerebral performance category (CPC) ≤ 2 ; status assessed at hospital discharge.

ALS: advanced life support; BLS: basic life support; CPR: cardiopulmonary resuscitation; ECMO: extra-corporeal membrane oxygenation; EMD: electro-mechanical dissociation; EMS: emergency medical services; EMS-RT: EMS response time intervals (from call to arrival at scene); ER: emergency room; IO: intra-osseous; IQR: interquartile range; IV: intra-venous; MMT: mobile medical team; OHCA: out-of-hospital cardiac arrest; ON: Ontario; PEA: Pulseless electric activity; ROSC: return of spontaneous circulation; SGA: supraglottic airway device; VF: ventricular fibrillation; VT: ventricular tachycardia;

* 'Département'; highest French administrative level of intraregional subdivision