



Clinical paper

Survival of cardiac arrest patients on ski slopes: A 10-year analysis of the Northern French Alps Emergency Network[☆]



Damien Viglino^{a,b,*}, Maxime Maignan^{a,b}, Arnaud Michalon^c, Julien Turk^d, Sarah K. Buse^a, Marc Blancher^a, Tom P. Aufderheide^e, Loïc Belle^f, Dominique Savary^c, François-Xavier Ageron^c, Guillaume Debaty^{a,g}, the Northern French Alps Emergency Network RENAU group

^a University Grenoble Alps – Emergency Department and Mobile Intensive Care Unit, CHU Michallon, Grenoble, France

^b University Grenoble Alps – HP2 Laboratory INSERM U1042, Grenoble, France

^c Annecy-Genève Hospital, Emergency Department and Mobile Intensive Care Unit, Annecy, France

^d Chambéry Metropole Savoie Hospital, Emergency Department and Mobile Intensive Care Unit, Chambéry, France

^e Department of Emergency Medicine, Medical College of Wisconsin, Milwaukee, WI, United States

^f Annecy-Genève Hospital, Cardiac Intensive Care Unit, Annecy, France

^g University Grenoble Alps – TIMC-IMAG laboratory Team PRETA CNRS UMR 5525, Grenoble, France

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ABSTRACT

Aim: Intense physical activity, cold and altitude make mountain sports a cause of increased risk of out-of-hospital cardiac arrest (OHCA). The difficulties of pre-hospital management related to this challenging environment could be mitigated by the presence of ski-patrollers in ski areas and use of helicopters for medical rescue. We assess whether this particular situation positively impacts the chain of survival compared to the general population.

Methods: Analysis of prospectively collected data from the cardiac arrest registry of the Northern French Alps Emergency Network (RENAU) from 2004 to 2014.

Results: 19,341 OHCA were recorded during the period, including 136 on-slope events. Compared to other OHCA, on-slope patients were younger (56 [40–65] vs. 66 [52–79] years, $p < 0.001$) and more often in shockable initial rhythm (41.2% vs 20.1%, $p < 0.001$). Resuscitation was more frequently started by a witness (43.4% vs 26.8%, $p < 0.001$) and the time to the first electric shock was shorter (7.5 min vs 14 min, $p < 0.001$), whereas time to the advanced life support (ALS) rescue arrival did not differ. The 30-day survival rate was higher for on-slope arrests (21.3% vs 5.9%, $p < 0.001$, RR = 3.61). In multivariate analysis, on-slope CA remained a positive 30-day survival factor with a 2.6 odds ratio (95% confidence interval, 1.42–4.81, $p = 0.002$).

Conclusion: Despite difficult access and management conditions, patients undergoing OHCA on ski slopes presented a higher survival rate, possibly explained by a healthier population, the efficiency of resuscitation by ski-patrols and similar time to ALS facilities compared to other cardiac arrests.

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1 Introduction

Out-of-hospital cardiac arrest (OHCA), with an incidence of 20–140/100,000 people per year, accounts for approximately 500,000 events per year in the United States and 430,000 in Europe,

with less than 15% survival [1,2]. With more than 100 million visitors per year worldwide, winter sports resorts are not spared [3]. OHCA account for 30% of mountain deaths, i.e. one for 780,000 ski hours [4]. The relative risk of CA in skiers over 34 years of age is double the rate in the general population [5]. This increased risk can be explained by both a particular population and favourable environmental and circumstantial conditions. More than 90% of CAs occur in men [6], with coronary history the main risk factor [7]. The high altitude and its association with hypoxemia can trigger myocardial injury [3]. The addition of physical exercise in this population

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* Corresponding author at: Service des Urgences Adultes, CHU Michallon, BP 217, 38043 Grenoble Cedex 09, France.

E-mail address: dviglino@chu-grenoble.fr (D. Viglino).

is probably the last key element explaining the increased risk of OHCA [8].

The management of sudden cardiac arrest (SCA) in mountain ski resorts can be challenging for emergency medical services (EMS). Nevertheless, the almost systematic presence of witnesses and a physically fit population could provide a better chance of survival than the general population. In addition, winter sports resorts are well organized with the presence of ski-patrols equipped with an automated external defibrillator and trained in basic life support (BLS) [9]. Similarly, the extensive use of an emergency medical helicopter in the French Alps allows advanced life support (ALS) and a priori rapid evacuation, which could contribute to improving the outcome of CAs despite the difficult environment. Our aim was to compare the characteristics and survival of patients with CAs on ski slopes in relation to CAs occurring in the general population, as well as the response times observed in such circumstances.

2 Methods

2.1 Study design and data collection

We carried out an observational analysis of all patients presenting an OHCA in the Northern French Alps between 1 January 2004 and 31 December 2014. We excluded OHCA without attempted resuscitation. Patients with a traumatic context were included.

2.1.1 Cardiac arrest registry data collection

This study is based on patient data prospectively collected from 2004 to 2014 by the Northern French Alps Cardiac Arrest Registry, previously described by Ageron et al. [10]. All patients for whom EMS was dispatched to start cardiopulmonary resuscitation following OHCA were included in the registry. The Northern French Alps Emergency Network comprises all hospitals and EMS systems in the three counties (Isère, Savoie and Haute-Savoie), including 13 Mobile Emergency and Resuscitation Services, primary care physicians in ski resorts with training and equipment to handle medical emergencies, as well as other rescue services (fire department, ski-patrols, etc.). The area covers 18,000 km² with a population of 2 million inhabitants, including more than 100 ski resorts, and up to seven rescue helicopters intervene on the network's ski slopes. The network has elaborated the regional protocol for acute coronary disease and CAs and organizes several meetings every year with the participation of many emergency physicians. Since 1 January 2004, each case of OHCA has been recorded in electronic form completed by the emergency physician in charge of the patient and the dispatch center. The form includes relevant variables such as age, place of OHCA, presence of a witness, CPR, initial cardiac rhythm recorded, presumed aetiology, defibrillation and intervention times. The patient's status (alive/dead and date of death, cerebral performance category [CPC], date of discharge) was obtained at 30 days from the receiving unit, and research associates performed phone interviews for both the 1-year status and the 30-day status if the hospital discharge was obtained.

On-slope CAs were tracked by searching in the dispatch centres' database. All OHCA occurring in the network's municipalities with ski slopes, from 8 am to 6 pm and from December to April were reviewed. The dispatch center database was used to check the location on the slope, whether or not trauma was involved, and who used defibrillation (automated external defibrillator [AED] from the ski-patrol or EMS). Other OHCA in the registry were considered as events not occurring in an open ski area. The study complied with the Declaration of Helsinki and was approved by the ethics committee of the University Hospital of Clermont-Ferrand, Clermont-Ferrand, France (IRB no. 5891).

2.2 Analysis

On-slope OHCA were compared to OHCA not occurring in the ski area. The qualitative variables were expressed as numbers and percentages, compared with the Pearson chi² test or the Fisher exact test when appropriate. The numerical variables were expressed in median and interquartile range (IQR), and compared using a Mann-Whitney test. Times to intervention were calculated from the first emergency call. A multivariate logistic regression analysis was performed on the explanatory variables of survival (age, sex, CA witnessed by a bystander performing CPR, time to the first responder's arrival and the characteristics of the SCA (initial rhythm and presumed aetiology) in order to determine the survival odds ratio of an on-slope SCA. A sensitivity analysis was carried out by comparing on-slope SCAs with the SCAs occurring in the same municipalities during the opening hours of ski areas in order to control for the effect of the specific geographical context of ski resorts. The missing data were not replaced. All tests were bilateral with an alpha risk of 0.05. Analyses were performed using SPSS 22 software (IBM Corp., Armonk, NY, USA).

3 Results

3.1 Population and OHCA characteristics

Overall, 19,341 OHCA were recorded in the study period, including 12,636 in which resuscitation was undertaken (Fig. 1). We identified 473 OHCA occurring in ski resorts during the opening hours of the slopes, of which 136 on ski-slopes. Compared to other CAs (Table 1), on-slope patients were younger (56 [40–65] years vs. 66 [52–79] years, $p < 0.001$) and more often males (89% vs. 70.5%, $p < 0.001$). Bystander CPR was more frequently started on-slope (43.4% vs 26.8%, $p < 0.001$). The median time from call to CPR was 14 min shorter, whereas CAs did not occur more often in presence of a witness (78.7% vs 74.2%, $p = 0.23$). The initial rhythm was shockable in a larger proportion for on-slope OHCA (41.2% vs 20.1%, $p < 0.001$) and the time to the first electric shock was shorter (7.5 min vs 14 min, $p < 0.001$), whereas the time to the first professional rescue arrival was not significantly different (10 min vs. 11 min, $p = 0.26$).

The comparison of the on-slope OHCA with those occurring in the same municipalities but not in the ski area (sensitivity analysis) shows the same differences (Supplementary data, Table S1).

Concerning on-slope OHCA, the defibrillator was placed by the ski-patrols in 60 patients (44.1% of the cases), allowing an external defibrillation for 53 (88%) of these patients. Helicopter rescue was triggered in 83.1% of the cases. Bad weather (making it impossible to take off or fly to the site) was the reason found for non-commitment of the helicopter in on-slope patients ($n = 23$) in all instances.

3.2 Outcomes

Compared to other CAs (Table 2), the return of the spontaneous circulation (ROSC) rate was higher in on-slope patients (51.5% vs. 29%, $p < 0.001$) with a shorter median time to ROSC: 17 min vs. 25 min ($p = 0.031$). The 30-day survival rate was higher for the on-slope CAs (21.3% vs 5.9%, $p < 0.001$, OR = 3.61), with a good 1-year estimated cerebral performance category (i.e. CPC 1 or 2) for all 29 survivors. In multivariate analysis (Table 3), an on-slope CA victim was more likely to survive at 30 days with a 2.61 adjusted odds ratio (95% CI, 1.42–4.81, $p = 0.003$).

Similar results were observed in sensitivity analysis focused on the ski resort population (supplementary data, Table S2 and S3), with a 30-day survival adjusted OR of 3.72 (95% CI, 1.55–8.86, $p = 0.003$) for on-slope CAs.

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