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Clinical paper

Survival after avalanche-induced cardiac arrest☆

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ABSTRACT

Aim: Criteria to prolong resuscitation after cardiac arrest (CA) induced by complete avalanche burial are critical since profound hypothermia could be involved. We sought parameters associated with survival in a cohort of victims of complete avalanche burial.
Methods: Retrospective observational study of patients suffering CA on-scene after avalanche burial in the Northern French Alps between 1994 and 2013. Criteria associated with survival at discharge from the intensive care unit (ICU) were collected on scene and upon admission to Level-1 trauma center. Neurological outcome was assessed at 3 months using cerebral performance category score.
Results: Forty-eight patients were studied. They were buried for a median time of 43 min (25–76 min; 25–75th percentiles) and had a pre-hospital body core temperature of 28.0 °C (26.0–30.7). Eighteen patients (37.5%) had pre-hospital return of spontaneous circulation and 30 had refractory CA. Rewarming of 21 patients (43.7%) was performed using extracorporeal life support. Eight patients (16.7%) survived and were discharged from the ICU, three (6.3%) had favorable neurological outcome at 3 months. Pre-hospital parameters associated with survival were the presence of an air pocket and rescue collapse. On admission, survivors had lower serum potassium concentrations than non-survivors: 3.2 mmol/L (2.7–4.0) versus 5.6 mmol/L (4.2–8.0), respectively ($P < 0.01$). They also had normal values for prothrombin and activated partial thromboplastin compared to non-survivors.
Conclusions: Our findings indicate that survival after avalanche burial and on-scene CA is rarely associated with favorable neurological outcome. Among criteria associated with survival, normal blood coagulation on admission warrants further investigation.

1. Introduction

In North America and Europe, 150 patients are killed by avalanche burial every year, which corresponds to a mortality rate of 52% following complete burial.[1] There are three main causes of cardiac arrest (CA) following avalanche burial: asphyxia, severe trauma and/or profound hypothermia.[2,3] Asphyxia is the leading cause of death and poor neurological outcome,[2–5] although severe trauma can also lead to death or unfavorable outcome.[3–5] While less frequent,[2,3] CA induced by isolated profound hypothermia is associated with better neurological recovery regardless the duration of burial.[6–9]

In clinical practice, the exact cause of CA may be unclear because CA and profound hypothermia can be independently present in an avalanche burial situation. This may lead to futile prolonged resuscitation in the emergency room (ER), including extracorporeal life support (ECLS) rewarming, and inevitably raises the question of the usefulness of such treatments for all patients. In this regard, international guidelines recommend the termination of cardiopulmonary resuscitation (CPR) in buried patients with asystole if they are lethally injured or completely frozen, if the airway is packed with snow and the burial duration exceeds 35 min.[2] A serum potassium concentration higher than 12 mmol/L on hospital admission is another criterion used to terminate CPR. In view of the difficulties faced in the ER making a medical decision on this group of patients,

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we conducted a retrospective analysis on buried avalanche victims with on-scene CA over the last 20 years in the Northern French Alps to describe factors associated with outcome.

2. Patients and methods

We retrospectively analyzed all consecutive patients admitted to the ER following avalanche burial and on-scene CA during the 20 last years (1994–2013). Pre-hospital triage and resuscitation of avalanche victims were conducted according to international guidelines and performed by emergency physicians (Fig. 1). On admission, the decision to perform ECLS rewarming was made according to the results of bedside imaging modalities, i.e., chest and pelvic radiography, abdominal and thoracic ultrasonography, serum potassium measurements and body core temperature. Blood samples were obtained from femoral artery or vein access sites. Patients with severe trauma or with a body temperature higher than 32 °C were not eligible for ECLS.[2,7,10,11] A serum potassium concentration exceeding 10 mmol/L on admission was another criterion to refute ECLS.[11]

Data were extracted from the registry of the Northern French Alps Trauma System, which prospectively collects data after major trauma using the Utstein-style.[12] This registry was approved by the French National Committee for the protection of personal and public liberties. This committee approved access to anonymous data on relevant patients in the trauma registry. The data collected included the duration of burial, first recorded pre-hospital body core temperature measured with an oesophageal probe, treatments on admission, and biological data. Also noted were the presence of airway obstruction or of an air pocket before extraction, the occurrence of a rescue collapse during the body extraction, evidence of trauma, the first recorded cardiac rhythm at extrication, a return of spontaneous circulation (ROSC), and transport under chest compressions. Rescue collapse was defined by the occurrence of CA relating to the extrication or transfer of the patient in profound hypothermia. Survival status was reported at discharge from the intensive care unit (ICU). Neurological outcome of survivors was assessed using cerebral performance category (CPC) score at 3 months.[13] A good neurological outcome was defined as a CPC score of 1 or 2.

Data were expressed as median and range (25–75th percentiles or minimum–maximum). Categorical variables were compared with Chi2 test, and continuous variables were compared using the non-parametric Mann–Whitney test (StatView SE program, SAS Institute, Cary, NC). Due to the limited size of the study population, we conducted univariate analysis only. Statistical significance was declared when $P < 0.05$.

3. Results

Over 70 patients were admitted to the ER following avalanche burial during the study period, 22 had no on-scene CA. Those considered for analysis were 45 patients (93.8%) referred to the Grenoble University Hospital and three (6.2%) to the Annecy General Hospital (Fig. 2). Pre-hospital characteristics of the studied patients are shown in Table 1. The median duration of CPR was 90 min. Seven patients (16.7%) had vital signs preceding CA such as spontaneous breathing, palpable pulse, or movements at the initial presentation. Thirty patients (62.5%) were transferred to ER with no ROSC during the pre-hospital management.

Characteristics of the study population at admission to the ER are shown in Table 2. Although all patients had marked metabolic acidosis, only four (8.3%) had a serum potassium concentration higher than 12 mmol/L. Twenty one patients (43.8%) were eligible for ECLS rewarming: two (4.1%) with pre-hospital ROSC though presenting hemodynamic instability on admission, and nineteen patients (39.6%) with refractory CA (Fig. 2). In patients with refractory CA, first recorded cardiac rhythm was asystole for 14 patients (29.2%) and pulseless electrical activity for 5 patients (10.4%). CPR was terminated for eleven patients (22.9%) with refractory CA because of a serum potassium concentration exceeding 10 mmol/L (nine patients), a severe chest trauma (one patient) or a body core temperature higher than 32 °C (one patient).

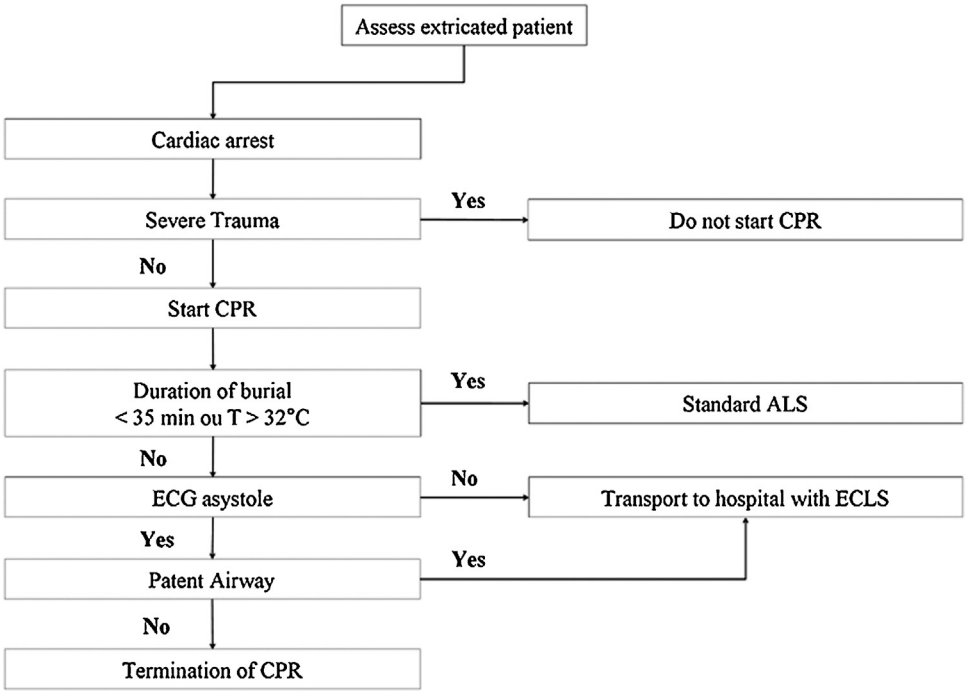

Fig. 1. Cardiac arrest management of a buried avalanche victim. CPR, cardiopulmonary resuscitation; ALS, advanced life support; ECG, electrocardiogram; ECLS, extracorporeal life support.