Images in Cardiovascular Medicine

Electrical Heart Activity Recorded During Prolonged Avalanche Burial

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A man in his mid-thirties triggered an avalanche at an elevation of 2750 m (9022 ft) while skiing and sustainer complete avalanche burial for 253 minutes before being located with an avalanche transceiver device, probed, and extricated by a rescue team. The burial depth (ie, depth of the head) was 30 cm (1 ft). The victim was in a supine position with a patent airway and a clearly visible air space in front of the mouth and nose with a size of 15×15×5 cm (0.5×0.5×0.2 ft) and frozen inner surface, which was not reported to the emergency physician on site. The victim had a Glasgow Coma Scale of 3 (E1V1M1), no vital signs, and no obvious traumatic fatal injuries. Extrication proceeded without reading the core body temperature or ECG. Because of severe weather conditions and the impending risk for the rescue team, the emergency physician withheld an on-site attempt of resuscitation. The victim was evacuated down to the valley by helicopter and declared dead. While the victim’s body was being handled in the mortuary, it was revealed that the victim was equipped with a multifunction sport watch and transmitter chest belt. The recorded dataset included heart rate, cutaneous temperature, and elevation, and was downloaded and saved according to the operating manual of the device. We present here the first recording of cardiac activity ever obtained during complete and prolonged avalanche burial in a human. The victim’s relatives gave informed consent for the use of the data.

Heart rate, cutaneous temperature at the wrist, and elevation were recorded without disruption for a 24-hour period from the beginning of the ascent. The Figure shows the recorded parameters over the duration of burial. During ascent, heart rate (mean, 146±12 bpm; range, 96–164 bpm) showed values reflective of physical effort. On rest at the peak, heart rate was abnormally high (mean, 113±13 bpm; range, 88–154 bpm) because of the elevation. Over the course of burial, 5 distinct phases of cardiac activity are apparent: (i) 0 to 18 minutes: highly variable frequency in heart rate with a mean of 83±25 bpm (range, 28–144 bpm); (ii) 18 to 35 minutes: sustained rate of 154±0 bpm; (iii) 35 to 70 minutes: sustained bradycardia with a mean of 51±14 bpm (range, 46–154 bpm); (iv) 70 to 253 minutes: sustained tachycardia with a mean of 176±13 bpm (range, 72–180 bpm) with variability occurring in the final minutes; and (v) 253 minutes: cardiac arrest on extrication of the avalanche victim.

Simple heart rate monitoring without support from an ECG does not allow the distinction of atrial and ventricular rhythms nor the determination of whether or not a rhythm is perfusing; nevertheless, these data provide an indication that electric cardiac activity persisted throughout burial and ceased on extrication of the patient from the snow mass. Furthermore, to exclude any technical failure, disruption of conduction, and/or interference from the avalanche transceiver device, both the watch and the victim’s transceiver were tested under surveillance of the manufacturer.

The pathophysiology of complete and prolonged avalanche burial in humans, especially with respect to hypothermia and circulatory dysfunction, remains largely unknown. According to previous studies, complete avalanche burial cannot be survived longer than 35 minutes if the airway is obstructed1,2; thereafter, if trauma can be excluded, the airway is patent and oxygen supply is sufficient to maintain cardiac function, hypothermia develops and is considered protective against irreversible hypoxic cell damage.3 Furthermore, the presence of an air pocket is considered to be an additional predictive parameter for survival.2 The cooling rate during avalanche burial is still debated and estimates range from 0.7°C/h (33.3°F/h) to 9.0°C/h (48.2°F/h). In humans presenting with hypothermia, atrial and ventricular arrhythmias may occur with a core body temperature <32.0°C (89.6°F), and heart rate is assumed to decrease gradually with cooling. Animal models have confirmed that severe hypothermia, in addition to a drop in cardiac output, may induce fatal dysrhythmias both with and without mechanical stimulation and asystole.4 It is also generally assumed in hypothermic patients that arrhythmias and VF can be triggered by rough movements of the trunk and extremities.2 Therefore, the 2010 guidelines for cardiovascular resuscitation underline the strict avoidance of unnecessary movements and the need for cardiac monitoring in avalanche victims before the initiation or termination of full resuscitative measures and during patient transport.3

Interestingly, the phases of cardiac activity seen in these data are similar to the patterns of survival reported in the literature for completely buried avalanche victims.1 Survival probability drops between 18 and 35 minutes postburial...
because of deaths from asphyxia, and from 90 minutes because of the combination of hypoxia, hypercapnia, and hypothermia. Stimulation of the midbrain from asphyxia, probably mediated by enhanced autonomic activity, may be the reason for the highly variable frequency in the first 18 minutes after burial. Thereafter, the sudden changes in heart frequency do not comply with the generally assumed gradual decrease in heart rate with cooling, but could be due to the interplay of cooling and asphyxia. Moreover, it remains unclear whether or not the persistent tachycardia of 180 bpm between 70 and 253 minutes postburial corresponded to a perfusing rhythm.

The potential long-term electric cardiac activity in an avalanche victim with a patent airway is confirmed by this recording. The case highlights the importance of assessing the airway at extrication and cardiac monitoring before removal and transport to detect arrhythmias provoked by movement of the patient. It also supports the most recent statement of the American Heart Association guidelines—avalanche victims in cardiac arrest on extrication after burial of >35 minutes and with a nonobstructed airway should be treated optimistically, ie, with full resuscitative measures including extracorporeal rewarming.

**Disclosures**

None.

**References**

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