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Editorial

Cardiac arrest from accidental hypothermia, a rare condition with potentially excellent neurological outcome, if you treat it right

In this issue Schober et al. report the experience of the University Hospital Vienna, Austria, a tertiary referral centre, in the treatment of patients with cardiac arrest due to accidental hypothermia.[1] The authors screened 3800 cardiac arrest patients treated from 1991 to 2010. Overall, 18 patients were identified with presumed hypothermic cardiac arrest (core temperature of <28 °C) and a return of spontaneous circulation. Of these, 50% ($n = 9$) survived to hospital discharge and all of those (100%, $n = 9$) survived with good neurologic outcome. Although the patient sample size is small, the outcome is markedly better compared with studies involving normothermic cardiac arrest patients and similar to previously published accidental hypothermia case series.[2]

Patients who cool to a low core temperature before developing cardiac arrest are somewhat protected from ischaemia given that cerebral oxygen consumption decreases by ∼6% per 1 °C of cooling.[3] In normothermic cardiac arrest without cardiopulmonary resuscitation (CPR), ischaemia >∼3–5 min is associated with considerable neurologic injury. With deep hypothermic circulatory arrest (DHCA), usually 18–20 °C, ≤30 min of cardiac arrest is commonly used to facilitate aortic surgery without neurologic dysfunction. In the absence of CPR almost all patients will suffer neurologic dysfunction with >60 min of cardiac arrest, even in the presence of deep hypothermia. Traditional CPR may provide ≤40% of normal cerebral blood flow and is therefore used during cardiac arrest to provide oxygen delivery during resuscitation attempts.[4] In hypothermic cardiac arrest, patients are able to tolerate prolonged periods of CPR (≥5 h) with good neurologic outcome.[5]

In accidental hypothermia case series patients typically have a good neurological outcome or do not survive to hospital discharge. Explanations for the good outcomes may include deep hypothermic conservation during relatively short (<60 min) non-asphyctic cardiac arrest, or an undetectable low flow state prior to emergency medical services (EMS) assessment complicated by rescue collapse (i.e. cardiac arrest) at first contact. The hypothermic myocardium is extremely irritable and the simple process of positioning and transporting a patient may be enough to trigger asystole or ventricular fibrillation.[6] The non-survivors are likely a mix of normothermic cardiac arrest with subsequent cooling, patients with co-morbidities who cannot tolerate a low flow state and hypothermic cardiac arrests with too long ischaemic time. It can be difficult for an EMS provider to differentiate between severe hypothermia with occult rescue collapse (i.e. potential survivor) and normothermic cardiac arrest with subsequent cooling (i.e. presumed non-survivor). Therefore, if the history is unknown or suggests that hypothermia may have been the cause of cardiac arrest, no cold patient should be declared dead on-site unless they the whole body is frozen solid or they have obvious conditions incompatible with life.[7] Instead, high quality CPR should be commenced until better prognostication and treatment options are available in the hospital.[8]

The University Hospital Vienna mainly drains patients from an urban area. This explains why many hypothermic patients in the present study were intoxicated, while in other studies involving patients from mainly outdoor sports environments intoxication was not reported at all.[9] In the present paper, Schober et al. identify intoxication as a prognostic marker for a good outcome, while terminal illness or severe trauma were considered markers of non-survival. Hence alcohol intoxication may be a surrogate marker for cooling prior to cardiac arrest, potentially due to the behavioural and thermoregulation inhibiting effects of alcohol that predispose these patients to accidental hypothermia. Given the small sample size and the lack of corroborating literature, the generalizability of this finding remains uncertain.

Reliable clinical prognostic markers are needed for cardiac arrest patients with hypothermia. Until now only serum potassium is an accepted outcome parameter,[10–12] yielding a high positive predictive value for death ($K > 12\,\text{mmol}\,\text{L}^{-1}$) but it is not helpful to predict survival ($K < 12\,\text{mmol}\,\text{L}^{-1}$).[13,14] Thus, many hypothermic cardiac arrest patients with normal or supra-normal potassium are rewarmed, may have a return of spontaneous circulation (ROSC), and may eventually die a few days later due to hypoxia-induced massive cerebral oedema and multiple organ failure. The low discrimination capability with serum potassium is likely complex and multifactorial. In cases of non-survivors with normal potassium, a form of pseudohypokalemia may exist where peripheral vein samples may be normal, despite high levels in veins draining blood of hypoxia-sensitive and irreversibly injured organs (e.g. heart and brain). In cases of survivors with very high potassium, it may be real or pseudohyperkalemia from sampling haemolysis. Better prognostication tools are badly needed and Near-Infrared-Spectroscopy (NIRS) is a promising technology, as it allows a real-time glimpse at the oxygen tension of the brain, which is the target organ of CPR efforts.[15,16] However, more studies assessing the benefits and limits of NIRS are required until NIRS can be recommended for widespread clinical use.

Schober et al. report at least six different regimens for rewarming 18 arrested hypothermic patients. This is a remarkable lot, but in the light of other studies a hardly surprising therapeutic heterogeneity. A similar un-concerted approach was reported in a survey on rewarming practices from 2000 to 2008 in a Dutch

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university medical centre, i.e. 18 different rewarming regimens in 84 patients.[17] This impressive heterogeneity may be owed to the rarity of severely hypothermic patients with spontaneous circulation and arrested hypothermic patients. The admitting hospitals simply may not have a standard operating procedure (SOP) for the treatment of these critically hypothermic patients such as in myocardial infarction patients. Indeed, we are aware of only one published accidental hypothermic cardiac arrest SOP, the Bernese Hypothermia Algorithm, however a recent review article provides a generic template as a starting point for SOP development.[8] Due to this lack of SOPs some groups in Europe and Canada have started to develop local and national protocols for referral and rewarming of critically hypothermic patients.[18]

Present guidelines state that prehospital care and emergency medicine personnel should be aware of this condition and severely hypothermic patients with signs of imminent cardiac arrest (e.g. systolic blood pressure <90 mmHg, ventricular arrhythmia, and core temperature <28 °C) and arrested hypothermic patients should be transferred directly to a centre with extracorporeal rewarming facilities, because survival may be as high as 100%.[19] If there are no signs of imminent cardiac arrest and spontaneous circulation is sufficient, minimally invasive rewarming techniques (e.g. forced warm air and warm infusions) applied in an intensive care unit of a peripheral hospital will suffice, given that there are no other critical underlying illnesses.[8,10,12]

Important issues remain unsolved in cardiac arrest patients with hypothermia such as selection of those patients with realistic survival chances, rewarming rate,[20] and the ideal post-resuscitation bundle. Given that even high volume centres will rarely have >10 hypothermic cardiac arrest cases per year, an International Hypothermia Registry (www.hypothermia-registry.org) has been installed to derive better treatment options of the collective experience from hospitals worldwide. Additional centres are encouraged to join.

In conclusion, Schober et al. present encouraging data on the excellent chance of survival and good neurologic outcome after hypothermic cardiac arrest in an urban population. Patient selection, high quality CPR and transport to a centre with extracorporeal rewarming (even if several hours of CPR is required en route) are the cornerstones of therapy. Further work is required to develop tools for early prognostication and optimal management. Creation of SOPs and contribution to the International Hypothermia Registry are likely to help improve future outcomes.

Conflict of interest statement

No conflicts of interest to declare.

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