

## **Avalanche First Aid**

### **Key points:**

- **Companion rescue and first aid/resuscitation are an avalanche victim's best chance of survival.**

Thankfully, not many of us have been in an avalanche rescue situation, which is why it is important to practice search and rescue each tour. But the scenario practice usually stops when you dig the transceiver out, so what happens in real life when you dig a victim out? This article attempts to explain some of the key science and strategy behind avalanche first aid. This should also be practised or visualised before every tour, so you know what to do in the high stress of a real-life rescue.

### **Avalanche Mortality and Survival**

In North America and Europe approximately 150 people are killed per year in avalanches, and this statistic has remained relatively constant despite the rising popularity of winter sports.

The overall survival rate of avalanche victims is approximately 77%, and survival depends on:

- the degree and duration of burial
- presence of an air pocket and a free airway
- the severity of trauma
- density of the snow (e.g., heavy, wet snow vs light, dry powder)

The degree of burial is still the strongest single factor for survival – so if the first rule of avalanche survival is “**don't get avalanched**”, the second rule is “**don't get buried**”. From Swiss data, the mortality rate is 52.4% in completely buried (head below the snow) victims, but only 4.2% in partially buried (head above snow) victims.

By preventing burial Avalanche Airbag systems may dramatically improve survival; in one study effectively reducing the likelihood of complete burial from 39% to 16.2% and thus lowering mortality rate from 22% to 11%.

Survival is inversely related to the duration of burial, and bio statistical analysis in Switzerland and Canada has given similar Survival curves (see Fig 1), where the different phases of the timeline of survival are determined by:

- the severity of trauma – highly dependent on the terrain (e.g., rocky, forested) and snow composition (e.g., heavy, wet snow),
- the presence or absence of free airway (unobstructed air tube from mouth/nose to lungs), plus the presence or absence of an air pocket (a clearly visible air space in front of the mouth and nose on extrication) – necessary for survival beyond 30 minutes even if clear airway.
- the pathological processes of asphyxia and hypothermia (cooling rate of up to 9°C per hour of burial)

**Figure 1 - Avalanche Survival Curve**

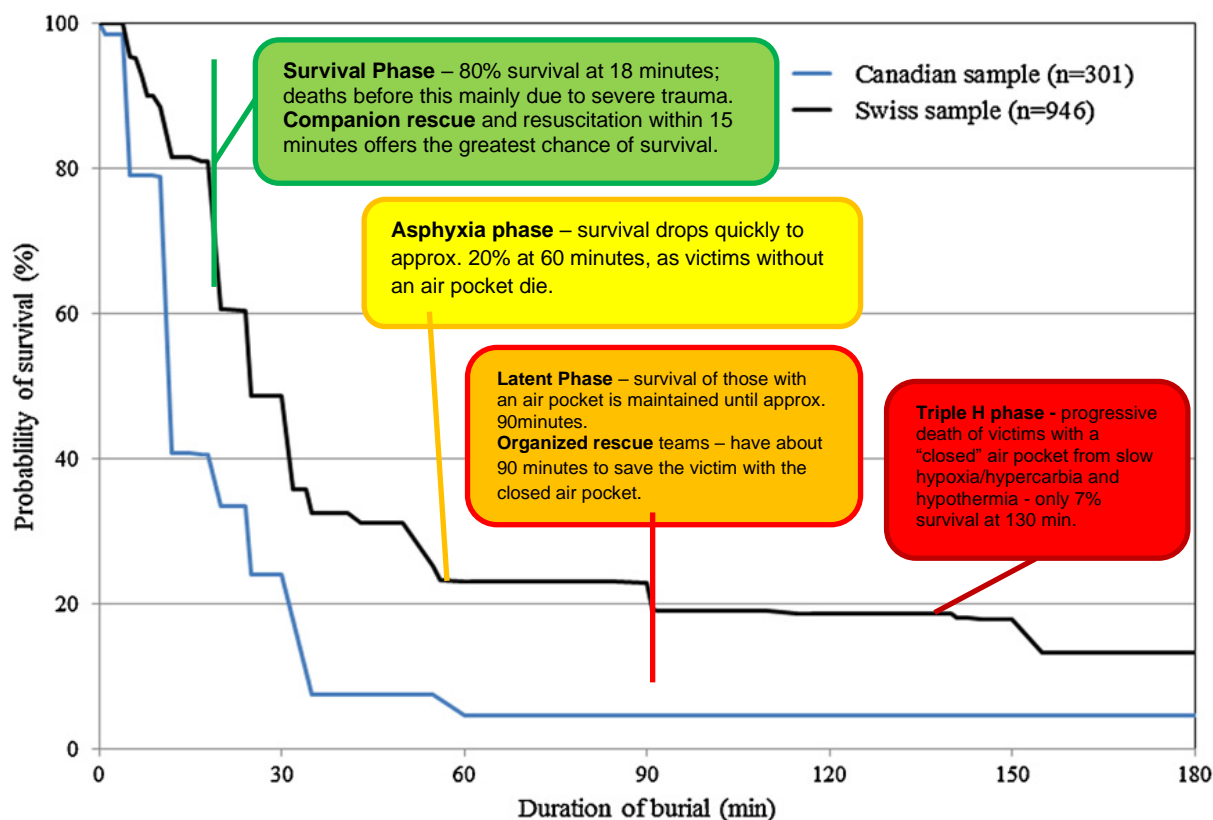


Fig 1 – Comparison of survival curves in Canada (Blue; n= 301) and Switzerland (Black; n=946) from 1980 to 2005. Extracted from Haegli P., et al (2011).

Comparative data from Colorado on survival by type of rescue shows that Companion rescue offers the best chance of survival (63% survival by companion rescue but only 19% survival by organised rescue).

Every minute counts and effective companion rescue needs strategic leadership, methodical transceiver search and probing, with efficient shovelling to dig the victim(s) out as quickly as possible. See the collected resources suggested on the Avalanche Awareness pages for further reading.

So, when an avalanche victim is dug out, the rescuer (medical or non-medical) needs a straightforward and memorable structure for the resuscitation/first aid. Many rescuers will already be familiar with the basic principles of first aid using the A, B, C, D approach, and the First Aid training mnemonic **Safety, ABCDEFG** is used in this article and algorithm as a way of remembering and providing structure to avalanche first aid.

# Avalanche Victim First Aid Algorithm



Note:	
Time of Avalanche	.....
Time face exposed	.....
Air pocket	Y/N
Time Rescue Services contacted	.....
First Aider Contact details	.....

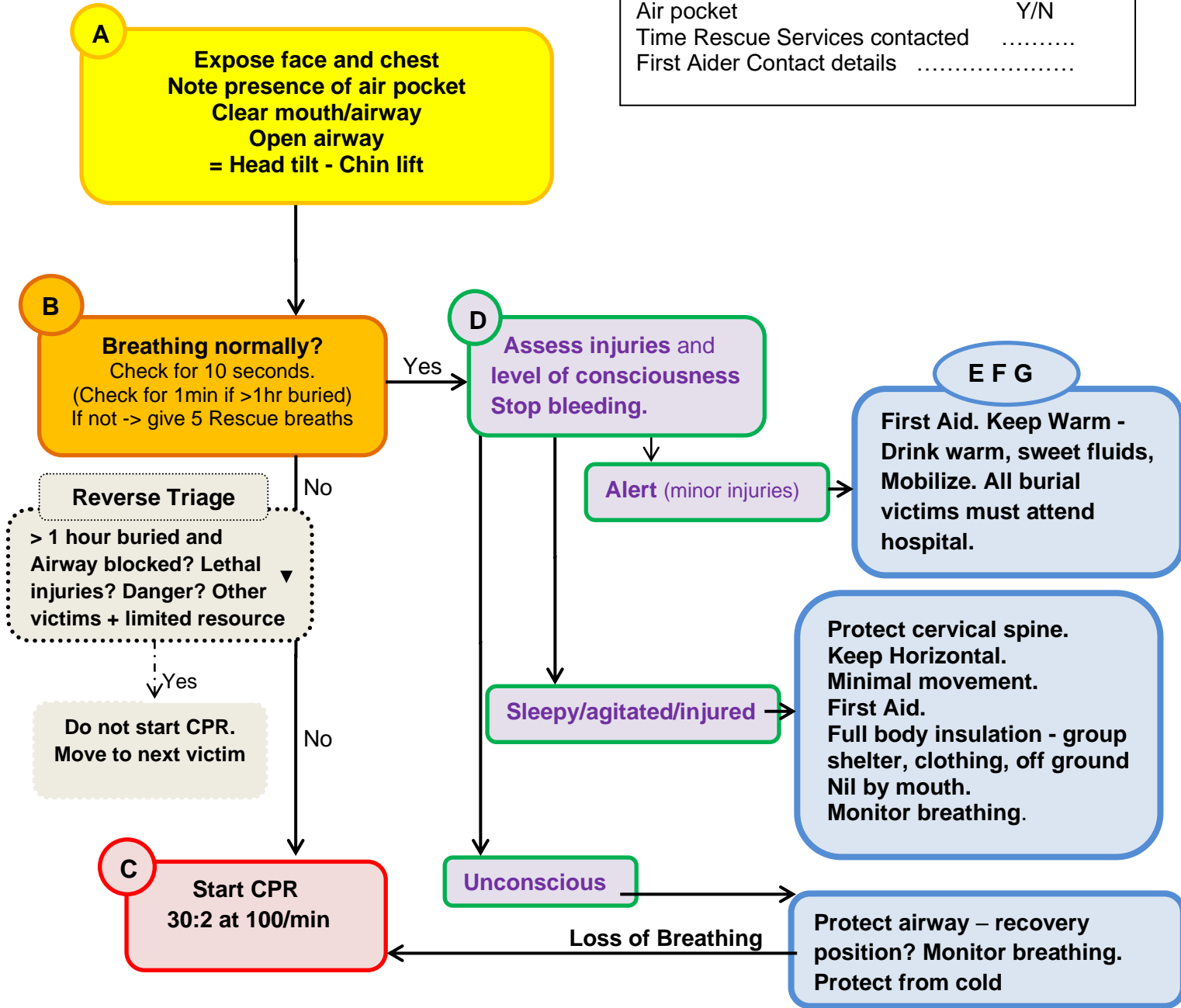


Figure 2 – Avalanche First Aid algorithm (2023 revision) developed by Dr Catherine Mangham - UIAA Diploma in Mountain Medicine - Available as A5 printout for lamination and use as **ESC Avalanche First Aid Card**

## Avalanche First Aid

- Extract and assess victim as quickly but as carefully as possible, using **Safety, A, B, C, D, E, F, G, H** approach – managing problems as you proceed.
- Note:
  - **Time elapsed from avalanche to Time face exposed** – this may be crucial in determining the duration and extent of resuscitation.
  - if **Air pocket** around mouth or airway blocked with snow.
  - if any obvious **Fatal injuries** – it is emotionally and clinically difficult for a non-medical companion rescuer to confirm death. In practice, fatal injuries may be distressingly obvious to a non-medical rescuer, though there may also be clinical levels of complexity beyond the scope of a first aider. However, in a multiple burial scenario moving on from a victim with clear fatal injuries may allow you to save someone else (see below for detailed discussion on Reverse Triage).

### Safety

- **S = Safety** – safety check for risks (e.g., secondary slide, uncontrolled fall) - safety should be assessed at the start of the rescue but needs to be continually monitored throughout the process.
- **s = Send for help only if can be delegated** (enough rescuers) **and feasible** (in an area where organised rescue might arrive < 60 minutes). If within Mobile phone range immediate call for help, but **do not divert scarce Rescuer resource from immediate companion rescue for the first 15 minutes.**

### A = Airway

- **Clear snow from around face and off chest**, to allow effective breathing.
- Check if **Air pocket** is present.
- **Clear snow from mouth and airway if blocked.**
- If the victim is unresponsive and **not breathing normally** (<8 or >30 breaths/minute) - the rescuer should **open the airway** - use **Head Tilt - Chin lift** technique (= place one of your hands on the victim's forehead and apply gentle, firm, backward pressure using the palm of your hand. Place the fingers of the other hand under the bony part of the chin. Lift the chin up and support the jaw, helping to tilt the head back). This manoeuvre will lift the victim's tongue away from the back of the throat and provide an adequate airway. This position needs to be physically maintained while an unconscious victim is on their back until they can be safely turned into the recovery position.

### B = Breathing

- **Check for breathing for up to 10 seconds** – usually obvious, but if in doubt check the rise and fall of chest by resting a hand lightly on the chest. In a hypothermic victim, buried >60 minutes, breathing may be very shallow and may need careful assessment for up to 1 minute.
- If unconscious but breathing, place in **Recovery Position**.  
<https://www.nhs.uk/conditions/first-aid/recovery-position/>  
If you suspect spinal injury and you have sufficient rescuers, you might choose to maintain the Head Tilt - Chin Lift position and other spinal precautions until definitive rescue arrives.
- If unresponsive and not breathing – give **5 Rescue Breaths** (tilt the head back, pinch the nose closed and administer 5 separate mouth to mouth breaths sufficient to inflate the chest) and start CPR as soon as head and chest are free.

## C = Circulation

- If still no response or signs of life after 5 rescue breaths - **Start Cardiopulmonary Resuscitation (CPR)** according to **Basic Life Support (BLS)** algorithm **30:2 at rate 100 compressions/minute** = 30 chest compressions at a rate of 100 per minute, followed by 2 rescue breaths – repeated.
- Note – current resuscitation guidance for non-medical first aiders no longer requires checking for a pulse before starting CPR; and this would be especially difficult in an avalanche situation with cold hands, cold victim.
- Note - as asphyxiation is a likely cause of cardiac arrest in the avalanche setting, it is imperative to include the breathing part of CPR starting with Rescue breaths, regardless of infection risk. The rescuer may carry a mask in their first aid kit if this is a problem.
- Note – depth of compression needs to be 5-6 cm.
- Duration of attempted CPR depends on the situation:
  - Resources and personnel on scene – CPR is very tiring and will exhaust a single rescuer quickly – if possible, take turns every 2 minutes.
  - Time to definitive rescue by an organised medical team with Automatic external defibrillator (AED) – in the side country of a ski resort this may be <15 minutes; in European alps <30 minutes; on a remote expedition = days
  - Duration of burial –
    - If < 60 minutes – organised rescue teams would attempt CPR for at least 30 minutes in the absence of hypothermia <30°C and asystole on the ECG.
    - if > 60 minutes the body may have been cooled and protected by “metabolic icebox” effect, and victims of a potential hypothermic cardiac arrest with a patent or unknown air pocket should be resuscitated until rewarmed to core body temperature >30°C before a final decision is made (**“not dead until rewarmed and dead”**).

## D = Disability

- Use AVPU scale to assess conscious level.
  - Alert fully
  - Voice only
  - Pain only
  - Unconscious
- Altered level of consciousness may be the result of head injury and/or hypothermia.
- Any impairment of consciousness after a prolonged avalanche burial should be interpreted as serious advancing hypothermia (temperature < 32°C) and prompt **extra care in handling, aggressive prevention of further hypothermia** (see E below) and **transfer to appropriate hospital** (see H below).

## E = Exposure

- **Keep victim warm and prevent further heat loss** - by Ground insulation/Extra clothes, hat, gloves/ Blizzard bag/Group shelter.
- Change wet clothing, only if possible without unnecessary movements or increased exposure. **Further insulation layers** over wet clothing may be more effective.
- **Hot, sweet, non-alcoholic drinks** only if conscious at least to voice and able to swallow.
- **Gentle extrication and immobilise horizontally**– in a hypothermic victim (buried >60 minutes) rough movements of limbs especially the legs may force cold blood from the peripheries to the heart and trigger cardiac arrest (“post rescue collapse”) Allow an uninjured, shivering, mildly hypothermic victim to exercise and generate heat but otherwise nurse horizontal to maintain blood pressure and circulation.

## **F = Fractures**

- **Spinal precautions from the start, but airway and CPR take precedence.** Avoid unnecessary movements of neck and spine and if sufficient help available, then a rescuer may place both hands on either side of the victim's head to hold the head gently but firmly in a straight-line position and to keep it from moving. If competent, log roll techniques may be used to move victim onto insulation while awaiting definitive rescue and spinal care.
- **Treat injuries**
  - Stop bleeding – direct pressure to wound.
  - Splint and immobilise fractures – to reduce pain and bleeding.

## **G = General**

- If further **Help** is required, and not already requested – use mobile phone/radio or send someone with verbal/written report with nature of incident, duration of burial, numbers and status of victims, exact grid reference.
- If **Helicopter** on the way - Prepare for safe level helicopter landing – Secure and tie down all equipment, rucksacks, loose clothing, or anything that might blow away. Protect victims face and eyes from downdraft blizzard. Attract attention of helicopter by standing and facing it with both arms in air making Y shape. Down draft can knock you over. Do not approach helicopter unless signalled to do so by pilot.
- **Care and Debrief after incident** - it is important to acknowledge that all the members of the group may have been exposed to intensely traumatic circumstances, and may perhaps hold personal feelings of responsibility, guilt, or failure as well as grief and bereavement. There is no single way to best offer emotional support, but an initial debrief to clarify facts or to update the group, should also focus on open non-judgemental and supportive discussion amongst the group. The group is often the best supportive environment until the team can return home where grief reactions or PTSD may need professional help. More analytical significant event review should follow later at some emotional distance.

## **H = Hospital**

Even after successful search and rescue and basic first aid, there are further ongoing risks to the victim such as:

- Pulmonary oedema – thought to be caused by negative pressure.
- “Afterdrop” – further and potentially fatal drop in temperature after rescue.

Transfer of the victim to hospital will usually be part of organised rescue, but the First aider should know the following principles:

- All full burial victims if responsive– should be assessed in the nearest A+E department.
- All full burial victims if not responsive to voice or with hypothermia – should be transferred to hospital with hypothermia resuscitation knowledge and active rewarming facilities.
- Any hypothermic victim (burial time > 60min or temp < 30°C) in cardiac arrest – should ideally be transferred to a hospital with facilities for extracorporeal circulation life support (ECLS), where the blood is recirculated externally through a rewarming machine.

A **Handover** from First aider to Rescue/Hospital team is important and could be verbal or ideally written. It should include key data on time of avalanche; time to face and chest exposed; presence/absence of air pocket; nature of injuries and first aid measures carried out. The ICAR Avalanche Checklist (see below) can be printed out and used for handover purposes.

## Triage

Note: this article is intended to provide a basic first aid algorithm for the companion rescuer. It is not intended to cover the Triage of all avalanche scenarios which will vary with circumstances such as multiple burials, burial time; burial depth; snow hardness; availability of companion rescue resources, and time to organised rescue and definitive medical care.

- **Normal triage** is the preliminary assessment of casualties to determine the urgency of their need for treatment and the nature of treatment required. Where available resources are adequate, care of the most seriously injured is prioritised.
- **Reverse triage** applies where there is a shortage of rescue resources for multiple victims, and hard decisions have to be made to focus on the victims with good survival chances and only requiring moderate rescue resources. (e.g., buried <2m; buried <18 min; responsive and breathing). Prioritisation of the rescue aiming for “greatest good for greatest number of victims” may involve moving on and postponing CPR for a victim in cardiac arrest, to save another victim with better chance of survival. The grey box areas of this basic algorithm can only hint at some of these difficult choices.

## Organised Rescue and Definitive Medical care

From the survival curve studies, it is known that in the absence of fatal injuries, resuscitation strategies are determined by the duration of burial and the victim's core temperature.

- **With a burial time < 60 minutes survival depends on preventing asphyxia by rapid extrication, clearing the airway and cardiopulmonary resuscitation CPR – this is the basis of Companion First Aid**
- **With a burial time > 60 minutes tackling hypothermia is of utmost importance, and gentle extrication with core temperature and ECG monitoring is recommended.** The possibility of hypothermic Cardiac arrest should be considered for victims with a burial time of > 60 minutes without signs of life but a patent or airway of unknown patency. **Pulseless victims buried > 60min with a patent airway and/or core temperature < 30°C should receive uninterrupted CPR and be transported to a hospital with extracorporeal rewarming facilities -This needs specialist Organised Medical Rescue.** Hypothermic cardiac arrest may be considered, at the rescuer's discretion, despite a burial duration of ≤ 60 minutes in a victim with a patent airway and no signs of life when there is the possibility of very rapid cooling because of inadequate clothing, a lean victim, an environment favourable to rapid cooling, or burial after physical exertion.

**Organised rescue** with a fully equipped medical/paramedical team follows a more complex algorithm aimed at identifying those prolonged burial victims that are profoundly hypothermic and might benefit from prolonged resuscitation techniques including rewarming and Extra Corporeal Life Support ECLS.

The Wilderness Medical Society guidelines of 2017 give a comprehensive summary of the evidence base for the prevention and management of avalanche accidents.

The European Resuscitation Council “Guidelines for Resuscitation 2021- Cardiac arrest in special circumstances” gives detailed guidance for physicians and other advanced life support personnel with an advanced Avalanche algorithm Fig 7 (see Bibliography).

The International Commission for Alpine Rescue (ICAR) has also recently produced a detailed summary guidance for on the On-site management of Avalanche victims, including Initial and Advanced management algorithms. These algorithms form the basis for a revised **Avalanche Resuscitation Checklist card** to give guidance and aid documentation in

Avalanche resuscitation. This checklist was developed primarily for the use in the field by organised rescue teams and rescue professionals, with studies confirming that adherence to the ICAR checklist results in a higher survival rate. The ICAR guidance, primarily directed at organised rescue services is reproduced in Appendix 1 below for completeness, though the **ESC Avalanche First Aid Card** may be more use to the non-medical companion rescuer.

## Bibliography

**Wilderness Medical Society Practice Guidelines for Prevention and Management of Avalanche and Non-avalanche Snow Burial Accidents** Christopher VanTilburg et al; Wilderness & Environmental Medicine 28, 23–42 (2017) [https://www.wemjournal.org/article/S1080-6032\(16\)30237-X/fulltext](https://www.wemjournal.org/article/S1080-6032(16)30237-X/fulltext)

**European Resuscitation Council Guidelines 2021: Cardiac arrest in special circumstances.** Resuscitation. 2021;161:152–219. doi: 10.1016/j.resuscitation.2021.02.011.

<https://www.cprguidelines.eu/assets/guidelines/European-Resuscitation-Council-Guidelines-2021-Ca.pdf>

**ICAR Medical Management of Avalanche victims – Brief Summary**

<https://www.alpine-rescue.org/system/production/article/documents/file/004/418/c450e05585a019e3e8b3ee7ec42b80e5e17bd30f58e60de522f03952e0485eba/2022%20Final%20ICAR%20Medical%20Management%20of%20Avalanche%20victims%E2%80%9320an%20updated%20recommendation.pdf?1680020938>

**On-site treatment of avalanche victims: Scoping review and 2023 recommendations of the international commission for mountain emergency medicine (ICAR MedCom)**

[https://www.resuscitationjournal.com/article/S0300-9572\(23\)00021-7/fulltext](https://www.resuscitationjournal.com/article/S0300-9572(23)00021-7/fulltext)

**ICAR Avalanche Resuscitation Checklist 2023**

<https://www.resuscitationjournal.com/cms/10.1016/j.resuscitation.2023.109708/attachment/c8708594-8ec5-4edf-b717-6e7c6e51ea64/mmc6.pdf>

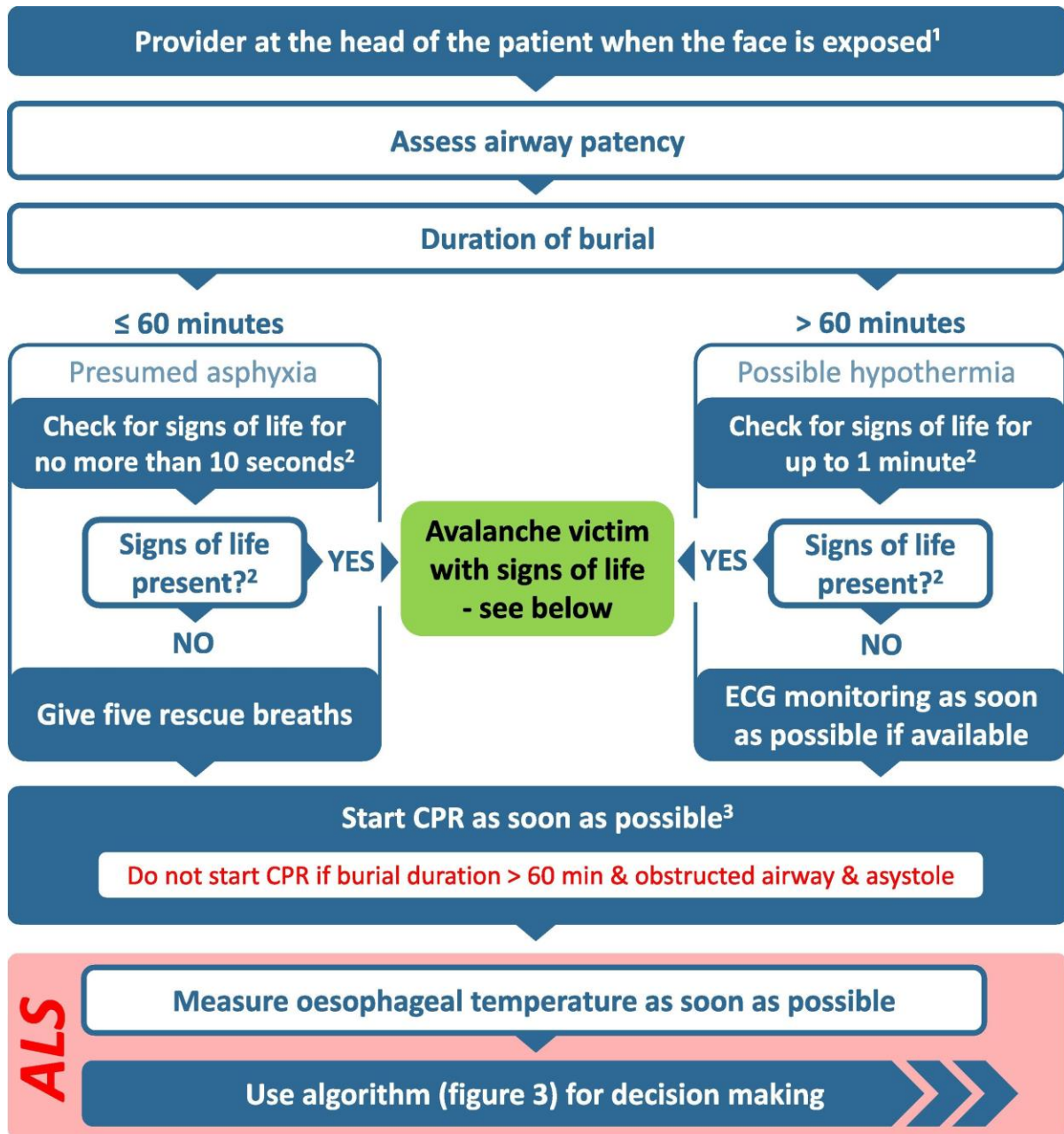
Updated September 2023

Dr. Declan Phelan - UIAA Diploma in Mountain Medicine



# Appendix 1 – ICAR Avalanche Resuscitation Algorithms

## Initial management of critically buried avalanche victims.



### Critically buried avalanche victim with signs of life

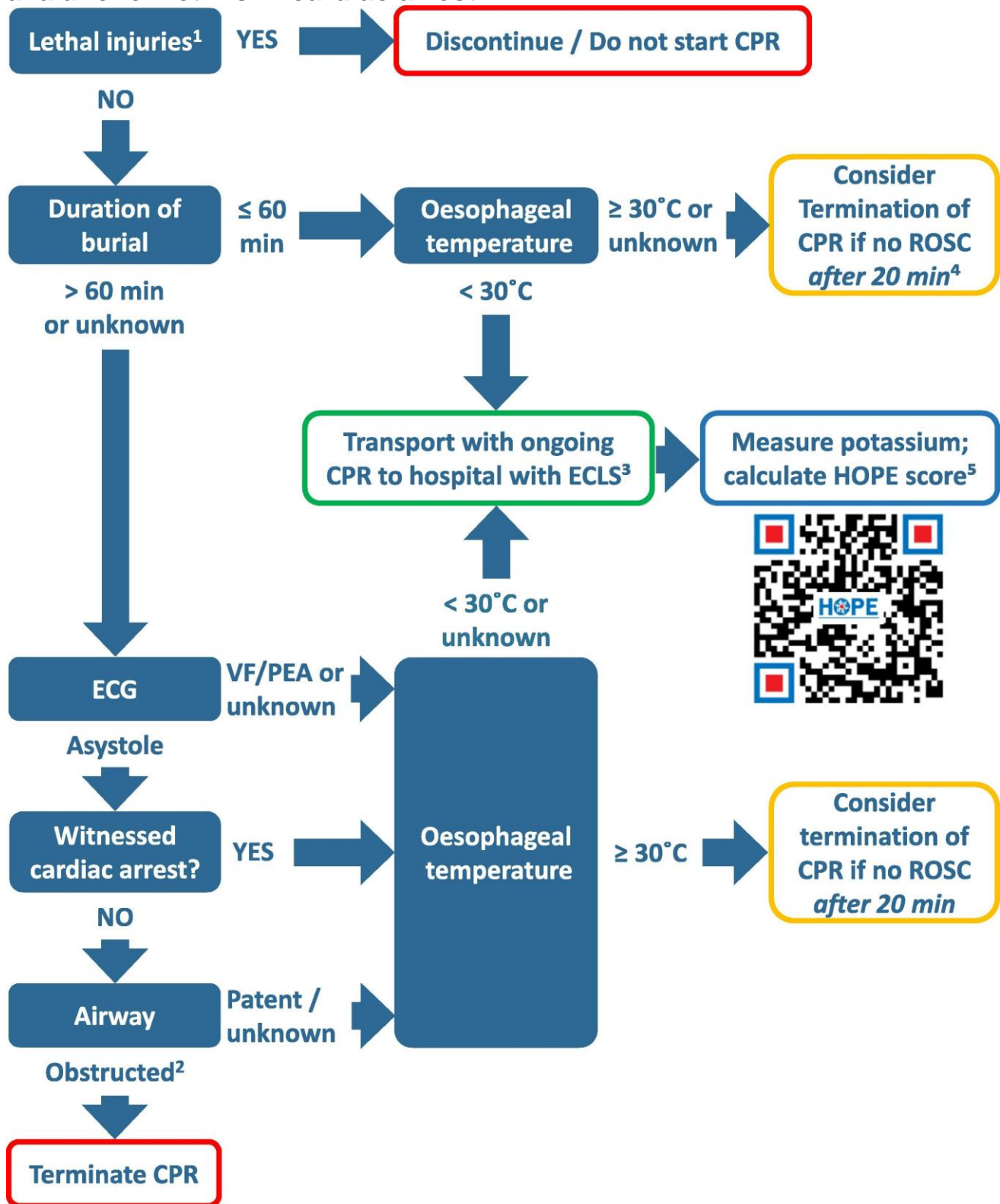
- ECG monitoring as soon as possible (ideally before handling or moving the patient)
- Gentle handling and consider potential trauma
- Transfer to the most appropriate hospital
- Consider transfer to an ECLS hospital for hypothermic patients with:  
Core temperature <30°C or ventricular arrhythmia or systolic blood pressure <90 mmHg
- The management of medical conditions which are not specific to avalanche victims (e.g. hypothermia, trauma) should follow the most recent recommendations

1. Assess for lethal injuries: decapitation; truncal transection; whole body decomposed. If present, do not start CPR.

2. Signs of life include any of the following: A, V or P from AVPU (alert, responsive to verbal stimuli, responsive to pain, unresponsive) or Glasgow Coma Scale >3, any visible movement, respirations, or a palpable carotid or femoral pulse (for experienced ALS providers).

3. Standard compression / ventilation rates. Drug dose and defibrillation depending on core temperature or, if not available, burial duration. If ventricular fibrillation persists after three shocks, delay further attempts until the core temperature is ≥30°C. Withhold epinephrine (adrenaline) if the core temperature is <30°C.

# Decision-making algorithm for advanced management of critically buried avalanche victims in cardiac arrest.



1. Decapitation, truncal transection, whole body decomposed
2. An obstructed or blocked airway requires that both the nose and mouth be completely filled with compact snow or debris.
3. With a deeply hypothermic patient (<28°C), if rescue is too dangerous consider delayed CPR and if transport is difficult consider intermittent CPR.
4. If core temperature measurement is not available, hypothermic CA may be considered, at the rescuer's discretion, despite a burial duration of ≤60 minutes in a victim with a patent airway and no vital signs when there is a possibility of very rapid cooling (e.g burial during ascent, low body mass index or small persons, minimally dressed, sweating before burial).
5. In-hospital prognostication of successful rewarming in an avalanche victim should include estimation of the survival probability using the HOPE score. If any doubt exists whether the avalanche victim may have asphyxiated despite critical burial, the HOPE score should be calculated using the NON-ASPXYXIA option. This will reduce the risk of under-treatment. If the HOPE score cannot be determined, the combination of a potassium <7 mmol/L and a temperature <30°C may be used instead to help indicate ECLS rewarming.