Survival Chance Optimized Procedures in Rescue and How to Minimize Injuries During Excavation

Manuel Genswein, Switzerland

In companion rescue as well as in the start-up phase of organized rescue, shortage of rescue resources are very likely if multiple buried subjects / patients are present. Therefore, not everyone can be excavated or medically taken care of simultaneously. Triage strategies give advice on the most survival change optimized sequence of actions in order to provide “greatest good for the greatest number”. The remote reverse triage criteria give guidance on most likely areas of survival and the sequence of excavation. The now proposed AvaLife strategy supports the rescuers concerning remote and local triage, in particular the critical phase when some patients are already excavated while others are still fully buried.

The last phase of rescue and excavation in immediate vicinity of the buried subject is often the most time consuming part of the entire rescue effort. The combination of close proximity and the general urgency of the situation may lead rescuers to overlook the potential for unnecessary stress for the buried subject. During the excavation of a buried subject, mechanical impact to the body of the buried person may lead to injuries, compromise a potential respiratory cavity, compromise breathing by inhibiting thorax motion/decompression etc. Whereas the likelihood for the imposed impact to lead to fatal consequences is marginal, precautions to limit the chance and extent of impact should be taken as long as they do not compromise the goal of saving the life of the buried subject in a single burial accident or saving as many lives as possible in a multiple burial event. This comprehensive summary outlines the considerations to be taken into account for a wide range of influence factors such as burial time, burial depth, snow hardness, availability of rescue resources as well as the interface to the first medical assessment.

Keywords: AVALANCHE TRIAGE, EXCAVATION, INJURIES

Introduction

In companion rescue as well as in the start-up phase of organized rescue, shortage of rescue resources are very likely if multiple buried subjects / patients are present. Therefore, not everyone can be excavated or medically taken care of simultaneously. Triage strategies give advice on the most survival chance optimized sequence of actions in order to provide “Greatest Good for the Greatest Number”. The remote reverse triage criteria give guidance on most likely areas of survival and the sequence of excavation (Ref 20).

The now proposed, more comprehensive AvaLife strategy supports the rescuer throughout the entire rescue in various aspects of optimization decisions starting at the basic question of “send someone for help or rescue first”, the focus on buried subjects with higher survival chances based on terrain and burial depth criteria, the medical triage criteria as well as the evacuation priorities. AvaLife helps to make survival chance maximizing decisions during the critical phase when some patients are already excavated while others are still completely buried. AvaLife only advises which rescue techniques, medical treatments etc. should be applied in which sequence, but does not describe the individual techniques in detail. Instructions on the individual rescue and medical procedures and strategies, such as how to search and excavate a buried subject, apply CPR or the criteria for termination of CPR are already widely taught and have been published in previous ISSW Proceedings, ICAR.
Recommendations and publications by ICAR/UIAA Medcom in various medical journals. The second part of the paper is not about AvaLife, it describes an extension of the existing “V-shaped Show-Conveyor Belt” excavation strategy for advanced recreational and organized rescue. Whereas saving burial time is the most important optimization criterion for an excavation strategy, measures to protect the buried subject from unnecessary mechanical impact should be taken in consideration when sufficient rescue resources are available or burial time has passed 35min.

AvaLife - Survival Chance Optimized Decisions and Procedures in Avalanche Rescue

AvaLife describes the rescue and medical procedures for single and multiple burial accidents. Concerning single burial events, it describes the status quo, except for the consideration on when to call/go for help vs. rescuing first. Most of the new considerations implemented in AvaLife show their effect in multiple burial / multiple patient events. It dynamically adapts to the changing balance between available rescue resources and buried subjects / patients in need of help. It therefore dynamically optimizes the delicate balance between reverse and normal triage:

- Reverse triage in case of shortage of resources, often at the beginning of a rescue operation
- Normal triage when the available resources clearly overcome the extent of the rescue problem

In reverse triage, the focus is on patients who have good survival chances and require only a moderate rescue effort. Normal triage allows to treat everyone in need simultaneously and to allocate all necessary resources - even to patients who require a lot of rescue effort and/or have only little survival chances.

Greatest Good for the Greatest Number

In case of shortage of resources during a rescue operation for multiple buried subjects / patients, the limited resources should try to optimize their procedures in a way that provides “Greatest Good for the Greatest Number”. The optimization criterion is therefore the overall outcome / survival rate for a group of buried subjects / patients in need. The procedures and sequence of actions have to be systematically analyzed and optimized in a strictly survival chance oriented focus.

While the problem of shortage of rescue resources persists, a reverse triage scheme has to be followed. In reverse triage, the little available rescue resources focus their efforts on patients who have statistically good survival chances and absorb only little rescue resources. Rescue efforts for patients with statistically low survival chances or for buried subjects who absorb a lot of resources have to be postponed until more resources become available.

In companion rescue, external help needs to be alerted to provide additional resources. In case communication networks allow calling for help from the accident location, the emergency call only absorbs limited time, but as soon as a companion rescuer needs to leave the accident site to go for help, the benefit of the action needs to the carefully balanced against the loss of resources on site. Whereas the drop of survival chances is marginal within the first 18min of burial time, there is a very strong decrease between 18 and 35min. For those buried subjects who were able to survive the first 35min of burial time, survival chances only slowly decrease over time.

The fact that loss of survival chances over time is not linear, but includes periods where loss is very dramatic and periods where survival chances do not drop considerably over longer periods of time strongly influences priorities and procedures in a survival chance optimized rescue algorithm. AvaLife is based on ICAR Medcom procedures for the optimal treatment of patients in snow avalanches. These existing guidelines and recommendations assume that there are sufficient rescue, medical and transport resources available to treat everyone in need of help simultaneously. However, in companion rescue and in the start-up phase of organized rescue, shortage of resources is very likely in case of multiple buried subjects/patients. As the verdict is set for a majority of buried subjects within the first 18 to 35min after the accident, even in locations with very good availability of rescue resources such as in the European Alps, it is unlikely that all organizational as well as rescue and medical tasks can be simultaneously performed for everyone in need of help. As soon as shortage...
of resources is an issue, the challenge is to prioritize the tasks to achieve “Greatest Good for the Greatest Number”. In order to optimize the survival chances for multiple buried subjects/patients, AvaLife compares survival chances of the buried subjects and patients and takes the ratio between amount of rescuers and amount of buried subjects/patients into account.

Many rescuers and mountain rescue physicians are emotionally strongly bound to the “in dubio pro reo” principle and therefore it is a major challenge for them - almost a change of paradigm - to postpone a rescue effort or medical treatment of a person with statistically low, but not inexistent survival chances for the benefit of another person in need with considerably better survival chances. As much as the “in dubio pro reo” paradigm is ethically defendable for a single patient or when resources are unlimited, the “Greatest Good for the Greatest Number” paradigm is the most ethical approach when there is more than one person in need and rescue is short of resources.

Version 1.0 of AvaLife is the first tool which advises in a clearly formalized algorithm on how to proceed in order to achieve the “Greatest Good for the Greatest Number” goal. The Basic Version is recommended for basic level companion rescuers, the Advanced Version for advanced companion rescuers, mountain guides, ski patrol, organized rescue etc. AvaLife does not change the existing ICAR Medcom recommendations and criteria for termination of CPR for ALS and BLS trained rescuers. It simply advises on the most survival chance optimized use of the available resources.

AvaLife Triage Considerations

The comparison of triage criteria applied in AvaLife with existing triage schemes for multiple casualty accidents (START, ReSTART, Ref. 21-25) clearly shows, that there is more resistance in avalanche rescue to re-allocate resources from patients with statistically low survival chances towards patients with considerably higher survival chances.

The most important and most prominent example in this context clearly represents the triage strategy for non-breathing patients. Whereas all multiple patient triage algorithms for non-avalanche settings immediately assign a very low treatment priority (i.e. expectant / black) to non-breathing patients after opening of the airways, there is very much resistance to postpone treatment for this category of (normotherm) patients in avalanche rescue. This is particularly problematic in the first 20min after an avalanche where the statistical probability of survival of a randomly chosen buried subject is much greater than the probability for a positive outcome for a non-breathing buried subject. In
Rescue and Medical Care in Advanced Companion and Organized Rescue

**AvaLife 1.0 Advanced**

### Rescue

- **Accident - Start here!**
- Are there non OR partially buried subjects?
  - YES: Search for buried subjects! Maximize probability of detection and minimize search time!
    - Prioritize unsearched terrain with increased probability of survival: No forest, no high cliffs, no seracs or crevasses.
    - Prioritize buried subjects with “increased survival chances” indicated by vital data capable search devices.
  - NO: Excavate head and chest!
- Deep burial? (Hard debris: > 1.5m; Soft debris > 2m)
  - YES: Other buried subjects present?
    - YES: 2 or more rescuers per remaining buried subject?
    - NO: NO or ND
  - NO: Excavate head and chest!

### Medical Care

- Patient responsive, no life-threatening injuries?
  - YES: Breathing normally?
    - YES: >90%
    - NO OR ND: YES to all
  - NO: Fire rescue breath procedure or unacceptable to perform, only open airways and proceed.
- Breathing normally?
  - YES: Immediately clear airways.
  - NO OR ND: NO to any
- Other buried subjects present?
  - YES: Severe multiple trauma?
    - NO: Burial time < 20min?
      - YES: CPR for 5 min, 1 rescuer
      - NO: Vital signs returned?
  - NO: More rescuers than buried subjects?
    - YES: CPR
    - NO: More rescuers than buried subjects?
      - YES: CPR
      - NO: CPR

Excavate rest of body, protect cervical spine, body check, treat injuries, treat patient gently, protect from further cooling. If in CPR, continue until ICAR MEDCOM criteria for termination of CPR for BLS/ALS trained rescuers is reached. Notify rescue/medical staff about approx. burial time, status of airways at time of excavation and treatment on sight.

Footnote: (1) If unfamiliar with rescue breath procedure or unacceptable to perform, only open airways and proceed.
When transport capacities are very limited, flying times long or there is serious doubt that helicopter(s) may not come in for an extended period of time due to flying constraints, reassess sequence of transport priority and/or postpone departure of helicopter if more buried subjects are expected to be excavated soon.

Tolerance for interruptions of CPR during evacuation: burial time < 35min: no tolerance; burial time >35min: short interruptions ~5min i.e. during hoist operation acceptable.
companion rescue, there is the unique chance to get physical access to the buried subject within a very short period of time (Ref 26), even for lay rescuers with minimal training (Ref 27). Companion rescuers have therefore the chance to reach the patient in a stadium where asphyxia has only limited impact or severe, asphyxia-induced breathing suppression is present but has not lead to cardiac arrest yet. A few moments later in the timeline of rescue, these patients may be considered to be part of the “witnessed cardiac arrest” subgroup of the “CPR on pre-hospital cardiac arrest patients” group and therefore have approx. 8x better chances for a positive outcome of CPR (Ref 10-12). Another few moments later in the timeline of rescue, these still normotherm patients (burial time < 35min) do not belong anymore to the subgroup of “witnessed cardiac arrest”, as the rescuers reached them with a time delay of several minutes after cardiac arrest. This last group of normotherm patients only has very low chances for a positive outcome in BLS CPR (Ref 10-12) on an avalanche and therefore time and resources invested for this category of patients have to be very restricted in case there are still buried subjects present. In version 1.0 of AvaLife, the duration of CPR is limited to 5min for normotherm patients without vital signs when the rescue operation is short on resources. The longer BLS CPR continues without visible success, the lower the chance for a positive outcome (Ref 12, 13, 18, 19, 28). These are the considerations behind the 5min criteria. The 20min criteria may be seen as aggressive, but simply leads to a sharper separation between patients with a statistically good prognosis for a positive outcome and patients with less positive prognosis. The longer the time frame to judge the quality of the outcome, the shorter this duration has to be set, i.e. comparing status at arrival in the ED with neurological outcome at time of hospital discharge. Furthermore, early triage decisions lead to shorter burial times for the subsequently excavated patients and allow head access times of <35min, for multiple buried subjects (Ref. 26, 27).

Implications of “Greatest Good for the Greatest Number”

Rescuers and mountain rescue physicians who point out that they have seen positive surprises with longer burial times and long-lasting, companion rescue CPR should consider that AvaLife does not imply any modifications to the current ICAR Medcom recommendations and guidelines in case there is only one patient or no shortage of resources. In particular, AvaLife does in no circumstance modify any of their current recommendations and guidelines concerning final termination of CPR. However, as a tool with the goal to provide “Greatest Good for the Greatest Number”, the AvaLife algorithm strictly has to allocate resources to rescue tasks which lead to the greatest overall survival chances. This implies that rescue efforts and medical treatments which absorb a considerable percentage of the available resources over a longer period of time have to be postponed. In the practical application this leads i.e. to the effect that buried subjects in high burial depth will be excavated only after the partially buried subjects and fully buried subjects in shallow burial depth have been taken care of. Concerning medical triage this implies i.e. that treatment for a patient in traumatic cardiorespiratory arrest has to be postponed due to the very marginal chance for a positive outcome in this category of patients (Ref. 16 p. 1420; Ref 1-7).

Considerations on rescue breath and compression-only CPR

Based on the European Resuscitation Council Guidelines for Resuscitation 2010 (Ref 14), chest-compression-only CPR is not as effective as conventional CPR for cardiac arrests of non-cardiac origin (e.g., drowning or suffocation) in adults and children (Ref 15). Chest compression combined with rescue breaths is, therefore, the method of choice for CPR delivered by both trained lay rescuers and professionals. Laypeople should be encouraged to perform compression-only CPR if they are unable or unwilling to provide rescue breaths. These facts are reflected in AvaLife as initial rescue breaths are included, standard CPR is advised and the footnote (1) specifically makes reference to only opening airways and performing compression-only CPR.
How to Minimize Injuries During Excavation

During the excavation of a buried subject, mechanical impact to the body of the buried person may lead to injuries, compromise a potential respiratory cavity, compromise breathing by inhibiting thorax motion/decompression etc. Whereas the likelihood for the imposed impact to lead to fatal consequences is marginal, precautions to limit the chance and extent of impact should be taken as long as they do not compromise the goal of saving the life of the buried subject in a single burial accident or saving as many lives as possible in a multiple burial event.

Based on a study carried on by Brugger et al (Ref 28), many survivors of a full burial situation describe the last phase of their excavation as one of the most frightening moments of the entire event. Looking at the significant number of Post Stress Disorder problems reported by the above quoted study, there is as well an interest of reducing psychological stress and trauma by taking precaution when getting in close proximity to the buried subject.

No compromise against survival chances

In spite of the interest to access the buried subject as gently as possible, NO compromise may be made between “saving lives” and “limiting potential for mechanical impact” in the first 35min of burial time where survival chances in the asphyxia phase drop very rapidly and every single minute spent on a more gentle approach may lead to severe, irreversible brain damage or death.

Practical implications and procedures

In the generic design of the V-shaped snow conveyor belt, several strategies have been taken into account to ensure a good balance between reduction of excavation volume / burial time and reduction of mechanical impact to the buried subject. First, the probing spiral is applied in most cases perpendicular to the slope angle, which makes that the rescuers access the buried subject not from straight above, but cave in along the probe. Second, in case of a very shallow burial depth (<50cm, in very soft snow more) the starting point of the “V” is 1m below the probe with two rescuers in the tip of the “V” from the start of the excavation procedure. Third, in difference to improvised excavation techniques or BCA’s “strategic shoveling”, access to the buried subject applying the V-shaped snow conveyor belt is purposely kept in a narrow, approx. 30 to 40 degree angle. The relatively narrow tip of the “V” minimizes the likelihood of impact to the buried subject and keeps the required excavation volume as low as possible until the first visual contact of the patient is established. Only at this point, two rescuers work in immediate proximity of the patient and adapt the shape of the “V” to the visual outline of the patient.
Probing spiral with multiple probe hits

As a new, additional measure to avoid mechanical impact during excavation, a probing spiral with multiple probe hits should be applied when burial time has passed 35min or when many rescuers are available. While one rescuer proceeds on the probing spiral to achieve multiple probe hits, the remaining rescuers start the “V” already 1 to 1.5m downslope. Ones several probe hits have been made, set the lead probe for the excavation crew in the middle of the probe hit pattern to avoid reaching an extremity of the buried subject first. In case the probe hit pattern indicates that the body is parallel to the fall line, place the lead probe in half of the height of the probe hit pattern, very slightly offset sidewise so that the flank of the “V” is adjacent, but not directly overlapping the expected position of the buried subject.

Influence factor “hardness of debris”

Fortunately, very hard debris are statistically seldom. As hard debris require more invasive snow removal techniques such as the cutting snow blocks in half moons to effectively access the buried subject, the potential for a more severe mechanical impact increases. In particular because hard debris compromise the ability of the rescuer to quickly detect a change in consistence when touching the buried subject for the first time with the shovel, additional measures should be considered. In very hard debris, apply a probing spiral with multiple probe hits already earlier than recommended by the “burial time” criteria as a suboptimal alignment of the access point / access angle of the excavation crew may lead to severe complication in close proximity to the buried subject and therefore to a strong increase of head access time.

The harder the debris, the more difficult it is to feel subtle changes in consistence of the probed debris which may indicate a probe strike as the force required to penetrate the probe into hard debris compromises the tactile feeling. In despite of this problem, apply a probing spiral with multiple probe hits.

Deep burials

The above outlined strategies get applied in the moment when the remaining burial depth is smaller than the length of the probe and therefore a probe hit is possible. In case of burial depth greater than the probe length, the lead probe for the V-shaped snow conveyor belt is placed uphill of the spot where electronic search means show the lowest distance indication or highest amplitude of sound. The upper layers of the debris are first removed above the buried subject until the remaining burial depth allows a probe hit. Initiate at this point a secondary phase of fine search and pinpointing (probing spiral) in the already lowered tip of the “V”. As the rescuers get now in close proximity of the buried subject, the same consideration on minimizing potential damage to the buried subject as outlined above come in to play.

Acknowledgements

The author would like to thank the many organizations, colleges, friends and course participants who have with their advice contributed to the development of this paper, the AvaLife algorithm and the development for the procedures for a better protection of buried subjects during excavation. In particular I would like to mention concerning the development of AvaLife: MD Peter Paal, MD Herman Brugger, MD Anna Brunello and MD Melanie Kuhnke. For the procedures for a better protection of the buried subject: MD Alessandro Calderoli of Servizio Valanghe Italiano SVI for his determined role as an advocate for the buried subjects and to Angelo Panza, Gianni Perelli and the national instructors of Scuola Centrale di Scialpinismo CAI for their effort, contribution and extensive testing for the further optimization of the V-shaped snow conveyor belt.

AvaLife Version 1.0 will be further optimized and updated in collaboration with ICAR Medcom, mountain rescue physicians, rescue organizations, etc. If you have a suggestion on how to further optimize AvaLife, please do not hesitate to contact the author.
References

24. E. B. Lerner et al. Mass casualty triage: An...


