

STRATEGIC SHOVELING: THE NEXT FRONTIER IN COMPANION RESCUE

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ABSTRACT

With the widespread use of digital avalanche transceiver technology, search times for companion rescue have decreased significantly. Dedicated transceiver training sites and increased avalanche education opportunities have further aided both recreationists and pros in reducing search times. But the excavation phase remains the most time-consuming component of an avalanche rescue. This phase offers the most potential for reducing overall rescue times and increasing survivability. Field tests in Colorado in the spring of 2006 suggest that significant time savings may be gained in companion rescue with a strategic approach to the excavation phase. This can also lead to a more useful working area once the victim is recovered, minimizing compaction of the victim's air pocket and providing adequate space to roll and treat the victim. Avalanche educators should include these strategies when instructing students in avalanche rescue.

KEYWORDS

Avalanche rescue, companion rescue, shovel, probe, transceiver, beacon

1. BACKGROUND

In the past eight years, great attention has been focused on avalanche transceivers and their use. This is mainly due to the rise of digital transceiver technology, aggressive marketing and advertising by beacon manufacturers, and popularization of this product category among the recreational public.

Not only are more avalanche transceivers being sold now than ever before, but more avalanche courses are being taught and more opportunities are being created for beacon practice. For example, Tracker DTS beacon manufacturer Backcountry Access, Inc. (BCA) has developed nearly 50 public transceiver training parks at ski areas and other accessible sites worldwide.

1.1 Decreasing Search Times

Analysis of U.S. accident data collected by the Colorado Avalanche Information Center (CAIC)

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and the authors shows that this trend is paying off: beacon search times are on the decrease. The mean rescue time with a transceiver for recreationists from 1977 to 2000 was 29 minutes (including search and excavation). From 2000 to 2006, the mean dropped to 18 minutes ($P_{t\text{-test}} = 0.030$).

Empirical evidence, based on eight years of transceiver field education, has convinced BCA educators that search times have improved dramatically among both recreationists and pros for both single and multiple burial victims. But over this time period, there have been few advancements in the area of avalanche victim excavation. Incremental product improvements include oval shafts and stronger, lighter aluminum blades. However, there have been no significant advancements made over the last decade in technique or education.

Anecdotal and empirical evidence suggests that the great majority of time in companion avalanche rescue is consumed in the excavation phase, once the victim has been located. The greatest potential for decreasing overall rescue times—and mortality rates—is in the excavation phase. If excavation times can be decreased at the same rate that beacon search times have

decreased, then we can expect an even greater improvement in survivability than has been accomplished with improvements in transceivers and transceiver education.

Equally as important as excavation time, however, is excavation quality. In at least two U.S. avalanche rescues the victim's air pocket has been severely compromised as rescuers dug down to the victim. Anecdotal reports have been heard from around the world but not documented. In other cases, excavation progress or treatment of the victim has been severely compromised by lack of maneuverability within the excavation area, for example, stepping on or knocking substantial amounts of snow on to the victim. Any research into increasing the efficiency of excavation should include an inquiry into optimal excavation area size and dimensions.

1.2 Previous Research

A search of international literature revealed very little published research on the subject of avalanche victim excavation. Most books do not mention how to dig. Only very few books even offer tips. Germans Freudig and Martin (1995) advise to "dig downward along the probe. The hole must be particularly spacious." Tremper (2001) suggests that in deep burials (with tongue in cheek) it may require a hole "the size of a large jacuzzi that can hold thirty people." An avalanche rescue handbook published by the German Alpine Club (Semmel *et. al.*, 2005) says, "In order to save a buried one completely, a very large hole must be dug; a narrow hole at the probe is not sufficient." The handbook describes a technique in which shovelers form a line or triangle downhill of the probe strike to remove snow from the excavation area. Various publications from the Canadian Avalanche Association (CAA), Mountain Equipment Co-op, and Parks Canada focus on the basics of starting the excavation downhill of the probe and chopping the snow into blocks before removing (Ledwidge, 2005).

Field research performed over 20 years ago by Willy Pfisterer of Parks Canada offers the most detailed advice for avalanche excavations. His research supported the creation of terraces extending away from the probe strike to enable snow to be removed more efficiently. The authors contacted Pfisterer for his comments, but his findings are not published in writing. Likewise, the Association of Canadian Mountain Guides (ACMG) teaches a method based on

Pfisterer's research. While quite insightful, these guidelines have also not been published.

1.3 Research Goals

The aim of our research was twofold. The first goal was to provide a published proposal to the snow safety community for increasing the efficiency of avalanche victim excavation. This proposal could then serve as the basis for more quantitative future research. The second goal was to stimulate interest in the subject among avalanche educators. By providing educators with a set of specific strategies for the excavation phase, they are more likely to include this important phase in their curriculum when teaching students about avalanche rescue.

2. METHODS

Our research was performed in three stages: the initial literature review described above, a series of interviews with individuals that have been involved in companion rescue excavations, and three days of on-snow field research in the Colorado Front Range in the spring of 2006. The objective behind the first two stages was to determine the "state of the art" in excavation technique and to identify specific techniques for testing in the field. The objective of the field testing was to determine which of the techniques identified were most effective in a companion rescue situation and to test a basic set of guidelines that could be offered in a proposal to the snow safety community.

2.1 Parameters

At all three sites, the tests were performed on slope angles ranging from 0 to 15 degrees, which is typical of avalanche runout zones. The "victims" buried were either life-sized dummies borrowed from the local fire department or they were large canvas duffel bags filled with snow. The aim was to provide the rescuers with an object of about the same size and weight as a human to best approximate what kind of maneuverability would be required to locate the head and to roll and/or treat the victim. The dummies or duffels were buried in varying orientations with respect to the fall line. All were buried parallel to the snow surface, as this is the most common orientation in which avalanche victims are found.

All burials were between 1 and 1.5 meters deep. This depth was chosen because the average burial depth in the U.S. is 1.16 meters,

according to CAIC data. Below two meters, the chances of survival are extremely low: only 11 of 126 people (9%) have survived burials deeper than 2 meters. All rescuers were equipped with the same-sized BCA Traverse EXT aluminum shovel with extendable shaft. The victim was first located with a probe by the test organizers. Rescuers were advised to leave it in place.

Snow conditions varied at each site. They also varied over the course of each day, due to changing temperatures and reworking of the snow with repeated excavations.

The test results were all qualitative and subjective in nature, despite repeated efforts to generate quantitative data. At all three sites, excavation times were recorded for each individual or team and the final excavation areas were measured. However, the excavation times were so variable they were determined to be statistically insignificant. It became obvious that changing snow conditions and the motivation and conditioning of the respective shovelers played an even more important role in excavation times than shoveling technique.

2.2 Loveland Basin 4/9/06

These tests were performed in consolidated snow in a non-skier compacted area at Loveland Basin ski area. At this site, we had nearly two-dozen volunteers from the Loveland Basin National and Professional Ski Patrols, as well as several other non-affiliated volunteers recruited over the internet. We took advantage of this manpower to test techniques for multiple-rescuer excavations.

All excavations were performed in a “dual” format and the excavations were timed to stimulate competition and urgency. Rescuers were first advised to dig with no particularly strategy. Upon reaching the dummy, they were required to roll it over to establish an airway. In the next round of tests, volunteers were provided instructions on how large to make the initial hole and how to organize the excavation team. For large excavations involving three or four rescuers, they were briefed on the methods developed by Pfisterer.

2.3 Starter Holes

During these tests, it was quite obvious that digging with no strategy created a hole in which it was nearly impossible to roll or treat the victim (Figure 1). Often the rescuers were standing

directly on top of the victim, compromising the air pocket. Rescuers would invariably excavate in a cone shape down to the victim. Once deeper than their waists, rescuers were no longer able to throw snow clear of the hole, but had to lift it above the sides and deposit it. This creates high walls around the hole and exacerbates the problem of removing snow from the excavation area. By the time the rescuers reached the victim, the snow being removed often came right back into the hole and on to the victim again. It is not difficult to imagine the stress and possible harm this would cause to a live avalanche victim.



Figure 1. Excavating with no strategy usually produces a hole which compromises the victim's air pocket and the rescuer's maneuverability.

To prevent the problem of digging straight down to the victim and creating a non-workable hole, we determined that it was essential to clearly define the excavation area before digging. This area, called the “starter hole,” should be excavated first, preferably starting on one's knees. Once this hole is up to the rescuers' waists, then the next level can be excavated. Without this starter hole, rescuers tend to get “tunnel vision” and lose the opportunity to create a hole that will be workable when the victim is reached.

2.4 Terracing

In burials deeper than the rescuer's waist—or approximately one meter—the hole will need to be deepened further to reach the victim. This next level can be excavated closer to the victim,

creating a “terrace” effect up to the surface, as suggested by Pfisterer. The starter hole already excavated enables shovelers to throw snow clear of the hole instead of lifting and depositing it on the sides (Figure 2).



Figure 2. Proper terracing allows better snow removal and maneuverability for the rescuer. Sitting or kneeling is more ergonomic than standing.

Pfisterer suggests that the excavation starter hole should always begin at the probe strike and the terracing should extend down the fall line (if the deposition area is sloped). This decreases the probability of rescuers standing on top of the victim and trampling the air space. The ACMG suggests that the starter hole should surround the probe and the terracing should proceed on multiple sides. This increases the probability of locating the victim’s head so an airway can be maintained.

Our finding was that it is more efficient and faster—at least with limited manpower—to build the terrace system on one side (downhill) rather than multiple sides. This enables the rescuer to excavate deeper faster and therefore to reach the victim earlier. When revealing the victim, the snow can be removed relatively easily by “flaking” it from the wall rather than lifting. One shoveler can do this while the other removes the snow from the hole.

It should be noted that in our research we drew a clear distinction between companion rescue and organized rescue. In a companion rescue, there is normally less manpower available than in an organized rescue or in a mechanized guiding operation. In a companion rescue, it is often necessary to allocate limited manpower most efficiently. In an organized rescue or mechanized operation with greater resources, it indeed might make more sense to excavate the

starter hole around the probe and extend the terracing in more than one direction. While this would mean the rescue team would be working directly on top of the victim, this is often less important in an organized rescue; the victim most likely has been buried for a longer time and preserving their air space is not the highest priority.

In the multiple-rescuer scenarios, it also became clear that it is not always efficient to have all four shovelers excavating. When the starter hole is shallow (below the waist), all shovelers can throw snow to the sides, creating minimal interference with each other. But when it becomes necessary to jettison snow out the terraced side, both downhill (or “secondary”) shovelers should leave the hole to enable the uphill (“primary”) shovelers to throw their snow aggressively clear of the area. This provides the opportunity for one shoveler to rest while the other prepares the area for first aid and evacuation. In longer excavations, this opportunity for rest becomes very important.

2.5 Starter Hole Size

After experimenting with various hole sizes, we determined that the optimal y-axis—or downhill—length of the initial starter hole is approximately 1.5 times the burial depth (Figure 3). Hole sizes shorter than this tended to become too steep and high on the sides and therefore difficult for snow removal. A starter hole longer than this would delay locating the victim’s head. A starter hole length of two times the burial depth felt excessive to the shoveler, who would often resist starting this far away from the probe strike.

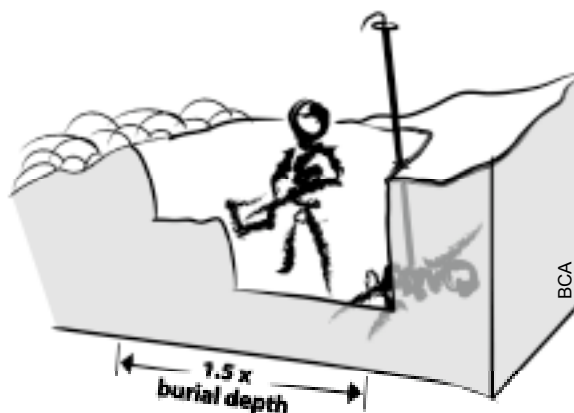


Figure 3. The optimal length of the hole should be 1.5 times the burial depth. Width should be 1.25 to 2 meters, depending on the number of shovelers.

We also determined that the width, or x-axis, dimension of the excavation area is more a function of the shovelers' working room requirements than it is a function of burial depth. If only one side of the hole is being terraced as described above, then burial depth does not come into play when determining the width of the hole; this dimension is better defined by the number of rescuers available to excavate. We would investigate this dimension in subsequent field sessions.

While it seemed counter-intuitive to the test subjects at first not to dig their starter hole directly at the probe strike, eventually they would determine that a hole that large would need to be excavated anyway to adequately be able to remove snow when the hole got deeper. Our experience was that if the entire starter hole is not dug immediately, then it will not be dug at all. Once the excavation is underway, shovelers tended to get "tunnel vision" and keep digging straight down until the victim is reached.

One alternative is to initially dig the portion of the starter hole nearest the probe first, and then extend it once the shoveler is up to his or her waist. This increases the probability of revealing a body part closer to the surface than the probe strike. This is the best option if the deposition area is flat and the shovelers are disciplined and well-trained. On a steeper slope, however, it is more ergonomic and efficient to start downhill and work into the probe.

2.6 Berthoud Pass 4/19/06

These tests were performed in slightly skier compacted snow at a popular ski touring destination. At this site, we excavated what we determined to be "ideal" holes for rolling and treatment of the victim, using ourselves instead of dummies as the victims.

After experimentation with several hole sizes, we determined that the final width of an optimal hole is about two meters, or about the length of an average human body. The other axis needs to have at least two meters of space to roll and treat the victim. To create a final work area this size, however, would require starting significantly wider, as our tests from Loveland Basin showed that rescuers invariably tend to narrow the hole in all dimensions as they progress—even when provided with a shoveling strategy. Of course, the rescuers do not know the orientation of the victim so it is unclear whether this two-by-two meter area is always necessary. In 235 U.S.

accidents where the victim's body position was recorded, 13 percent of avalanche victims were oriented on their side, 16 percent were vertical (sitting or standing), 26 percent were supine (face up) and 45 percent were prone (face down). Therefore, it is overly conservative to always create an excavation area this size under the time and manpower constraints of a companion rescue, as only about half will need to be rolled to clear the airway.

Since we knew that the optimal downhill length of the starter hole is about 1.5 times the burial depth, the next question was the optimal width. Since the victim's orientation is not known, this dimension is more a function of the number of shovelers available at the site. Field-testing at Berthoud Pass convinced us that if two shovelers are working side by side, then a two-meter width is most efficient to prevent interference with each other. If only one shoveler is available, then a 1.25-meter width—or about one "wingspan"—is optimal to prevent interference with the sidewalls.

Finally, at the Berthoud Pass site, we tested the German Alpine Club (DAV) shoveling method in which one shoveler excavates just downhill of the probe and any other shovelers are positioned further downhill to move the jettisoned snow away from the hole. These exercises indicated that it is more efficient to operate side-by-side than in line. In instances where the burial depth is less than two meters, it is almost always possible for the shovelers to throw snow clear of the hole if properly terraced. Therefore the second shoveler is not necessary for removing snow from the area. That resource is more valuable in making the hole wider close to the victim, to increase the probability of locating the victim's head earlier and providing an airway.

2.7 Pass Lake 5/25/06

Tests at this site near Loveland Pass were performed on hardened avalanche debris from a slab avalanche that released two days earlier. The debris softened over the course of the day due to rising temperatures. Volunteers included BCA employees, forecasters from the Colorado Avalanche Information Center (CAIC), and lift employees of nearby Arapahoe Basin ski area.

At this site, we confirmed that a hole length of 1.5 times the burial depth was optimal even in hardened avalanche debris and at varying slope angles. Shorter hole lengths resulted in final

holes with steep sides and lack of maneuverability. Tests with more than one rescuer confirmed greater efficiency operating side-by-side, as described above, than in line. Rescuers using the latter technique would always shovel more cautiously and tentatively to avoid striking the secondary shoveler with snow or their shovel blade. Invariably the secondary shoveler would be waiting for shovelfuls of snow from the primary shoveler so he could then move that snow from the area (Figure 4). While this provided needed rest for the secondary shoveler, it was an inefficient allocation of manpower compared to the side-by-side method.



Figure 4. Shoveling side-by-side (background) was more efficient than shoveling in line (foreground). In the latter technique, the primary rescuer shoveled tentatively and the secondary shoveler was often idle.

We also confirmed at this site that, when possible, it is best to shovel from a kneeling or sitting position, which are more ergonomic than a standing position. In addition, we confirmed that in hardened avalanche debris, it is more efficient to chop the debris and move it in blocks than to scoop varying amounts.

3. FINDINGS

Based on the preliminary research, interviews and field testing, we established the following guidelines for excavating avalanche victims in a companion rescue:

a) Leave the probe in place. This will confirm the exact depth and location of the victim. This will also create an imaginary line past which rescuers should not operate, decreasing the probability that the rescuers will stand over the victim and trample the air space. Using a probe

with depth markings is extremely valuable in determining the optimal size of the starter hole.

b) Clearly mark an outline of the area to be excavated. By marking this rectangular area and establishing a starter hole of that size, the shoveler will prevent excavating a restrictive tunnel or cone to the victim. Shovelers have a tendency to get “tunnel vision” while digging. By establishing a wide, rectangular excavation area, this effect is minimized. This excavated area also enables snow to be thrown clear of the area once the snow surface is above the rescuer’s waist.

c) The initial starter hole should be 1.25 meters or one “wingspan” wide for a single shoveler, to ensure adequate working space. With more than one shoveler, it should be two meters wide to ensure adequate working space and to increase the probability of locating the victim’s head. This is a fixed dimension unrelated to burial depth.

d) The starter hole should extend downhill 1.5 times the burial depth. If the deposition area is flat, then it should extend in the direction where snow can most easily be thrown from the hole. This dimension ensures an angle of approximately 30 degrees from the bottom of the hole to the snow surface. At this angle, snow can be thrown from the hole rather than lifted and deposited on the sides, ensuring that it will clear the area and not have to be shoveled twice.

e) Begin the excavation process on the knees, removing snow to the sides of the excavation area, where it won’t have to be moved again. Excavate by chopping the snow into blocks, then removing from the hole. Stand up when the sides of the hole are up to the waist. Continue throwing snow to the sides.

f) In a sloped deposition area, it is most ergonomic to start downhill and to move uphill while excavating, digging two blade depths down before moving forward. In a flat deposition area, it is best to start at the probe, to increase the probability of reaching a part of the victim that is closer to the surface than the probe strike.

g) Once the sides of the entire starter hole are up to the shoveler’s waist, then the starter hole is complete. From this point, all snow should be removed to the downhill side, clear of the hole, rather than to the sides.

h) Once the starter hole is complete, excavate the next level. This should start approximately half the distance to the probe. By starting downhill of the probe rather than at the probe, the shoveler can create a bench on which to sit while excavating into the probe. From the sitting position, snow can very ergonomically be thrown from the hole at waist level.

i) Special attention should be paid to keep the downhill side of the probe exposed, particularly if the probe is perpendicular to the snow surface instead of plumb. If the probe is perpendicular to the snow surface and the uphill wall of the hole is excavated plumb from the surface down, then it is possible to excavate below the level of the victim without revealing the victim (see Figure 5). Since most professionals recommend probing perpendicular to the snow surface in a transceiver rescue, then special attention must be paid when this recommendation is followed. A reasonable guideline is that when the probe is perpendicular to the slope instead of plumb, then begin the starter hole one arm's reach uphill of the probe (avoiding stepping above the probe). This will ensure an uphill wall that is plumb rather than overhanging—and that will adequately reveal the victim.

j) Once the victim has been revealed, determine the location of the head and concentrate on revealing the victim's face. Establish an airway as quickly as possible.

3.1 Two Rescuers

If two shovelers are available, they should operate side-by-side, moving snow to their respective sides of the hole. Operating in line is inefficient, for the reasons explained above. A second shoveler behind the first also tends to force the first shoveler uphill or past the probe, potentially trampling the victim's air space.

Once the victim is revealed, the primary shoveler should remove adequate snow to provide an airway or roll the victim to provide an airway. This snow can be moved within the hole and then removed by the secondary shoveler, who is responsible for enlarging the hole to treat the victim.

3.2 More Than Two Rescuers

If more than two shovelers are available, the two primary shovelers should begin the starter hole at the probe and the third and fourth (secondary) shovelers can begin the starter hole

downhill, at 1.5 times the burial depth. All shovelers should clear snow to the sides. Once the primary shovelers are up to their waists in the hole and it becomes necessary for them to clear the snow downhill, then the secondary shovelers should exit the excavation area to rest and prepare for administering first aid and evacuation. For maximum efficiency, rescuers should rotate shoveling and resting approximately once every minute.

3.3 Deep Burials

Deep burials of two meters or more may require an intermediate step in removing snow from the excavation area. At this depth it can be difficult to throw snow clear of the hole even with a terraced design. In this case, the primary shovelers should lift their snow to the level of the secondary shoveler(s). The secondary shoveler(s) can then clear it from the hole. If there is more than one secondary shoveler, then one should leave the hole to rest and prepare for first aid and evacuation. The primary shovelers can then use this vacant area to dispose of their snow. The remaining secondary shoveler then clears it from the hole (Figure 5).

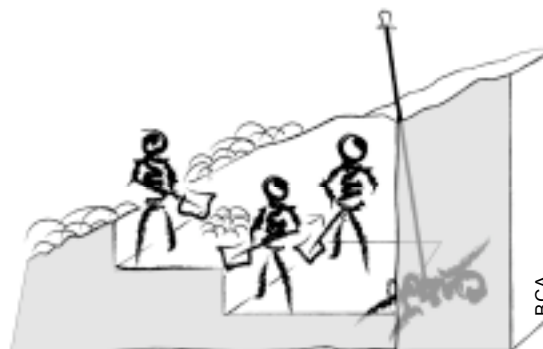


Figure 5. In burials deeper than two meters, it can be difficult to clear snow from the hole. Instead, it should be lifted to the next terrace, where it is removed by a secondary shoveler.

4. CONCLUSION

Strategic shoveling techniques show promise for decreasing overall companion rescue times and improving workspace during victim recovery. The techniques proposed here provide a baseline for future research and education. Future research should attempt to evaluate techniques quantitatively, based on comparative rescue times and workspace size.

The excavation phase is the most time consuming—and potentially the most physically demanding—portion of most companion avalanche rescues. Now that transceiver search times are on the decrease, the excavation phase holds the most promise for improving the chances of live recovery. Avalanche educators should include these strategic shoveling techniques in their curriculums when instructing students in avalanche rescue.

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