STRATEGIC SHOVELING: The next frontier in Companion rescue

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Background

In the past eight years, great attention has been focused on avalanche transceivers and their use. 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.

In the past six years mean rescue times with a transceiver for recreationists have dropped by a third. These times include both searching and excavating. Based on U.S. accident data collected by the Colorado Avalanche Information Center (CAIC), the average search time was 29 minutes from 1977 to 2000, then dropped to 18 minutes based on data from 2000 to 2006.

During this time, transceivers have become significantly easier to use, due mainly to digital technology. However, there have been no corresponding advancements made over the last decade in excavation technique or education.

Anecdotal evidence suggests that the majority of time in avalanche rescue is consumed in excavation, after the victim has been located. Therefore, the greatest potential for decreasing overall rescue times is in this phase. If excavation times can be decreased at the same rate that beacon search times have, then we can expect an even greater improvement in survivability.

As important as excavation time 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. 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 onto the victim.

A search of international literature revealed very little published research on the subject of avalanche victim excavation. Most books don't mention how to dig, and the few who do limit their comments to starting the excavation downhill of the probe, and chopping the snow into blocks for removal.

Field research performed over 20 years ago by Willy Pfisterer of Parks Canada offers the most detailed advice for avalanche excavations. His research supports the creation of terraces extending away from the probe strike to enable snow to be removed more efficiently. Likewise, the Association of Canadian Mountain Guides (ACMG) teaches a method based on Pfisterer's research.

In order to verify Pfisterer's recommendations and the comments of individuals involved in rescues, we hosted three field tests in the Colorado Front Range to determine what shoveling techniques were most effective.

At all three sites, the tests were performed on slope angles ranging from 0 to 15 degrees. This is typical of avalanche runout zones, although depositions from small avalanches are sometimes found on steeper slope angles. The "victims" were either life-sized dummies or large canvas duffel bags filled with snow. 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.

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 shovel (BCA Traverse EXT aluminum shovel with an extendable, oval, shaft). The "victim" was first located with a probe by the test organizers. Rescuers were advised to leave it in place.

The test results were all qualitative, 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 variable enough so they were statistically insignificant. It became obvious that

changing snow conditions, motivation, and the conditioning of the shovelers played an even more important role in excavation times than shoveling technique. However, in a real companion rescue, motivation, conditioning and snow conditions are not variables; technique becomes a critical factor in rescue time.

The Importance of Strategy

We started our experiments at Loveland Basin with nearly two dozen volunteers.
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 particular strategy.

In the next round of tests, volunteers were given 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.

Digging with no strategy created a hole in which it was nearly impossible to roll or treat the victim. 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.

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.

In burials deeper than the rescuer’s waist—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 1).

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 established.

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 and faster, thereby reaching 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.

Manpower Considerations

It should be noted that in our research we drew a clear distinction between companion rescue and organized rescue. In a companion rescue, it is necessary to allocate limited manpower 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.

In the multiple-rescuer scenarios, it 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.


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Figure 1. Proper terracing allows better snow removal and maneuverability for the rescuer. Sitting or kneeling is more ergonomic than standing.

Key Dimensions: Length

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 2). 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.

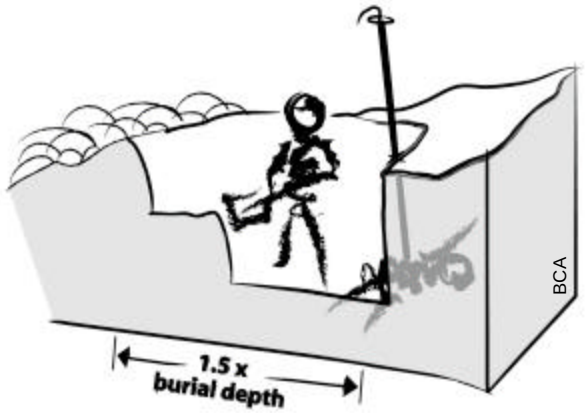

Figure 2. The optimal length of the hole should be 1.5 times the burial depth. Width should be 1.25 to 2 meters, depending on the number of shovelers.

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.

On a separate day, at Pass Lake, near Loveland Pass, 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.

Key Dimensions: Width

Since we knew that the optimal downhill length of the starter hole is about 1.5 times the burial depth, our objective here was to determine the optimal width.

We began by excavating what we determined to be "ideal" holes for rolling and treatment of the victim, using ourselves instead of dummies as the victims. This was extremely time consuming and most likely, extremely conservative. According to the CAIC data, only half the time will it be necessary to roll the victim to create an airway. 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).

Since the victim's orientation is not known, we determined 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.

Rescuer Positioning

Tests with more than one rescuer confirmed that side-by-side shoveling was more efficient than shoveling in-line. Rescuers using the in-line technique would always shovel more cautiously 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 3). While this provided needed rest for the secondary shoveler, it was inefficient compared to the side-by-side method.

Conventional wisdom says that it's best to position shovelers in-line so the second shoveler can move the excavated snow further downhill. But this is unnecessary if the snow is initially thrown to the sides and then thrown properly out the back. The second shoveler is best positioned side-by-side so he can help make the hole wider near the victim, increasing the probability of locating the head.

Figure 3. 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.

Summary

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 to confirm the exact depth and location of the victim. This also creates an imaginary line past which rescuers should not operate, so that they will not 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 the area to be excavated. By marking this rectangular area and establishing a starter hole of that size, the shoveler will avoid excavating a restrictive tunnel or cone to the victim. 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. 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. In a flat area, it should extend in the direction where snow can most easily be thrown. This dimension ensures that snow can be thrown rather than lifted and deposited on the sides, and 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 it from the hole. Stand up when the sides of the hole are up to the waist. Continue throwing snow to the sides.

f) On a slope, it is most ergonomic to start downhill and to move uphill while excavating, digging two blade depths down before moving forward. In a flat 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 when standing, 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 (as is normally recommended in a transceiver rescue) 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 4).

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.

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.

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.

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.

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. One secondary shoveler may need to exit the hole to create room for this intermediate step.

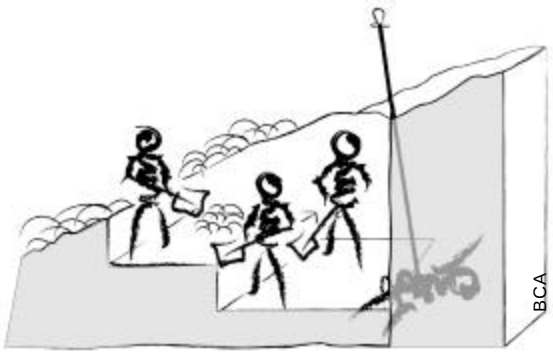

Figure 4. In burials deeper than two meters, it can be difficult to clear snow from the hole. Instead, it should be lifted to the next terrace, where it is removed by a secondary shoveler.

Conclusion

Strategic shoveling techniques show promise for decreasing excavation time and improving workspace during victim recovery. The excavation phase is the most time consuming 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. We believe avalanche educators should include these strategic shoveling techniques in their curriculums and that further research should be performed to better quantify the most efficient methods for excavation.

Acknowledgements

The authors would like to thank the many volunteers who participated in the shoveling experiments, including Halsted Morris, Backcountry Access employees, and the Loveland Basin National and Professional Ski Patrols. They also appreciate the technical advice provided by Jim Conway, Willy Pfisterer, Dave Gauthier and Colin Zacharias.

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