SHOULD AVALANCHE AIRBAGS BE MANDITORY?

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ABSTRACT: Avalanche airbag backpacks have been shown to be effective at reducing avalanche fatalities. However, they are yet to be considered mandatory safety equipment, which has long consisted of a transceiver, a shovel, and a probe. Evidence shows airbags reduce mortality by decreasing likelihood of burial. In addition, airbags probably reduce likelihood of trauma by providing a cushion and possibly delay asphyxia once buried by creating an air pocket. The data suggests airbags reduce mortality at a rate similar to transceivers. Despite this, airbags are not considered standard safety equipment. Multiple barriers exist for universal adoption, including cost, size, weight, and lack of community support and recommendations from professional societies and associations.

KEYWORDS: avalanche, airbag, burial

1. INTRODUCTION

All The avalanche airbag backpack was first patented by German skier Peter Aschauer nearly four decades ago. Early inspiration was reportedly based on the experience of forest ranger Josef Hohenester, who found that when he hauled large game on his back, he floated more easily in snow. Aschauer first demonstrated his airbag at Internationale Fachmesse fur Sportartikel und Sportmode (International Tradefair for Sporting Goods and Sportswear) in Munich in 1985. After nearly four decades, airbag design and functionality have been refined.

Avalanche airbags work based on the property of particle physics called granular convection. In a flow, particles of larger volume migrate to the top. Airbags increase the volume of users by 150 L or more and thus assist in keeping the user at the top of avalanche debris.

Airbags are widely available in Europe and North America. Airbags use two general systems, inflated by either compressed gas canisters or electronic fans. Canister airbags come with multiple configurations and gasses, such as air, nitrogen, argon, and carbon dioxide. In some models, compressed air canisters are refillable. Other systems use one or two single-use disposable canisters. Electronic fan airbags are powered by a rechargeable lithium-ion battery or a capacitor with battery backup. Both add significant weight, bulk, and expense compared to a standard, non-airbag backpack.

The benefits of canister airbags are that they tend to be lighter and less expensive. The downside is that canisters are not easy to refill or replace, are not standard among manufacturers, and can be limited for airline travel and shipping by regulations, especially in North America. For multiple deployments, canisters pose difficulty for practicing, for rearming an airbag that needs to be used more than once, and for sharing extra canisters in groups that use different airbag brands. The addition of extra canisters to a backpack increases both cost and weight.

The benefits of an electronic fan airbag are that multiple deployments and airline transport are simpler. This makes practicing easier and less expensive. A potential problem is that they rely on power and electronics, which may be affected by cold temperature and availability of power for charging.

2. PUBLISHED RECOMMENDATIONS

Avalanche airbags are used in backcountry areas around the world. Many organizations have provided recommendations regarding their use. Because of the varied infrastructure, legal, and governmental issues around the world, this review will only examine selected current recommendations in North America.

In 2024, a Wilderness Medical Society (WMS) practice guideline reviewed the avalanche literature. Similarly in 2024 an International Commission for Alpine Rescue guideline reviewed airbags. Both reinforced the effectiveness of airbags to prevent snow burial. However evidence is inconclusive if they decrease morbidity and mortality by preventing trauma or prevent asphyxia once buried by creating an airpocket. which also demonstrated effectiveness.

Despite these guidelines, other publications do not mention the utility of airbags. The textbook used by the Wilderness Medical Society Diploma in Mountain Medicine course omits mention of airbags altogether.

The three main North American avalanche organizations—American Avalanche Association (A3), Canadian Avalanche Association (CAA), and American Institute for Avalanche Research and Education (AIARE)—have no formal recommendation for airbag use on their websites or in their publications, as confirmed by published information, websites, and personal communication with the three agencies. For A3 airbags are part of the core curriculum for only one course titled Avalanche Rescue; this is one of five courses that range from basic to advanced. For AIARE, airbags are considered "additional safety equipment" in their 2021 student manual. In the CAA 2016 risk handbook, airbags are mentioned only once in discussion of risk statistics.

3. OVERVIEW OF LITERATURE

Like many topics in wilderness and mountain medicine, the literature on avalanche airbags is sparse. One study found that airbags reduced mortality from 19% to 3%. Another study reported on 245 accidents involving 424 injuries and a 19% overall mortality rate. A subset of the data looked at 66 accidents with both airbag and non-airbag users. In this subset, all non-critically buried fatalities were due to trauma. Mortality reduction of critical burials decreased from 34% to 11% with use of an airbag.

Of note, airbag deployment failure and device failure were found to be significant in both studies. One study found a 20% failure rate (7/35 participants) and another found a 20% failure rate (61/307 participants); this was due to user error, device failure, or device damage during avalanche.

A third study used a series of planned avalanches to test dummies equipped with and without airbags. Of the five dummies without airbags, burial depth was a mean of 43 cm and only 1 of 5 was visible from the surface. In contrast, of 14 dummies with airbags, burial depth was a mean of 15 cm, with all 14 visible from the surface. This study also found that among the 14 airbag dummies, with all but 5 the head was visible and with all but 2 the airway was less than 10 cm below the surface.

Similarly, the literature on transceivers is limited and outdated; most studies on transceivers are prior to widespread use of modern technology including digital processing, multiple antennas, firmware update capability, and self-checks by user with an app. But avalanche transceivers reduce mortality about equal to airbags once buried; but they do not prevent burial and do not prevent trauma. One study showed transceivers reduced time from burial to companion rescue from 120 to 30 min but did not have a significant reduction in mortality. Another showed that burial time was decreased from 102 to 30 min, and mortality decreased from 68% to 54%, with a transceiver. A third study confirmed burial time reduction from 125 to 25 min using a transceiver and a mortality risk reduction from 70% to 55%.

4. BARRIERS TO USE

The important messages from these studies are twofold. First, airbags are successful at decreasing mortality from avalanches, mostly in reducing risk of critical burials. But may also prevent trauma and prevent asphyxia once buried. As with any device, user error and equipment failure are substantial problems.

Second, mortality-rate reduction of airbags is similar to transceivers, with the limitations discussed previously.

Despite these studies, airbags are still not universally adopted as standard avalanche safety equipment. Several barriers exist to universal use of airbags.

Availability and equipment challenges. At one time, airbags were limited in availability in some regions. This has probably made adoption slow. However, now airbags are widely available.

Size and weight. Airbags are heavier and bulkier than standard, non-airbag backpacks. Whereas an average backpack can weigh as little as 0.5 kg, the lightest airbags are around 2 kg. However using the size and weight as a reason not to use an airbag is just a matter of priority. One is prioritizing, for example, to take a liter of water instead of an airbag, both of which weigh about the same.

Cost. Airbags are significantly more costly than standard packs. However, when cost is eliminated, such as with professionals like guides and ski patrollers, people still often choose not to use airbags.

Training. Airbags require additional training for both recreational enthusiasts, professionals, and educators.

Community use. The promotion of airbags in local communities via equipment retailers, social media, and professional organizations also likely plays a role. If a community has an important educational organization or mountain shop that promotes airbag use, airbags may be adopted more readily.

Risk tolerance. It's possible that airbags increase risk tolerance for users and thus may be both a deterrent and a perceived benefit for users. But most studies suggest that a) risk tolerance is unknown and b) it's similar with other safety devices like helmets.

Guidelines. Professional societies and associations, in scientific and lay publications and in textbooks, have neither recommended airbags as standard equipment nor provided much education or guidance about them in their curricula. This likely plays a large role in lack of universal use.

5. KNOWLEDGE GAPS

Aside from preventing burial, other questions worth considering are discussed below. These issues are important, as they possibly contribute to lack of adoption of airbags.

5.1 *Does the size of the balloon matter for flotation?* The standard is a 170-L balloon. A larger balloon may be more effective at keeping a user atop the avalanche debris but makes weight, cost, and design more difficult, including the need for a larger fan or canister.

5.2 Does the airbag protect one from trauma? Airbag use may be encouraged if we had data that demonstrated protection from trauma, considering trauma accounts for 25% of fatalities.

5.2 Once buried, do airbags create an air pocket and/or protect the airway to delay asphyxia? If airbags could help prevent asphyxia, as with trauma, airbags may be adopted more readily. We know that air pockets and patent airways help prolong survival. One brand and model of fan airbag deflates after inflation. In a recent study, researchers buried 12 volunteers with an airbag-created air pocket and measured oxygen saturation, end tidal carbon dioxide, heart rate, and respiratory rate. Participants with a simulated air pocket created by an airbag were able to move their head an estimated 11 cm forward and 7 cm backward. The conclusion was that it is possible that an air pocket from a deflated airbag could prolong survival.

6. CONCLUSION

Airbags have been shown to be effective at saving lives. Airbag mortality reduction are roughly equal to transceivers. Yet, standard avalanche safety equipment. This is due to several barriers as described above.

Based on the literature, if one wants to maximize safety in avalanche terrain especially when traveling solo, one should use an airbag in addition to other standard safety tools.

7. REFERENCES

Brugger H, Durrer B, Adler-Kastner L, Falk M, Tschirky F. Field management of avalanche victims. Resuscitation. 2001;51:7-15.

Brugger H, Etter HJ, Zweifel B, Mair P, Hohlrieder M, Ellerton J et al. The impact of avalanche rescue devices on survival. Resuscitation. 2007;75:476-83.

Campbell C, Conger S Gould B, Haegeli P, Jamieson B, Statham G (eds). Avalanche Association Technical Aspects of Snow Avalanche Risk Management. Revelstoke, Canada: Canadian Avalanche Association;2016.

Di Stefano LL, Libera BD, Roda P. Effectiveness and use of avalanche airbags in mortality reduction among witer-recreationalist. Journal of Travel Medicine 2023. DOI: 10.1093/jtm/taac133.

Haegeli P, Falk M, Procter E, Zweifel B , Jarry F, Logan S et al. The effectiveness of avalanche airbags. Resuscitation. 2014;85:1197-1203

Haegeli P, Rupf R, Karlen B. Do avalanche airbags lead to riskier choices in the backcountry? In: Proceedings International Snow Science Workshop. Innsbruck, Austria; 2018:1293-7. Available at https://arc.lib.montana.edu/snow-science/ ISSW2018_O15.6.pdf.

Hohlrieder M, Mair P, Wuertl W, Brugger H. The impact of avalanche transceivers on mortality from avalanche accidents. High Alt Med Biol. 2005;6:72-7.

Hutchinson J. Avalanche Fundamentals. In: Rodway GW, Weber DC, McIntosh SE (eds.) Avalanche fundamentals in Mountain Medicine & Technical Rescue. Herefordshire, UK: Carreg; 2016:398-414.

Lane JP, McIntosh SE. Avalanche Airbag Usage and Risk Attitudes of Backcountry Skiers and Snowboarders in American West. Wilderness and Environmental Medicine 2023; 34: 187-92.

McIntosh S, Little CE, Selbert TD, Polukoff NE, Grissom CK. Avalanche airbag post-burial active deflation - The ability to create an air pocket to delay asphyxiation and prolong survival. Resuscitation. 2020;146:155-60.

Meier L, Harvey S. How effective are avalanche airbags? Field tests of avalanche safety equipment. In: Proceedings International Snow Science Workshop. Anchorage USA; 2012: 756-63. Available at https://arc.lib.montana.edu/snow-science/objects/issw-2012-756-763.pdf.

Pasquier M, Strapazzon G, Kottmann A, Paal , Zafren K, Oshiro K, Artoni C, Van Tilburg C, Sheets A, Ellerton J, McLaughlin K , Gordon L, Martin RW, Jacob M, Musi M, Blancher M, Jaques C, Brugger H. On-site treatment for avalanche victims: Scoping review and 2023 recommendations fof the International Commission for Mountain Emergency Medicine (ICAR MedCom), Resuscitation 2023. DOI: 10.1016/j.resuscitation.2023.109708

Strapazzon G, Paal P, Brown D, Brugger H. Reconsidering the air pocket around mouth and nose as a positive outcome predictor in completely buried avalanche victims. Resuscitation 2020;152:210-1.

Van Tilburg CS, Paul P, Strapazzon G, Grissom CK, Haegeli P, Holzl N, McIntosh S, Radwin MI,Smith WR, Thomas S, Tremper B, Weber D, Wheeler AR, Zafren K, Brugger H. Wilderness Medical Society practice guidelines for prevention and management of avalanche and nonavalanche snow burial accidents. Wilderness Environ Med 2024. DOI: 10.1016/j.wem.2023.05.014.

Van Tilburg C. Should Airbag Backpacks be Standard Avalanche Safety Equipment. Wilderness and Environmental Medicine 2021

Zacharias, C. The Student Handbook for The AIARE Risk Management Framework. Vail, USA: American Institute for Avalanche Research and Education;2018.