



Australian Government
Australian Transport Safety Bureau

Helicopter winching accident involving Bell Helicopter Co. 412EP, VH-VAS

19 km south-south-east of Mansfield, Victoria | 31 August 2013



Investigation

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Addendum

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Safety summary

What happened

At about 1050 Eastern Standard Time on 31 August 2013, the crew of a Bell Helicopter Co. 412EP helicopter, registered VH-VAS, were tasked to pick up a patient who was reported to have sustained injuries during a fall in the hills around Macs Cove, near Mansfield, Victoria. Due to the confined winch area and the possible fouling hazard associated with nearby trees, the crew elected to conduct a double-lift extraction with the patient in a rescue strop, accompanied by a paramedic. As the paramedic and patient reached the helicopter's skid-landing gear, the patient became increasingly unresponsive and began slipping from the rescue strop. The paramedic and winch operator attempted to restrain the patient however, despite their efforts, the patient slipped out of the rescue strop and fell to the ground, sustaining fatal injuries.

VH-VAS



Source: Australian Helicopters

What the ATSB found

The ATSB found that, due to the compressive nature of the rescue strop around the patient's chest, combined with the patient's weight and pre-existing medical conditions, the patient probably lost consciousness during the winch operation. While the rescue strop was serviceable at the time, it was not suitable for the patient and contributed to their falling from the strop following their loss of consciousness.

The ATSB also identified that the operator and Air Ambulance Victoria had limited documented guidance to assist rescue personnel select the most appropriate winching rescue equipment.

What's been done as a result

Concurrent with the release of its preliminary investigation report on 10 October 2013, the ATSB issued a safety advisory notice to helicopter winch operators, noting the circumstances of this accident. The notice advised operators to consider the risk to patients, or other persons being winched, of slipping out of a rescue/retrieval strop and the implications for their operations.

Following this accident, the operator and Air Ambulance Victoria introduced a seat-type harness for patient recovery via winch and issued guidance to their crews on the order of priority of use for rescue equipment during over land winch operations. The Civil Aviation Safety Authority also issued an Airworthiness Bulletin clarifying the use and application of rescue/retrieval strops. In addition, various helicopter emergency medical service providers have improved information sharing to communicate operational knowledge and lessons learnt.

Safety message

The ATSB advises helicopter emergency medical service and other operators carrying out winching operations to note the circumstances of this accident and consider the implications for their operations of the risk of patients or other persons being winched slipping out of a rescue/retrieval strop. In this context the size, weight and medical condition of the person(s) being winched may indicate that other recovery options offer reduced risk.

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The occurrence

Departure

At about 1050 Eastern Standard Time¹ on 31 August 2013, the crew of a Bell Helicopter Co. 412EP helicopter, registered VH-VAS and operating as 'HEMS 5' (Figure 1), were tasked to recover a patient who was reported to have fallen and broken their ankle in the hills around Macs Cove, near Mansfield, Victoria (Figure 2). The helicopter was contracted by Air Ambulance Victoria to provide helicopter emergency medical service (HEMS) operations. The crew consisted of a pilot, an air crewman (ACM) and an ambulance rescue crewman (ARC). The crew were informed that the patient weighed between 130 and 140 kg and that, due to the difficult terrain and the size of the patient, a winch extraction would likely be required. The helicopter departed from its base at Essendon Airport, Victoria, for the scene at 1105.

Figure 1: VH-VAS

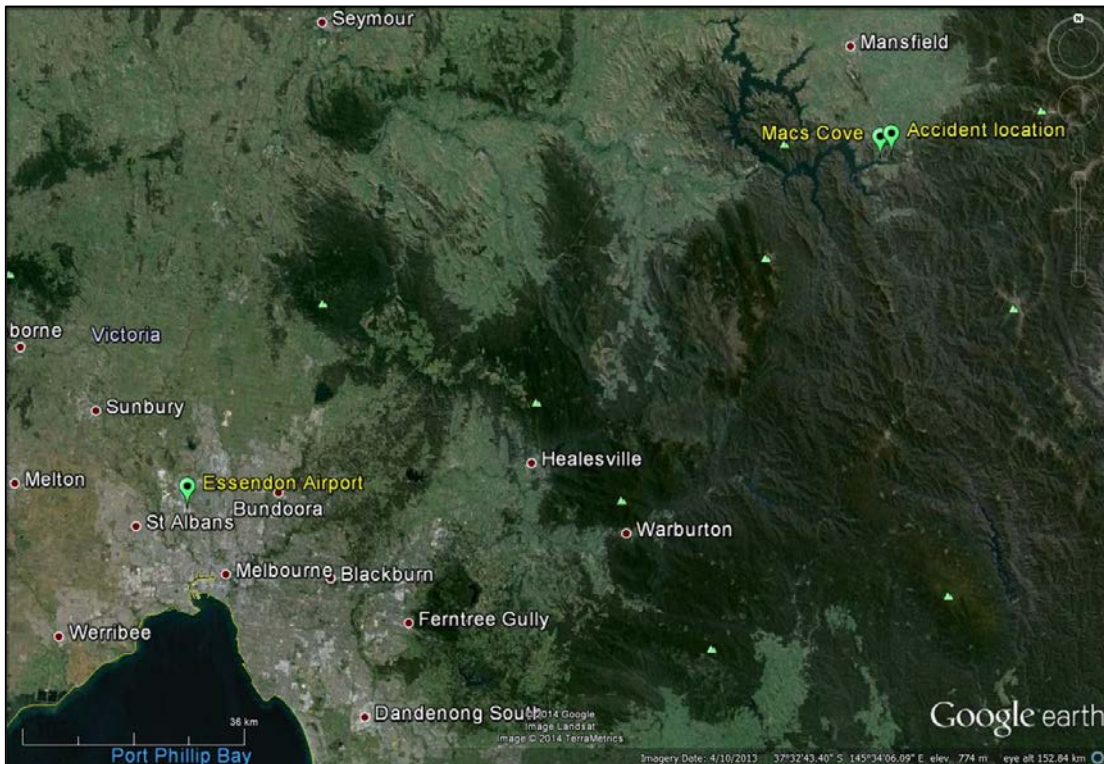


Source: Australian Helicopters

Prior to the helicopter being tasked with the patient recovery, a ground party commenced hiking to the patient's location. The ground party consisted of two Ambulance Victoria paramedics and a student paramedic, Victoria Police officers and State Emergency Service (SES) and Country Fire Authority (CFA) personnel. After about a 30-minute hike through rugged terrain, the ground party reached the site at about 1110. The paramedics provided clinical care to the patient, including pain relief for the ankle injury.

¹ Eastern Standard Time (EST) was Coordinated Universal Time (UTC) + 10 hours.

Figure 2: Accident location



Source: Google earth (modified by the ATSB)

Arrival at the scene

At about 1145 the helicopter arrived overhead the ground party and patient, who were located in a heavily-wooded area in steep terrain about 1 to 1.5 km from the nearest road (Figure 3). The trees in the surrounding area were up to 18 m high and the crew noted numerous dead branches that could create a hazard for winching operations.

The crew located a suitable area into which to winch the ARC to assess the patient’s condition and their suitability for a winch retrieval. They discussed likely retrieval options and decided that a stretcher winch would be not suitable due to the steep terrain and the possibility of fouling the stretcher on the surrounding vegetation. Following consideration of the options, the crew elected to conduct a double-lift² extraction with the patient in a rescue strop accompanied by the paramedic in a separate harness (see the section titled *Winching role equipment*).

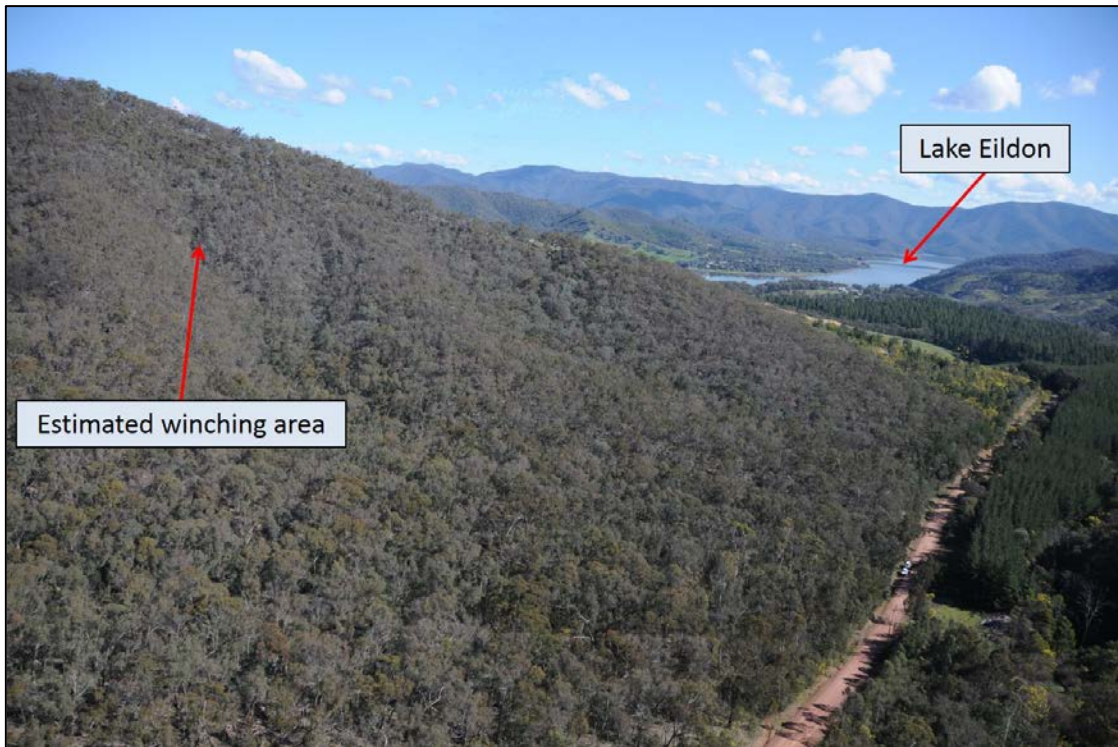
The ARC and ACM decided that the ARC would use standard winching hand signals to indicate whether a winch extraction would be required. After confirming with the pilot that there was sufficient fuel for the retrieval, the ACM winched the ARC in to the site at 1203. The pilot then flew the helicopter to land at Macs Cove, about 2 km to the south-west, and waited about 20 minutes before returning to the scene. This allowed the ARC time to assess the patient and winching area.

Once on the ground, the paramedics from the ground party briefed the ARC on the condition of the patient and the clinical treatment that had been provided. Care of the patient was then handed over to the ARC. After the handover, the ARC consulted with the SES personnel and organised for several surrounding trees to be felled to provide for a larger winching area for the double-lift extraction.

² A double-lift is a winch activity where two people are attached to the winch hook at the same time.

The ARC reported that, as part of the preparation for the winch, they briefed the patient on what to expect during the winch procedure, the use of the strop and its chest strap and the importance of the patient keeping their arms down by their side when in the strop to prevent slippage. The ARC stated that prior to the winch they confirmed that the strop was securely fastened, with the chest strap fitted, and that the patient was alert, cooperative and understood the instructions provided. The ground party assisted with relocating the patient to the winching area, which was on sloping terrain, in preparation for the extraction.

Figure 3: General location of the ground party and patient, looking south-west



Source: Victoria Police (modified by the ATSB)

Winching operation

At 1224 the helicopter departed Macs Cove to return to the winching area. On arrival overhead the pilot and ACM noted the enlarged winching area and that the patient had been moved to that area. About 5 minutes later, the ARC signalled to the ACM that he was ready to be winched. The pilot established the helicopter in a hover about 80 ft above the winching area, or about 20 ft above the surrounding trees.

The ARC and ACM reported that the winching procedure initially appeared to proceed normally. The ARC recalled holding the patient's arms down and the ACM reported that the ARC appeared to have his arms and legs wrapped around the patient, in accordance with the normal winching procedure. Video footage of the winch showed the patient positioned low in the rescue strop for the lift and that the ARC's legs were wrapped around the patient's body and their arms resting on the patient's arms. The imagery also showed that the patient's upper arms were initially extended away from the downwards position and at times appeared to be extended forward of the patient in a near horizontal position.

Soon after the ARC and patient were lifted clear of the ground the winch was paused for about 6 seconds to ensure they were stable. When the ARC and patient were about 30–40 ft above the ground, the ACM noticed that they were close to the upper branches of the trees and stopped winching in the cable. The pilot was advised and the ACM assisted in repositioning the helicopter back and right about 2 m. This took about 9 seconds.

The ARC stated that during the initial stages of the winch he contacted the surrounding tree branches and used both hands to fend them off. As they came through the tree canopy, the ARC noticed that the patient appeared uncomfortable. The ARC reported that when about 60 ft above the ground, clear of the tree canopy and 15 ft below the helicopter, they could see that the patient was starting to wriggle and that his arms were coming up.

The ARC reported yelling to the patient a number of times to keep their arms down and, although the patient appeared to be looking at the ARC, they did not respond or follow the ARC's instruction. The ARC tried to push the patient's arms down but the patient started to slip down in the strop. The ARC advised later that they considered aborting the winch at that stage. However, due to their proximity to the helicopter, the absence of a clear path through the tree canopy back to the ground and their inability to signal the ACM as a result of holding the patient's arms down, the winch was continued.

The ACM reported that once the ARC and patient were clear of the tree canopy, the ARC repositioned their legs around the patient and that things seemed to be progressing well. In accordance with normal winching safety procedures, as the ARC and patient approached the helicopter, the ACM stopped the winch momentarily for a control check before resuming the winch.³

When the ARC and patient were about 5–10 ft below the helicopter, the ACM could see that the patient had moved position and had their arms out and that the ARC was shouting at the patient and struggling to hold him. Video footage taken from the ground also showed that at least one of the patient's arms was displaced away from his body at that time. The ACM informed the pilot that the patient was slipping and, due to their close proximity to the helicopter, elected to continue winching the ARC and patient towards the helicopter.

As the ARC and patient reached the helicopter's right skid-landing gear, the ARC was facing the helicopter and the patient was facing outwards. This was normal practice to allow the ACM to assist the patient into the helicopter. The ARC reported attempting to pin the patient against the skid to prevent him from slipping as by that stage the patient was limp, unresponsive and making no apparent effort to hold on.

The ACM continued winching until the ARC's head was level with the middle of the door opening. At that stage the ACM informed the pilot that he could see the patient slipping further. The ACM let go of the winch control pendant and reached down, grabbing the patient's shoulder and arm in an attempt to stop them slipping further. The ACM also noted that the patient appeared to be limp and not holding on to anything.

Despite the crew's efforts, about 70 seconds after commencing the winch, the patient slipped out of the rescue strop and their synthetic jumper and fell to the ground, sustaining fatal injuries.

³ The control check confirms correct winch operation, in particular the ACM's winch control pendant. The procedure normally only takes about a second.

Context

Personnel information

Pilot

The pilot held a Commercial Pilot (Helicopter) Licence that was issued in 2010. He was endorsed on the Bell Helicopter Co. 412EP (412) and held a Command (Multi-engine Helicopter) Instrument Rating. The pilot also held a valid Class 1 Aviation Medical Certificate.

The pilot's logbook indicated that, prior to the flight, they had accrued a total of 2,316 hours helicopter flight time, of which 561 hours were in 412 helicopters. The pilot's most recent flight review was an instrument rating renewal on 10 February 2013 and their last company winch check flight was carried out on 26 May 2013. The pilot had been employed as an emergency medical service pilot with the operator for about 2.5 years. The pilot's last recorded flight prior to the winch at Mac's Cove was a winch training flight that morning.

The training flight involved the same crew that carried out the subsequent winch recovery and met the recommendation in the operator's operations manual that pilots conduct a winch at least every 6 months to maintain winch proficiency.

Air crewman

The air crewman (ACM) joined the operator on 1 October 2012 and completed his 412 winch endorsement training on 22 October 2012. The ACM had about 4 years' experience as an ACM, having completed their ACM training on 9 April 2009, while serving in the Australian Army. The ACM's logbook indicated that they satisfied the operator's 12-month currency requirement and had accrued a total of 689 hours flight time.

The operator's operations manual recommended that an ACM conduct a winch at least every 6 months to maintain winch proficiency. The ACM's most recent day winch was during the morning training flight.

Ambulance rescue crewman

The ambulance rescue crewman (ARC) joined the ambulance service in 1986 as a student ambulance officer. They went on to become a mobile intensive care ambulance paramedic, before joining Air Ambulance Victoria in 1998. His most recent winch procedure was a 3-month winch currency check that was carried out on the training flight with the other crewmembers that morning. This involved a double-lift with a simulated patient in a rescue strop with the hypothermic strap deployed (see the sections titled *Rescue strop* and *Rescue strop with hypothermic strap*).

General

All crew members reported being well rested and in good health. Their last duty was a day shift the previous day.

Patient information

Medical records indicated that the patient was a 65 year-old male who weighed 138 kg and was 175 cm tall. Their medical history included the diagnosis of atrial fibrillation,⁴ congestive cardiac failure⁵ and hypertension.

⁴ A rapid, randomised contraction of the heart's atrial myocardium that causes an irregular, often rapid ventricular rate. This results in the heart not pumping blood as efficiently as normal.

⁵ An ongoing condition in which the heart muscle is weakened and cannot pump as effectively as normal.

It was reported that the patient was on a hunting trip when they stumbled in steep terrain, injuring their ankle. After assessing the patient's condition, the ground party paramedics administered morphine intravenously for pain relief and applied an inflatable splint to the patient's injured left ankle. The paramedics recalled that throughout the preparation for the winch, the patient was alert and able to follow instructions.

The patient's autopsy report stated the cause of death as the result of 'multiple injuries sustained in a fall from a height'. The report concluded that it was not possible to determine the reason for the patient's reported unresponsive episode during the winch, with sudden cardiac arrhythmia, hypoxia or a vasovagal syncope (fainting) all possible.

Meteorological information

The weather at the time was reported to be fine with no cloud along the flight path or in the vicinity of the winching area. The pilot reported a light north-westerly wind of about 10 to 15 kt (19 to 28 km/h) in the area, with no noticeable turbulence in the hills. Photographs and video imagery taken at about the time of the accident showed the sky was clear of cloud.

Aircraft information

The 412 is a medium-sized, single main rotor and tail rotor helicopter powered by two turbine engines. The helicopter has skid-type landing gear.

VH-VAS was equipped with an electrically-powered rescue winch that was fitted on the right of the helicopter, adjacent to the rear cabin. The winch had a maximum allowable lifting weight of 272 kg, a usable cable length of 258 ft (78.64 m) and a cable winching and lowering speed that varied between 45 and 74.4 m/min, depending on the weight on the cable. The weight on the cable at the time of the accident was at least 34 kg below the maximum allowable.

A review of the helicopter's documentation confirmed that the helicopter had a current maintenance release at the time. In addition, all of the required maintenance had been completed on the helicopter and winch.

Winching role equipment

The helicopter operator regularly used various types of Civil Aviation Safety Authority (CASA)-approved winching rescue equipment that were similar to those commonly used by other helicopter emergency medical service (HEMS) operators in Australia and internationally. This included use of the rescue harness, stretcher, rescue strop and rescue strop with hypothermic strap as discussed in the following sections.

Rescue harness

The rescue harness is a full-body harness worn by the helicopter ACM, the ARC and, in some situations, the person being retrieved (Figure 4). The harness is designed to provide a secure, comfortable lift for the occupant and is available in various sizes. At the time of the accident, spare harnesses were not carried on board the helicopter as standard retrieval equipment for patients. Although the ARC's harness could have been used for a patient during a single-person lift, the ARC's harness would not have fitted the patient on this occasion.

Figure 4: Rescue harness



Source: Safety Equipment Technical Services Pty Ltd

Stretcher

The stretcher allows a patient to be carried securely while flat on their back (Figure 5). In order to counteract the tendency of stretchers to spin under a helicopter’s rotor wash, a trained person on the ground uses a stabilising rope (tag line) attached to the stretcher. Stretcher use in confined areas is limited by the size of the stretcher and the possibility of it, and the tag line, fouling on obstacles such as trees.

Figure 5: Stretcher double-lift using a tag line



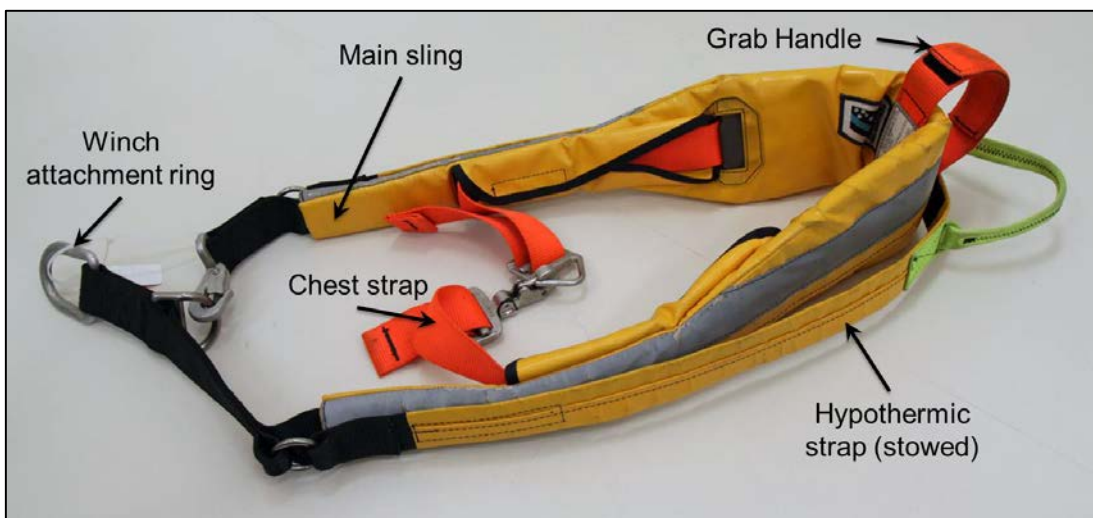
Source: Westpac Life Saver Rescue Helicopter-Lismore, New South Wales

Rescue strop

The rescue strop (Figure 6), which was manufactured by Safety Equipment Technical Services Pty Ltd, is a padded strap designed to fit around the back and under the arms of the person being winched. A chest strap is incorporated to assist in maintaining the person's winch position. The manufacturer produced a manual detailing the operating instructions, limitations and maintenance requirements for the rescue strop. There were no weight or size limitations associated with its use.

The operator's operations manual specified that, in a single-lift application, the rescue strop was typically only to be used to rescue trained or pre-briefed personnel who were physically able to keep themselves in the strop (see the section titled *Guidance for rescue equipment selection*). Single-lift of untrained personnel using the strop was to be avoided unless there was no practical alternative. The preferred method for lifting untrained people with a rescue strop is the double-lift method, which involves an ARC accompanying the patient on the winch wire up to the helicopter.

Figure 6: Rescue strop



Source: ATSB

Rescue strop with hypothermic strap

The rescue strop with a hypothermic strap, sometimes termed a double sling, is a strop with the addition of a (hypothermic) strap that goes under the patient's knees, keeping them in a seated position (Figure 7). It was originally designed for rescuing people who had been immersed in cold water for a period of time, but is also applicable for use in a range of other situations. The hypothermic strap assists in preventing blood rushing to the lower extremities during a winch, which could result in a loss of consciousness. The rescue strop that was used on the day of the accident incorporated a hypothermic strap stowed under a cover in the main sling.

The rescue strop with hypothermic strap is fitted by slipping the hypothermic strap under the person's knees and passing the strop around the person's chest. If required, the strop can be unlatched at the D-ring directly under the winch attachment ring to assist with passing the strop around the person's chest (Figure 6).

Figure 7: Rescue strop with hypothermic strap deployed



Source: Safety Equipment Technical Services Pty Ltd

Strop examination

The ATSB conducted a detailed examination of the rescue strop used for the winch. The strop's label indicated that it had a service expiry date of 28 December 2020. The strop was dimensionally correct in accordance with the manufacturing data and the webbing width dimensions were greater than the minimum requirements.

The rescue strop was maintained in accordance with the manufacturer's maintenance schedule. The required maintenance was confirmed to have been completed with no defects identified.

All of the strop's components appeared to be in good condition with no evidence of component failure. There was no significant fraying of any of the webbing or stitching and no significant wear on the attachment hardware or the main sling cover.

The chest strap hardware was examined and found to be serviceable. The chest strap extension dimension at the time of the winch could not be determined due to movement of the strap in the adjustment buckles when the strap was not under load. When under load, it was confirmed that the chest strap retained its set length.

Research and testing of rescue equipment

Research on helicopter winching equipment

Effect of being winched on breathing and heart/circulatory function

In November 1995, a rescue helicopter in Norway was dispatched to a fishing boat to rescue a fisherman who was experiencing a severe asthma attack. The patient refused to lie down and was therefore retrieved with a rescue strop. During the 20 to 30 second winch procedure, the patient lost consciousness but was brought into the aircraft cabin and subsequently revived.

Following the incident, Haagensen and others (1998) compared the lung ventilatory capacity⁶ of 12 healthy male subjects who were suspended in a rescue strop, a rescue strop with hypothermic strap or in a stretcher. Ventilatory capacity was found to be significantly reduced amongst the participants in all lifting techniques as compared to the standing position. The rescue strop was

⁶ Total volume of air inspired (or inhaled) and expired from the lungs.

assessed by 10 of the 12 participants as having the most adverse effect on their breathing capacity.

The researchers concluded that the reduction in ventilatory capacity would be easily tolerated by healthy individuals, but should be considered when planning to winch patients with severe respiratory problems. They also noted that an unconscious patient can slip out of either a rescue strop or a rescue strop with hypothermic strap, and that therefore patients at risk of losing consciousness should be hoisted in a stretcher.

Following an accident during training when a young solidier was left suspended in a rescue strop unobserved for 6 minutes and subsequently died, Madsen and others (1998) examined the effects of being suspended in a rescue strop with hypothermic strap for nine healthy adult subjects ranging in weight from 71 to 82 kg. Eight of the subjects displayed increases in mean arterial pressure and heart rate, but were able to remain suspended for up to 60 minutes. One subject experienced presyncopal symptoms (see the section titled *Research in the climbing and other related industries*) and was taken down after 50 minutes.

Murphy and others (2011) noted that current winch rescue methods have significant limitations, 'including the potential for cardiorespiratory compromise due to direct chest compression and/or posture'. They compared the effects on 27 healthy adult subjects in Australia ranging in weight from 45 to 106 kg of being suspended in a rescue strop, rescue strop with hypothermic strap, a rescue stretcher and a rescue basket (Figure 8). The researchers measured forced expiratory volume in 1 second (FEV1)⁷, forced vital capacity (FVC)⁸, FEV1/FVC ratio, inspiratory capacity (IC)⁹ and heart and respiratory rates. These measurements were compared to those when in a normal seated position.

The rescue strop was associated with significant decreases in FEV1, FVC and IC and significant increases in heart and respiratory rates. The rescue strop with hypothermic strap and the stretcher resulted in decreases in FEV1 and FVC, but much less than those for the rescue strop and. no significant variations of heart and respiratory rates were observed. The rescue basket had no influence on any of these parameters. The researchers concluded that further caution was required regarding the use of the rescue strop and that the use of the rescue strop with hypothermic strap was a more benign alternative.

⁷ Forced expiratory volume (FEV) measures how much air a person can exhale during a forced breath. The amount of air exhaled may be measured during the first (FEV1), second (FEV2) and/or third seconds (FEV3) of the forced breath.

⁸ Forced vital capacity (FVC) is the total amount of air exhaled during the FEV test.

⁹ Inspiratory capacity is the volume of air that can be taken into the lungs in a full inhalation.

Figure 8: Rescue basket



Source: Travis County STAR Flight

Winching via rescue strop and seat-type harness – a comparison

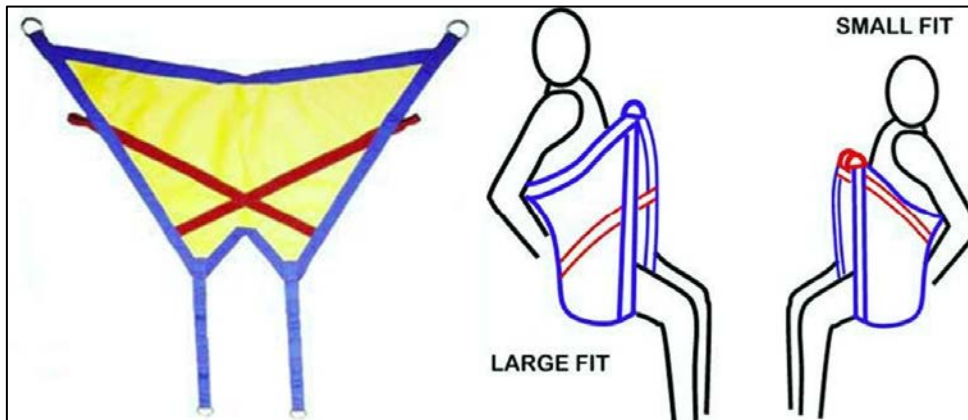
Kempema (2011) reported on research conducted by a rescue helicopter operator in the United States. The research compared the use of two types of rescue strops (one known as a cinch collar) and a seat-type harness (Figure 9), and involved 23 healthy volunteers who were winched a short distance off the ground for about 4 minutes. A number of the participants' resting statistics, including heart rate and blood pressure, vital capacity, FEV and peak flow, were compared to those after 1- and 3-minute periods suspended in the respective rescue equipment.

The seat-type harness was considered by the participants the most comfortable, and had minimal physiological effects. Both of the rescue strop devices caused dramatic increases in heart rate and blood pressure and a significant restriction in extremity circulation. These devices also resulted in a significant decrease in vital capacity, FEV and peak flow amongst the participants and consistently had very high pain scores. Several of the participants could not tolerate more than 3 to 4 minutes suspended in each device.

In discussing the Kempema research, Krussow (2012) stated:

Lifting a body by a strap around the chest and back forces the victim into a very uncomfortable and tiring position. It quickly begins reducing the amount of air a patient is able to exchange, and can significantly reduce his or her ability to breathe. This negative effect is exaggerated in larger or obese victims. And for those victims who are already suffering from a physiological condition or impact such as low blood pressure, hypothermia, shock or a heart-related illness the added insult of suspending them in a cinch-type device may quickly cause their condition to worsen significantly.

Figure 9: Seat-type harness



Source: Travis County STAR Flight

Research in the climbing and other related industries

There has been concern over the years in climbing and industries such as construction about the adverse health effects of being suspended in different types of harnesses for a prolonged period after a fall, with terms such as ‘suspension trauma’ being widely used. As described by Adishes and others (2009):

In ... a number of published articles, suspension trauma was used to describe the situation of a person falling into suspension on a rope and then becoming unconscious. In this scenario the loss of consciousness is not due to any physical injury but rather it is thought that orthostasis, motionless vertical suspension, is responsible. “Trauma” is therefore an inappropriate epithet, which may be better replaced by the descriptive term “syncope”.

Syncope is the sudden transient loss of consciousness and postural tone with spontaneous recovery. The causes of syncope can be classified as vascular: resulting from changes to blood vessels or their reflex responses, cardiac: relating to structural abnormalities of the heart or to changes in its rhythm, neurological: conditions such as migraine or seizures, metabolic: due to ingested or other toxicants e.g. drugs or alcohol and including abnormalities of biochemistry, psychogenic: anxiety, panic and somatisation disorders, and finally, syncope of unknown origin.

Syncope occurring with vertical suspension is principally related to the motionless state... Pooling of blood in the gravitationally dependent legs leads to the clinical state described as orthostasis... This may produce symptoms such as light-headedness; nausea; sensations of flushing; tingling or numbness of the arms or legs; anxiety; visual disturbance; or faintness. This state is often referred to, as “presyncope” i.e. if some postural or physiological correction does not take place syncope will consequentially follow. In suspension with some types of chest harness the discomfort caused may lead to increased pressure within the chest cavity further reducing venous blood return...

The term “suspension syncope” or indeed “suspension presyncope” does not therefore assume that any one pathological mechanism is responsible for the loss of consciousness or symptoms occurring in suspension and acknowledges that multiple factors may operate.

Seddon (2002) reviewed the research literature on the health effects of being suspended in different types of harnesses. The review discussed several studies since the 1970s that found that being suspended in a harness or rope around the chest led to discomfort or adverse effects much quicker than suspension in a full body harness.

Roeggla and others (1996) noted that although training institutions recommended the use of a chest harness only in combination with a sit harness, many mountain climbers still only used a chest harness. The researchers compared the effects of being suspended in a chest harness versus a sit harness. No adverse effects were identified with suspension in a sit harness but, after 3 minutes in a chest harness, subjects demonstrated significant decreases in FVC, FEV and cardiac output, and significant increases in heart rate and blood pressure. It was noted that the changes in respiratory parameters were induced by restriction of the chest and possibly to

diaphragm motion. Similarly, the changes in blood pressure and cardiac output could be explained by the elevation of intrathoracic pressure as a result of the chest harness.

Role equipment testing

Previous research has examined the effect of different rescue equipment on healthy subjects in a normal weight range. The ATSB examined the effects of being suspended in the rescue strop that was used for the patient recovery on the day, including on a subject with a similar weight as the patient.

Trials were conducted involving three subjects weighing 65 kg, 80 kg and 140 kg respectively. Each subject was suspended from a gantry in a laboratory environment in the rescue strop only and in a rescue strop with hypothermic strap. The trials were repeated with each subject wearing a shirt and then donning a synthetic jumper similar to that worn by the patient. Results for the rescue strop and rescue strop with the hypothermic strap are detailed in Table 1.

The rescue strop was considered by all three subjects to be the most uncomfortable. Use of the hypothermic strap improved user comfort and breathing, as well as increased the time the subjects could tolerate being in the equipment. All subjects noted that the chest strap on the rescue strop loosened as their weight was being taken and that the strop naturally repositioned during the lifting process. All the subjects reported that it was difficult and took considerable effort to keep their arms low and hands clasped when in a vertical lift in the rescue strop. Once their arms were raised, whether deliberate or through fatigue, it was almost impossible to lower them.

Without a hypothermic strap, the 65 kg and 80 kg subjects could only slip out of the strop when they lifted their arms while wearing a synthetic jumper. The 140 kg subject could slip out easily wearing a shirt but only with their arms lifted. In all cases, the subjects were secure with their arms held down.

During the trial it was found that pulling the rescue strop grab handle (Figure 6), as would be done by the ACM to assist a person into the helicopter, altered the position of the strop around the subject's shoulder blades. This increased the risk of slipping out of the strop.

The ARC's full body harness was also trialled on the 80 kg subject. The subject reported that the harness was very comfortable and that they were able to breathe normally when suspended.¹⁰ The harness could not be trialled with the 140 kg subject as it would not fit.

¹⁰ The 65 kg subject had previous experience wearing the harness and reported a similar level of comfort in those cases as reported by the 80 kg subject in this trial.

Table 1: Rescue strop trial summary¹¹

	65 kg subject		80 kg subject		140 kg subject	
	Strop	With hypothermic strap	Strop	With hypothermic strap	Strop	With hypothermic strap
Ability to hold arms down	Achieved with difficulty.	Easier.	Achieved with difficulty.	Easier.	Struggled to keep arms down. A lot of pressure under the arms and around the chest area.	Started getting 'tingling' in finger tips after 1 minute 30 seconds but able to keep hands clasped.
Breathing	Breathing was affected making it hard to keep arms down.	Much easier, only a little restricted.	Unrestricted.	Unrestricted.	Breathing was laboured and developed 'shakes'.	Breathing easier but became laboured towards end of trial.
Comfort	Fingers were 'tingling'.	Significantly reduced pressure under the armpits.	After 90 seconds arms started 'tingling'.	Pressure across back of knees.	Incredibly uncomfortable after 15 seconds, and shoulder cramp after 30 seconds.	Significantly more comfortable, some pressure under the legs and across top of knees.
Time able to be maintained in equipment	121 seconds.	No effort required, trial terminated after 110 seconds as the subject reported no effect from securing the strap.	165 seconds.	No effort required, trial terminated after 150 seconds as the subject reported no effect from securing the strap.	40 seconds.	Less effort required, trial terminated after 120 seconds.
Security in equipment (wearing shirt)	Lifted arms, no slippage. Chest strap lost tension as soon as person lifted.	No slippage with and without chest strap secured. Wriggling had no effect. Physically had to bring arms inside rescue strop to promote slippage.	Lifted arms, no slippage. Chest strap lost tension as soon as person lifted.	No slippage with and without chest strap secured. Wriggling had no effect. Physically had to bring arms inside rescue strop to promote slippage.	Lifted arms, slipped out easily. Chest strap lost tension as soon as person lifted.	No slippage with and without chest strap secured. Wriggling had no effect. Had to bring arms inside rescue strop to promote slippage, and then slipped very quickly.
Security in equipment (wearing synthetic jumper)	Lifted arms, easier to slip out.	Not tested.	Lifted arms, slipped out in less than 7 seconds.	Not tested.	Lifted arms, slipped out very easily.	No slippage with and without chest strap secured. Wriggling had no effect. Had to bring arms inside rescue strop to promote slippage, and then slipped very quickly.

¹¹ Unless otherwise annotated, all testing was done with the chest strap secured.

Organisational and management information

Contractual arrangements

The helicopter operator owned and operated a number of helicopters throughout Australia on various contracted tasks, including the HEMS role in six locations. In addition to Victoria Police, it was one of two commercial operators that provided helicopter emergency medical transport services for Air Ambulance Victoria. One helicopter (HEMS 5) was provided as part of this contract, which commenced operations in March 2009.

Under the contract the operator provided the helicopter, pilots, ACM and maintenance personnel. The operator also trained selected Air Ambulance Victoria paramedics in the ARC role and the use of the winch equipment.

Guidance for rescue equipment selection

The selection of the appropriate rescue equipment in a given situation is a function of operational and clinical considerations. The decision involves technical input from the helicopter crew and consideration of the ARC's on-ground clinical assessment of the patient. The following sections discuss the helicopter operator and Air Ambulance Victoria guidance as it applied to the patient recovery at Macs Cove.

Helicopter operator's operations manual

The operator's operations manual detailed the specific items of rescue equipment available to its helicopter crews for land and water rescue and retrieval situations. A detailed description was provided for each item, together with information regarding their use. The manual also detailed the order in which patients, rescue personnel and equipment were to be recovered in a retrieval situation. However, the manual provided limited information on the preferred hierarchy for using different types of rescue equipment.

The manual stated that a double-lift was the '...preferred method of recovering survivors from water, life raft, vessel and over land hoists'. It also stated that

If a single lift is to be conducted and a harness is available, the person being winched should be harnessed and attached to the hook via the harness. The use of the rescue strop [in a single lift] is typically used for the rescue of trained or pre-briefed personnel (military applications), who are physically able to keep themselves in the strop. Single winching of untrained personnel using a rescue strop is to be avoided unless there is no other practical alternative.

The section on the use of a strop with hypothermic strap stated:

The use of the hypothermia strop is a lift technique that maintains the survivor in the sitting position while being recovered to the aircraft and is used when personnel in the water are suspected of having hypothermia or have been in the water for a considerable period of time.

The hypothermia strop should be used as a matter of course when recovering unfamiliar or untrained people using the rescue strop alone in a single lift. The rescue strop safety belt should be used whenever practicable.

The manual also provided detailed information about the requirements for using stretchers. In discussing when to use a stretcher, it stated:

When a survivor is injured or unconscious and conditions permit, a stretcher lift should be carried out... To optimise patient care the preferred method of recovering the stretcher is with a double lift using a tag line...

The operator provided its ARC and ACM with regular training in the use of the available items of rescue equipment using a winch simulator and in the helicopter. Currency checks were required for ARC personnel every 3 months for a double-lift with the rescue strop with hypothermic strap and every 6 months for single- and double-lifts with the stretcher.

Air Ambulance Victoria

Air Ambulance Victoria also provided instructions and guidance material for application in the ARC role. However, at the time of the accident, none of these instructions or guidance material discussed when it was appropriate to use the rescue strop versus the rescue strop with hypothermic strap.

Winching statistics

A review of Air Ambulance Victoria patient winch extraction data identified 96 patient extractions by the organisation between November 2010 and August 2013. Of these, 52 were conducted via stretcher, 37 involved double-lifts using a rescue strop with hypothermic strap (35 over land and two over water), and seven double-lifts were carried out using a rescue strop (three over land and four over water). Helicopter HEMS 5 was used during 15 of these extractions, including 10 stretcher lifts, three winches using a rescue strop with hypothermic strap (all over land) and two winches using a rescue strop (both over land).

Previous occurrences

Air Ambulance Victoria reported that it had been conducting winching operations using rescue strops for about 30 years. It was not aware of any similar accidents involving the use of a rescue strop.

There have been several winching accidents in Australia since 1986, none of which were similar to that involving VH-VAS (see appendix A). Additionally, a review of worldwide winching accidents did not identify any that were similar to this accident.

Safety analysis

Introduction

Following a combined clinical/operational assessment of the injured patient and the surrounding terrain, the decision was made to recover them in to the helicopter using a double-lift winch procedure. This involved winching the patient in a rescue strop while being assisted by the ambulance rescue crewman (ARC) in a separate harness. During the winch, the patient became increasingly unresponsive and started slipping down in the rescue strop. As the patient was winched to the rear door of the helicopter, and despite the efforts of the ARC and the air crewman (ACM) to manually retain the patient, the patient slipped out of the rescue strop and fell to the ground.

The rescue winch, strop and related equipment were serviceable and there was no technical failure of any of the equipment. The rescue crew were appropriately qualified for the flight and were experienced in using all of the available equipment.

Helicopter winching is an essential role for emergency medical services. Accidents during helicopter winching are rare, and a worldwide search of occurrence data found no previous instances of this type of accident.

This analysis will examine the circumstances that led to the patient becoming unresponsive and slipping from the rescue strop and discuss a number of issues concerning the selection of rescue equipment.

Loss of consciousness

The ARC and ACM stated that towards the end of the winch the patient became unresponsive and limp and was not attempting to hold on. Based on these observations, it seems almost certain that the patient had become unconscious or incapacitated.

Research has shown that a rescue strop, or similar equipment such as a chest harness, can affect respiratory and cardiac function even on healthy subjects. Demonstrated effects include a significant reduction in ventilatory capacity, increased breathing difficulty, increased heart rate and decreased blood pressure.

In support of their own investigation of this accident, the Victorian Coroner requested an emergency medical physician, with significant experience of helicopter winching techniques, to review the available medical evidence. The physician concluded that:

...the overwhelming likelihood is that [the patient] lost consciousness due to the effect on his respiratory and cardiac function from use of a single strop technique resulting in thoracic compression and vascular collapse. This was significantly exacerbated by his underlying comorbidities of morbid obesity and congestive cardiac failure which could have both amplified the compressive effect and reduced his ability to compensate for the predictable physiological changes associated with this rescue technique.

The ground party paramedics administered a quantity of morphine to the patient that they considered consistent with the level of injury and the patient's weight. Based on reports that the patient appeared alert and stable for a significant period after it was administered, the forensic pathologist that undertook the patient's post-mortem concluded that the dosage of morphine was unlikely to lead to a loss of consciousness.

Overall, the compressive effect of the rescue strop, combined with the patient's pre-existing medical conditions, was considered much more likely to have resulted in the loss of consciousness than from the effects of the morphine. The physical effort required by the patient to keep their arms down may have compounded the situation.

Research and testing by the ATSB identified that if a rescue strop is used without the hypothermic strap fitted, it is essential that the patient keeps their arms down by their sides and is conscious, fit and able to maintain their arms in such a position. Loss of consciousness by the patient increases the risk of their sliding down and out of the strop, even if they have the chest strap secured.

Rescue equipment selection

Prior to arrival at the winch area, the helicopter crew were briefed on the situation by the ground party, including an assessment/update of the patient's condition. Due to the steep terrain and injury sustained by the patient, it was decided that a winch extraction was the best method for retrieving the patient. The crew deemed that a stretcher extraction was not suitable due to the risk of fouling on the surrounding trees and elected to use the rescue strop in combination with a double-lift procedure.

The rescue strop could have been used with or without the integral hypothermic strap. However, the patient was sitting on sloping terrain, and the ARC reported that this would have made it difficult to fit the hypothermic strap. They also did not consider that the hypothermic strap was necessary on this occasion. In this respect, it was reported that the strop fitted the patient and that they were alert, co-operative and understood the relevant instructions. Another of the operator's ARCs reported that they also would not have used the hypothermic strap, as it would have made it more difficult for an ARC to keep the patient's arms down. They also thought it would have made the lift unstable with someone the same weight as this patient.

Each type of rescue equipment has advantages and disadvantages for different situations, and no type of equipment would be suitable in all situations. However, research has consistently shown that a rescue strop with hypothermic strap is more comfortable for patients, is able to be tolerated for longer periods and has less adverse effects on the patient's respiratory and cardiovascular systems. Separately, ATSB testing found that it was easier for patients to keep their arms down when the hypothermic strap was being used. Although an unconscious patient would still be at risk of falling out of the strop with hypothermic strap, the use of a hypothermic strap would appear to significantly reduce the potential for a patient to become unconscious during winching, before in turn slipping from that strop.

The operator's ARCs received regular training in the use of all the available items of rescue equipment, including the rescue strop with hypothermic strap. In addition, assistance was available to the ARC from ground personnel to move the patient if required to fit the strap. However, the ARC had never encountered a patient of the size and build of this patient and was unaware of the research demonstrating the adverse physiological effects on patients associated with the different types of rescue equipment. The operator also advised that there was limited awareness within its rescue personnel of the physiological effects of the use of the different types of equipment and the potentially compounding effect of patient build.

Progress of the winch procedure

As previously noted, it is essential when using a rescue strop that the patient's arms are kept by their side to prevent slippage from the strop. From the initial stages of the winch procedure, video footage showed that the patient's upper arms were displaced away from their body and that the patient was resting quite low in the rescue strop. Compounding the developing situation, the progress of the winch was delayed in the initial stages due to the need to avoid trees during the ascent.

In order to mitigate the slippage risk, the usual practice was for the ARC to hold down the patient's arms once in the rescue strop. The ARC was observed doing this; however, there were times during the winch when the ARC's attention was drawn to maintaining separation from tree branches as they ascended through the tree canopy. This required the ARC to remove their hands from the patient and fend off the branches. Once clear of the canopy, the ARC placed their hands back on the patient's arms.

Although the crew would not have anticipated the initial delay in the winch due to the tree canopy, the patient's early difficulty keeping their arms down could have suggested discontinuing the winch and exploring other options. Alternately, had the trees not been an issue and the ARC been able to focus on maintaining the position of the patient's arms, the accident may not have occurred.

In the event, when about 15 ft from the helicopter, the ARC observed the patient's apparent discomfort. However, the ARC later stated that it was not unusual for patients to be uncomfortable in the strop. Of note, by this stage of the winch the patient was about 60 ft above the ground, and the ACM considered that continuing the winch and getting the patient into the helicopter represented less risk than lowering the patient back to the ground. Given the patient's proximity to the helicopter, the significant distance from the ground and the likely similar difficulty and associated additional time getting the patient back to the ground, it would appear this was a reasonable decision.

Rescue equipment hierarchy of use

The operator and Air Ambulance Victoria both noted that there was no one item of rescue equipment to suit all patient extractions. The most suitable rescue equipment was selected on the basis of mission safety and in consideration of the limited storage space available within the helicopter. Once a winch was confirmed as the best option for the patient extraction, and the crew (which included air ambulance personnel) had evaluated the winching site and patient condition, they would select the most suitable item of equipment for the retrieval.

Prior to the accident, the operator and Air Ambulance Victoria provided limited guidance to crews about the order of priority in the use of rescue equipment for patient winch extraction. The helicopter operator's procedures stated that, where conditions permitted, a stretcher lift was preferred for an injured patient. However, there was no guidance on the relative merits, or priority, of the rescue strop with or without the hypothermic strap for over land rescues. Similarly, Air Ambulance Victoria instructions and guidance material provided no advice on the appropriateness of the use of the rescue strop as compared to the rescue strop with hypothermic strap.

Discussions with other helicopter emergency medical service (HEMS) operators identified that, prior to the accident, some did have documented guidance on the hierarchy of use of their rescue equipment. However, these operators have since revised their guidance to clarify the priority of use.

In addition, there appeared from those discussions to be varying levels of knowledge within the HEMS industry of the research into the physiological effects of using different types of rescue equipment. This knowledge could, if more widely known, influence crew selection of the most suitable piece of equipment for an extraction, and be included in relevant training activities. However, in general, operators, including the operator of VH-VAS, preferred the use a rescue strop with hypothermic strap in preference to using a rescue strop without a hypothermic strap. However, the decision of which equipment to use also had to take into account the clinical and operational circumstances.

Since the accident, the operator has initiated significant discussion amongst its personnel about the different rescue techniques. There have also been increased efforts to communicate between different HEMS operators regarding these techniques, the equipment available, lessons learnt, the research into the physiological effects of using different types of rescue equipment and a general discussion of their operational environments. Such communication increases the likelihood that all operators employ best-practice winch rescue techniques and equipment in the provision of this essential community service.

Findings

From the evidence available, the following findings are made with respect to the helicopter winching accident involving Bell Helicopter Co. 412EP, registered VH-VAS that occurred 19 km south-south-east of Mansfield, Victoria on 31 August 2013. These findings should not be read as apportioning blame or liability to any particular organisation or individual.

Safety issues, or system problems, are highlighted in bold to emphasise their importance.

A safety issue is an event or condition that increases safety risk and (a) can reasonably be regarded as having the potential to adversely affect the safety of future operations, and (b) is a characteristic of an organisation or a system, rather than a characteristic of a specific individual, or characteristic of an operating environment at a specific point in time.

Contributing factors

- During the winch retrieval the patient probably lost consciousness due to the compressive nature of the rescue strop around their chest, possibly compounded by the patient's weight and pre-existing medical conditions.
- The use of a rescue strop, without employing the integral hypothermic strap, was not suitable for the patient's size and medical condition and, following their loss of consciousness, contributed to the patient falling from the strop.
- **Limited guidance was provided by the operator and Air Ambulance Victoria to crews on the selection of the most appropriate winch rescue equipment given operational and medical considerations. [Safety issue]**

Other findings

- The rescue equipment used for the winch procedure was serviceable at the time.

Safety issues and actions

The safety issue identified during this investigation is listed in the Findings and Safety issues and actions sections of this report. The ATSB expects that all safety issues identified by the investigation should be addressed by the relevant organisation(s). In addressing those issues, the ATSB prefers to encourage relevant organisation(s) to proactively initiate safety action, rather than to issue formal safety recommendations or safety advisory notices.

All of the directly involved parties were provided with a draft report and invited to provide submissions. As part of that process, each organisation was asked to communicate what safety actions, if any, they had carried out or were planning to carry out in relation to each safety issue relevant to their organisation.

Limited documented guidance for rescue equipment selection

Number:	AO-2013-136-SI-01
Issue owner:	Australian Helicopters
Operation affected:	General aviation – aerial work
Who it affects:	Operators carrying out winching operations

Safety issue description:

Limited guidance was provided by the operator and Air Ambulance Victoria for to crews on the selection of the most appropriate winch rescue equipment given operational and medical considerations, and the conditions when various types of equipment should be considered.

Proactive safety action taken by Australian Helicopters

Action number: AO-2013-136-NSA-010

Immediately after the accident the operator suspended all winching operations pending their initial investigations. Following that investigation and an associated risk assessment, winch operations were recommenced.

An interim investigation report was published by the operator with associated safety action. That action included reinforcing the need to critically assess a patient’s physical and medical state and any associated risks before committing to using the rescue strop without utilising the hypothermic strap.

On 5 September 2013, the operator issued an Immediate Safety Notification to its air crewmen, rescue crewmen and pilots. The notice promulgated an order of priority use of rescue equipment for application in over land winch operations. The order of priority, in decreasing priority of use was to use the harness, followed by the stretcher, rescue strop utilising the hypothermic strap with the chest strap connected and then the rescue strop with the chest strap connected.

On 12 November 2014, the operator provided further advice of safety action taken within their organisation. This included, in conjunction with Air Ambulance Victoria, enhancing the existing on-scene patient assessment for possible recovery by rescue strop to include:

- Patient weight and weight distribution,
- Height of [the] potential winch in light of patient fitness/strength, weight and weight distribution, and
- Patient medical contraindications, specifically conditions that may adversely affect Heart Rate, Respiratory Function and/or ability to maintain consciousness.

Also in conjunction with Air Ambulance Victoria, the operator commenced the introduction of, and training for a Civil Aviation Safety Authority (CASA)-approved aviation rescue vest (seat-type harness).

Proactive safety action taken by Air Ambulance Victoria

Action number: AO-2013-136-NSA-012

Following the accident at Macs Cove, all winching operations involving Air Ambulance Victoria emergency medical service (EMS) helicopters were suspended. This suspension remained in place until the operator’s interim investigation report confirmed that an equipment fault did not contribute to the accident.

In addition, Air Ambulance Victoria, in conjunction with its EMS contractors, commenced a separate investigation that examined the availability of suitable alternatives to the current rescue/retrieval strop.

On 5 May 2014, Ambulance Victoria issued a Service Improvement System notice to its mobile intensive care ambulance Flight Paramedics. The notice provided guidance on the preparation and conduct of over land winch training and operations and an order of priority use of rescue equipment for application in over land winch operations. The notice also included the requirement for an ‘operational pause and reassessment’ to re-affirm the plan and necessity for the winch operation.

On 29 September 2014, Air Ambulance Victoria, in conjunction with Australian Helicopters, commenced the introduction of, and training for a CASA-approved aviation rescue vest (seat-type harness).

Proactive safety action taken by CASA

Action number: AO-2013-136-NSA-011

On 15 October 2013, CASA issued Airworthiness Bulletin (AWB) 25-025 to 'clarify use and application of Rescue/Retrieval Strops'. The AWB stated:

Rescue Strops were originally designed for retrieval of persons from the water in rescue situations. They were designed as an alternative to using 3 or 5 point harnesses which are problematic to don in a water environment. A separate version was developed to lift persons who may be suffering hypothermia.

A Rescue strop (excluding the Hypothermic version) requires the occupant to be conscious and compliant, and requires active participation from the occupant to ensure safe use. The occupant must follow directions correctly from a trained operator throughout the winch.

and recommended:

As a Rescue Strop requires active participation by an occupant who is not formally trained in its use and may likely be in a highly stressful situation, the following points should be considered prior to use of the strop:

- 1) whether life is at imminent risk;
- 2) the state of the person to be winched, particularly whether the rescuee will remain conscious and coherent during the winch process;
- 3) the potential for the person to remain compliant with winching brief;
- 4) alternative methods and devices to recover the person; and
- 5) whether the risk of falling from the device would not result in further serious injury or death.

Safety action taken by the ATSB

Action number: AO-2013-136-SAN-004

As part of its preliminary investigation report of 10 October 2013, the ATSB issued the following safety advisory notice to helicopter emergency medical service operators and other operators carrying out winching operations:

The Australian Transport Safety Bureau advises helicopter emergency medical service and other operators carrying out winching operations to note the circumstances of this accident and consider the implications for their operations of the risk of patients or other persons being winched to slip out of a rescue/retrieval strop. In this context the size, weight and medical condition of the person(s) being winched may indicate that other recovery options offer reduced risk.

Current status of the safety issue

Issue status: Adequately addressed

Justification: The ATSB is satisfied that the relevant organisations have taken appropriate safety action to address this safety issue. In addition, safety advisory information has been issued to other organisations conducting similar activities.

General details

Occurrence details

Date and time:	31 August 2013 – 1232 EST	
Occurrence category:	Accident	
Primary occurrence type:	Operational	
Location:	19 km south-south-east of Mansfield, Victoria	
	Latitude: 37° 12' 32.82" S	Longitude: 146° 09' 43.38" E

Aircraft details

Manufacturer and model:	Bell Helicopter Co 412EP	
Year of manufacture:	2008	
Registration:	VH-VAS	
Serial number:	36504	
Total Time In Service	3,357.7 hours	
Type of operation:	Aerial work –helicopter emergency medical service	
Persons on board:	Crew – 3	Passengers – 1
Injuries:	Crew – Nil	Passengers – 1 (Fatal)
Damage:	None	

Sources and submissions

Sources of information

The sources of information during the investigation included:

- the flight crew of the helicopter
- the operator of the helicopter
- Air Ambulance Victoria
- an independent helicopter emergency medical service (HEMS) specialist physician
- Victoria Police and Coroner
- a number of other HEMS operators.

References

Adisesh, A Robinson, L Codling, A Harris-Roberts, J Lee, C Porter, K 2009, 'Evidence-based review of the current guidance on first aid measures for suspension trauma', *Health and Safety Executive, UK*, research report RR708.

Haagensen, RE Sjöborg, KA Mjelstad, S Steen PA 1998, 'Lung function during hoist rescue operations', *Prehospital and Disaster Medicine*, vol. 13, pp. 73-76..

Kempema, J 2011, 'Physiological responses to air rescue hoist devices', *Waypoint Airmed and Rescue Magazine*, p. 22.

Madsen, P Svendsen, L Jørgensen, L Matzen, S Jansen, E Secher, N 1998, 'Tolerance to head-up tilt suspension with elevated legs', *Aviation, Space, and Environmental Medicine*, vol. 69, pp. 781-784.

Murphy, D Garner, A Bishop, R 2011, 'Respiratory function in hoist rescue: comparing slings, stretcher, and rescue basket', *Aviation, Space, and Environmental Medicine*, vol. 82, pp. 123-127.

Roeggla, M Brunner, M Michalek, A Gamper, G Marschall, I Hirschl, M Laggner, A Roeggla, G 1996, 'Cardiorespiratory response to free suspension simulating the situation between fall and rescue in a rock climbing accident', *Wilderness and Environmental Medicine*, vol.2, pp. 109-114.

Seddon, P 2002, 'Harness suspension: review and evaluation of existing information', *Health and Safety Executive, UK*, contract research report 451/2002.

Submissions

Under Part 4, Division 2 (Investigation Reports), Section 26 of the *Transport Safety Investigation Act 2003* (the Act), the ATSB may provide a draft report, on a confidential basis, to any person whom the ATSB considers appropriate. Section 26 (1) (a) of the Act allows a person receiving a draft report to make submissions to the ATSB about the draft report.

A draft of this report was provided to the helicopter crew, the helicopter operator, Air Ambulance Victoria, an independent HEMS specialist physician, the Victorian Institute of Forensic Medicine, the rescue strop manufacturer and the Civil Aviation Safety Authority.

Submissions were received from the helicopter operator, the air crewman, the ambulance rescue crewman and the rescue strop manufacturer. The submissions were reviewed and where considered appropriate, the text of the report was amended accordingly.

Appendices

Appendix A – Previous Australian winching accidents

The ATSB has investigated a number of winching accidents in Australia.¹² A summary of these investigations follows.

ATSB investigation 198601407

On 9 February 1986, a Bell Helicopter Company 205-A1 helicopter was tasked to retrieve a group of five firemen from steeply sloping terrain about 8 km south-west of Falls Creek, Victoria. The helicopter hovered at about 30 ft while the first two men attached themselves to the dual winch hook. They were then raised to the aircraft, followed by the next fireman. The remaining two men then attached themselves to the hook ready to be winched.

The last winch proceeded normally until the men were close to the helicopter's skid-landing gear. At this point the winch cable broke and the men fell to the ground sustaining serious injuries.

An inspection of the cable revealed that it came off one of the hoist's pulleys and jammed. The cable frayed before failing in overload about 4 m from the winch hook. The length of frayed cable was consistent with the dislodgement of the cable from the pulley and ultimate failure occurring on the final winch.

ATSB investigation 199002013

On 14 October 1990, an Aérospatiale SA365-C2 helicopter was hovering at a height of 35 ft about 5 km west of Prospect, New South Wales (NSW). The operation was part of a training exercise to provide a doctor and paramedic with experience in winching procedures.

The doctor, who was suspended on the winch cable, was within 5 ft of the helicopter when there was an uncommanded firing of the explosive winch cable cutter. The cable severed and the doctor fell 30 ft, sustaining serious injuries.

The ATSB found that the cable cutter activated as a result of a short circuit in the winch's electrical system. The short circuit was caused by a blown power resistor in the winch motor circuit, which allowed sufficient current flow in the cable cutter to fire the explosive squib.

ATSB investigation 199403932

On 30 December 1994, an Aérospatiale SA365-C1 helicopter was tasked to evacuate a stretcher patient from a remote site about 55 km south-east of Glen Innes, NSW. This required the helicopter to hover over the site with the pilot and winch operator on board and two paramedics and an aircraft crewman on the ground to attend to the patient.

The patient and a paramedic were winched up first. To stabilise the stretcher during the lift a tagline was attached to the stretcher and the crewman on the ground. The intent was for the paramedic to release the tagline from the stretcher as they approached the door of the helicopter. However, the tagline was not released and, as the helicopter transitioned into forward flight, the ground crewman was lifted from the ground. The ground crewman advised the aircraft crew that the tagline had not released and the pilot returned to the hover as the winch operator released the tagline. The ground crewman fell about 12 m to the ground and sustained back and leg injuries.

The tagline was fitted with an 80 kg 'weak-link'; however, the ground crewman weighed 70 kg with the result that the 'weak-link' did not operate. In addition, the winch operator was required to

¹² All available at www.atsb.gov.au.

ensure that the tagline was disconnected before clearing the pilot to transition into forward flight. In this instance the terrain and position of the stretcher precluded the winch operator from visually checking the tagline.

ATSB investigation AO-2009-068

At about 1500 on 9 November 2009, a Bell Helicopter Company 412 helicopter departed Horn Island Aerodrome, Queensland, to rendezvous with a container ship located about 132 km to the west of Horn Island. The purpose of the flight was to evacuate an ill crew member and transfer them to hospital.

Prior to arrival overhead the ship, the flight crew were advised that the patient would need to be recovered via rescue winch from the ship's forecastle. Approaching overhead the winching area, and as the rescue crew officer and paramedic were lowered by the winch and about 6 m above the deck, the pilot lost sight of the ship. Shortly after, the helicopter began drifting back towards a mast that was located on the forecastle.

Despite assistance from the winch operator to re-establish the hover, the pilot was unable to arrest the helicopter's movement and the winch cable fouled on the foremast while the helicopter continued to drift rearwards. The winch cable separated and the paramedic and RCO fell about 10 m to the ship's deck, seriously injuring both personnel.

ATSB investigation AO-2011-166

On 24 December 2011, an Agusta Westland AW139 helicopter responded to an emergency personal locator beacon in the Budderoo National Park, about 16 km west-south-west of Wollongong Airport, NSW. On locating the emergency beacon, the crew identified a seriously injured person on a rock ledge near the bottom of a waterfall. They assessed that it would not be possible to winch emergency personnel directly to the patient.

In response, the crew landed at a nearby clear area and devised a plan to access and retrieve the patient. Due to the reducing light during the retrieval, the paramedic and patient were inadvertently pulled from the rock ledge as the helicopter was manoeuvred in preparation to lift them out using its winch. The paramedic and patient struck rocks at the base of the waterfall and the paramedic sustained fatal injuries. The patient was subsequently transported to hospital for treatment.

Australian Transport Safety Bureau

The Australian Transport Safety Bureau (ATSB) is an independent Commonwealth Government statutory agency. The ATSB is governed by a Commission and is entirely separate from transport regulators, policy makers and service providers. The ATSB's function is to improve safety and public confidence in the aviation, marine and rail modes of transport through excellence in: independent investigation of transport accidents and other safety occurrences; safety data recording, analysis and research; fostering safety awareness, knowledge and action.

The ATSB is responsible for investigating accidents and other transport safety matters involving civil aviation, marine and rail operations in Australia that fall within Commonwealth jurisdiction, as well as participating in overseas investigations involving Australian registered aircraft and ships. A primary concern is the safety of commercial transport, with particular regard to fare-paying passenger operations.

The ATSB performs its functions in accordance with the provisions of the *Transport Safety Investigation Act 2003* and Regulations and, where applicable, relevant international agreements.

Purpose of safety investigations

The object of a safety investigation is to identify and reduce safety-related risk. ATSB investigations determine and communicate the factors related to the transport safety matter being investigated.

It is not a function of the ATSB to apportion blame or determine liability. At the same time, an investigation report must include factual material of sufficient weight to support the analysis and findings. At all times the ATSB endeavours to balance the use of material that could imply adverse comment with the need to properly explain what happened, and why, in a fair and unbiased manner.

Developing safety action

Central to the ATSB's investigation of transport safety matters is the early identification of safety issues in the transport environment. The ATSB prefers to encourage the relevant organisation(s) to initiate proactive safety action that addresses safety issues. Nevertheless, the ATSB may use its power to make a formal safety recommendation either during or at the end of an investigation, depending on the level of risk associated with a safety issue and the extent of corrective action undertaken by the relevant organisation.

When safety recommendations are issued, they focus on clearly describing the safety issue of concern, rather than providing instructions or opinions on a preferred method of corrective action. As with equivalent overseas organisations, the ATSB has no power to enforce the implementation of its recommendations. It is a matter for the body to which an ATSB recommendation is directed to assess the costs and benefits of any particular means of addressing a safety issue.

When the ATSB issues a safety recommendation to a person, organisation or agency, they must provide a written response within 90 days. That response must indicate whether they accept the recommendation, any reasons for not accepting part or all of the recommendation, and details of any proposed safety action to give effect to the recommendation.

The ATSB can also issue safety advisory notices suggesting that an organisation or an industry sector consider a safety issue and take action where it believes it appropriate. There is no requirement for a formal response to an advisory notice, although the ATSB will publish any response it receives.

Investigation

ATSB Transport Safety Report Aviation Occurrence Investigation

Helicopter winching accident involving Bell Helicopter 412EP, VH-VAS
19 km south-south-east of Mansfield, Vic., 31 August 2013

AO-2013-136

Final – 17 April 2015

Australian Transport Safety Bureau

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