Equipment and Procedures for Evacuating a Patient Underwater

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In a sump rescue, one or more patients are trapped inside a cave because they cannot exit through a flooded tunnel. Reasons for being trapped include medical problems, problems with their equipment, or something to do with the cave passage. In one scenario, a sump diver has a problem with the line or his or her diving equipment. A more common scenario is that people doing a dry cave trip get trapped because a passage floods. In this we will discuss part of the solution to the latter.

When rescuing patients from behind a temporary sump, using divers to swim out the patients is usually the last option. Finding a way to wait out the flooding and / or lower the water are vastly safer for everyone involved. Exceptions do exist, such as when the cave is rapidly flooding to the ceiling. We will briefly mention some of the human dynamics at the end of this article. This article will focus on equipment issues and rescuer procedures.

If you are going to swim a patient out through a flooded passage, you need to provide the patient with scuba equipment. In situations where you know ahead of time that you will be swimming the patient, this equipment includes some type of fins, harness, buoyancy control, and breathing apparatus. We'll discuss each of these.

You may be tempted to not put fins on the patient. Fins are just one more thing you need to transport through the cave. You may think you can move the patient yourself just fine. You are so used to only diving with skilled divers, that you have forgotten what it is like to see someone out of trim. You will need to deal with all of these issues in a rescue.

When propelling a patient, you will swim right above them. This assumes a large cave passage. You will take their wing's low pressure inflator, unclip it from their chest, and move it somewhere more accessible. This includes putting it on top of them, or clipping it to their left should d-ring where it's less accessible but also protected. To propel the patient, you will grab the shoulders of their harness and tow them as you swim along.

Swimming an inert patient is hard work. It is exhausting. For all but the shortest sumps, you will be happy to get a little help from the patient. Consider the tradeoffs between extra silting caused by the patient's poor finning, and saving your energy for critical moments. If and when you do have the patient fin, you and the patient will keep kicking each other. We are investigating techniques to mitigate this.

Remember that one important element of fins is their impact on trim. Even if you don't want the patient to do much finning, consider sticking something heavy on their feet to keep them in trim. You don't want to have to manage a patient who goes feet up any time you leave them.

This brings us to our next topic: managing the patient's buoyancy. In the sump rescue world, one of our main training exercises is to have a rescuer swim a mock patient up and down a sloping guideline. When doing this, you will be tempted to use the patient's wing to manage buoyancy for both of you as you lay on top of him or her; you will dump all the gas from your wing and only use the patient's. This reduces the number of bladders you need to control. This technique fails, potentially disastrously, when the rescuer has to get off the patient to manage some issue. Suddenly the rescuer is very negative and the patient very positive. You cannot predict all the times when this might happen. Therefore, the rescuer must make an effort to keep both people near neutral.

If you have been following sump rescue training efforts from a distance, you have probably seen photos of patients traveling in litters. That does make for exciting photos. The American sump rescue community, and most of the world, recommends against this. Litters are heavy, have buoyancy issues, and are hard to maneuver through restrictions. Patients with broken arms or legs can have their limb duct taped to another body part. Patients with head, neck, or spinal issues so severe that they warrant a litter when traveling through dry cave, will either receive enough body support just from being in the water, or are very unlikely to survive an underwater movement. An exception to litter use does exist in the case of very short duck-unders, when it's faster to give a patient in a litter a regulator and push them through the duck-under than to get them out of the litter and repackage them on the far side.

The last major piece of equipment is the breathing apparatus. We will discuss the tanks, regulators, and hose systems. In all of this, we assume you know ahead of time you will be swimming the patient. All the equipment for the patient is deliberately brought into the cave for them.

The patient should use aluminum scuba tanks with stage rigging. The rescuers must travel to the patient while wearing their own tanks, and transporting the patient's. This means the patient's tanks must be rigged with bungees, bands, straps, bolt snaps, etc so the rescuer can wear them in a stage-diving configuration. You may want an additional cord or climbing sling around the tank neck to ease hauling the tank up and down pits. Once at the patient, you will need to adjust the tank rigging so it can be used in a sidemount configuration. This may involve shortening straps or bungees. Let's transition to the regulators.

There should be a specific set of hoses on every first stage regulator that a patient will use. It must have a submersible pressure gauge. It must have a second stage regulator with a hose long enough for the patient to breathe from when swimming in sidemount configuration. It should have an inflator hose that can be used with the patient's buoyancy device or drysuit. It should have a hose with a male QC6 connector. This last hose is for integrating with the regulator that the patient will actually breathe from.

When rescuing a patient with limited or no diving experience, the patient will ideally breathe from a single second stage regulator. Having the patient switch between different regulators will significantly increase patient stress and the odds of something going wrong. Put a necklace on the regulator so it can be easily found if the patient loses the regulator. Whether the patient's second stage is a traditional second stage or a full face mask (FFM) will depend on equipment availability, the patient's comfort level, the patient's experience, the nature of any injuries to the patient's face, and whether you can find a FFM to fit the patient's face.

Connecting the patient's two sidemount tanks to his or her primary second stage will require some type of gas block. A hose going from each first stage will connect to the gas block with a QC6. The breathing gas will then flow through a third hose to the patient's second stage. While it seems natural to clip the gas block near the patient's shoulders, clipping it near the patient's butt d-ring is preferred. There is more space there, and less chance of the gas block being scraped when traveling through restrictions. This does mean the hoses need to be longer. You will want a 5' hose for the patient's second stage. Route all the hoses under the patient's harness and wing to the extent possible to protect them.

One interesting debate is whether the gas block can be a simple splitter or whether it should have a switch. The switch allows selecting which of the two sidemount tanks is in use. A splitter is simpler. A switch provides increased fault tolerance, but also the chance to make mistakes. Perhaps the top reason for a switch is to support decompression.

When moving a patient through a long or deep system of sumps, you may need to swap out the patient's scuba tanks while underwater. In America, there are extremely few deep sumps through which a patient might need to travel. They do exist in Mexico and parts of Europe. Switchable gas blocks are needed for these deep sumps.

The procedure for swapping tanks is related to that for stage diving. The patient's left tank is used exclusively during swaps and for air breaks. The patient normally only breathes from his or her right tank. During a swap, if the patient has a switchable gas block, switch them to their left tank. Disconnect the QC6 connecting their right tank to the gas block. Turn off the first stage and clip the tank on the line. Turn on the new tank, verify gas safety for the

depth, and that the first stage works. Connect the new tank's QC6 to the gas block's QC6. Switch the gas block over to the new tank. Throughout all of this, regularly check in with the patient. Confirm the patient is breathing okay after the gas switch. The second stages connected directly to the first stages are there in case anything goes wrong with the gas block system. Gas switches are another reason why aluminum tanks are important; taking a steel tank off a patient will cause a radical change in buoyancy and trim.

Attentive readers will have noticed that the tank swapping procedure made no mention of the inflator hose. When sidemount diving, one tank's inflator hose is connected to the wing, while the other tank's inflator hose is connected to the drysuit. While you can disconnect the inflator hose during a tank swap and connect a new one, there is a way to avoid this. This will save you time and complication. Attach a hose splitter between the gas block and the patient's second stage. One of the exiting hoses will go to the patient's second stage, while the other goes to the patient's drysuit. The splitter can also be placed between the patient's left tank and the gas block. This assumes you put the patient into a drysuit. Using a wetsuit is far simpler, but some situations are too cold for this to be viable.

The patient's fins, harness, wing, and breathing system are the major parts of the equipment that rescuers need to provide the patient. Minor equipment includes a helmet and light. Most patients will already have a caving helmet. Their helmet may be foam-filled and very buoyant. Giving the patient an underwater flashlight is good for their mental health. It will help them understand what is going on, and give some control over their situation. A helmet-mounted light is preferrable. A handheld light can be dropped, and occupies a hand that could be used for other tasks like following the guideline.

Should the patient even have his or her hands free? One school of thought is that if you don't trust a patient enough to use a regulator, and put them into an FFM, then why would you trust them not to grab you when they panic? The American sump rescue community is exploring the possibility of recommending that all non-divers be restrained. While the patients in the 2018 Tham Luong rescue were all restrained, this is the only known rescue where that was the case. One good argument in favor of restraint is that the two workers rescued at the start of that incident almost died because when they panicked, they were free to swim away from the rescuers.

Another area of discussion is whether rescuers must control the airway of patients. In regular scuba rescue classes, divers are taught to bring unconscious divers to the surface. The rescuers are trained to use one hand to hold the second stage in the patient's mouth, and to keep the patient's head and neck oriented to maintain a patent airway. Should sump rescuers do this? One argument in favor is that it may be the only way to ensure a patient doesn't panic and spit out the regulator. Another positive argument is that since every

scuba training agency teaches this method, if a sump rescuer doesn't do it and a patient dies, they may get sued. One argument against this technique is that is it for patients who are unconscious. Our procedure for unconscious patients is to use FFMs. Another argument against the technique is that moving a patient through a cave is so task intensive that the rescuer simply cannot spare a hand for the patient's regulator.

In this article we have discussed equipment and procedures for deliberately evacuating conscious non-diver patients through sumps. Patient psychology and training are largely ignored in this article. Before performing a rescue, the incident command staff must examine the variables of the patient, their equipment, and the cave passages. This will enable them to assemble a holistic set of equipment and techniques. Most of the current recommendations by the American sump rescue community were inspired by prior work in Europe and Australia. Much research remains to be done.