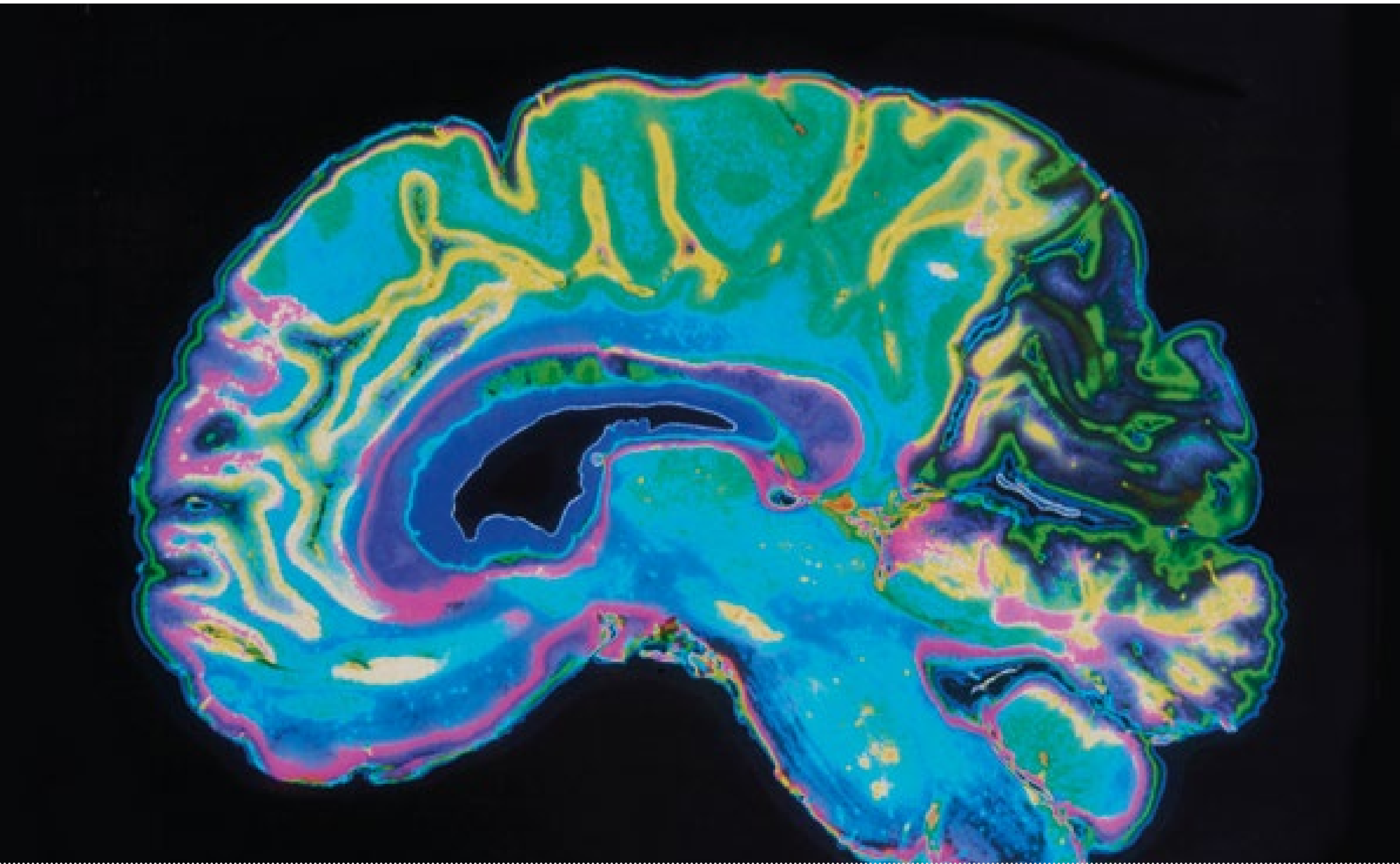
Changing the landscape of emergency

Millions of people, including emergency responders and military personnel, are at risk from traumatic brain injury, which can have devastating and enduring consequences. Our R&D team reports on promising medical developments for such injuries, calling for further research into its potential for other conditions

When one thinks of all of the potential for brain injury, there is a bevy of possibilities. Drowning can lead to moderate to severe brain damage, and an estimated 10 million people drown around the world annually, many of them in underdeveloped countries or areas prone to flooding. Members of the military are at a daily risk of brain injury from routine training exercises, to blast injuries from IEDs or mortar shells. In the US, the construction industry is responsible for more work-related traumatic brain injury (TBI), both fatal and non-fatal, than any other industry. With the newfound awareness of sports related concussion, emergency departments around the globe are seeing more and more instances of TBI than ever before. And of course, vehicle accidents are still one of the leading causes of head trauma and TBI.



Symptoms of brain injury can linger, sometimes becoming chronic

Highwaystarz | 123rf

TBI can have lasting consequences for a patient's physical and mental health. Many resolve themselves and patients experience little to no long term symptoms. But symptoms of brain injury can linger, sometimes becoming chronic and people have to live with cognitive deficits, balance and spatial trouble, or personality changes. Normobaric oxygen therapy (NBOT) or hyperbaric oxygen therapy (HBOT) could potentially combat the effects from these injuries.

For years, the medical community has largely set NBOT and HBOT aside. While it was well known that HBOT could help patients suffering with carbon monoxide poisoning or accelerate the healing of difficult wounds, this field of medicine has been defined by the lack of knowledge and scientific evidence available to support it and move it forward. Today, the landscape is changing. As more and

medicine & crisis response?

more evidence becomes available, it is becoming clear that HBOT can save lives, especially related to brain injuries, in ways that have been previously thought to be impossible.

A British physician named Henshaw first utilised compressed air for hyperbaric therapy in 1662. Unfortunately, two scientists followed by reporting ill-defined toxic effects of high concentrations of oxygen in 1789, effectively giving birth to the feeling of hesitation that would surround HBOT for nearly 250 years. Several historic hyperbaric chambers were built over the following years to treat everything from pulmonary afflictions to nervous disorders. The US Navy began using HBOT in the 1930s to treat divers with decompression sickness.

In addition to treating carbon monoxide poisoning and healing problem wounds, HBOT is today being used across the world for treating compromised skin grafts, compartment syndrome, thermal burns, anaemia, and other tissue afflictions. Still, there has been hesitancy to move hyperbaric medicine forward to treating more serious medical cases, stemming from the fact that it has been too difficult to create randomised trials with effective control groups.

In order to have an effective control group or standard placebo, patients assigned to that group must feel as though they are receiving treatment. The lowest change pressure that the human body can detect is about 1.3 atm. So the patients in any given control group must be exposed to an environment that contains air compressed to at least 1.3 atm to feel like they are receiving treatment. However, there is evidence that even a slight increase in pressure (ie 1.05 atm) can be beneficial for the patient. Therefore, treatment at 1.3 atm cannot be an "ineffectual treatment", as is required for an effective control group/placebo. This idiosyncrasy meant it was impossible to compare two groups and be confident in the results of a study, not to mention the ethical issues of withholding treatment known to be beneficial.

In 2013, doctors from Israel found a solution. Using a technique called the 'crossover approach', researchers were hoping to study the effects of HBOT on patients who suffered from chronic symptoms, or neural deficits over one year following TBI or stroke. To combat both the placebo and ethical dilemma, the approach randomly placed patients into two groups, both of which receive treatment. The first group received two months of 40 HBOT sessions, while the second group (the crossover group) received no treatment for two months, followed by two months of HBOT sessions.

This technique allows for three comparisons: Between two treatment groups; between treatment and no treatment in different groups; and between treatment in one group and no treatment in the other group. Patients were put through a battery of cognition tests to create a baseline before treatment, then the tests were repeated after treatment to see if there was any effect. The results were astounding. The mean general cognition score increased by around 15 per cent for each patient. In each of the categories tested, the patients in both the treatment group and crossover group outperformed their baseline after receiving treatment. SPECT scans (a type of nuclear imaging test) were also recorded before and after treatment, and each patient saw an increase in overall brain function.

The report says: "The results clearly demonstrate that HBOT can induce neuroplasticity and significant brain function improvement in mild TBI patients with prolonged post-concussion-syndrome at late chronic stage, years after brain injury." This first study of its kind can be used as a springboard into the modern realm of NBOT and HBOT research.

At the heart of hyperbaric medicine lies the idea of neuroplasticity and neurogenesis. Neuroplasticity is the process in which the brain's neural synapses and pathways are altered by environmental, behavioural and neural changes. Put simply, it is the natural 'editing' for the neurons and pathways within the brain. Conversely, neurogenesis is defined as the process by which new nerve cells are generated.

Rewiring neurons

When resting, the brain receives around 15 per cent of the body's cardiac output and uses approximately 20 per cent of the body's oxygen. This provides enough energy to keep only about a tenth of the brain's neurons active at any given moment. While this is a small number, it is more than enough to keep the brain functioning correctly.

When the brain is injured, whether from a fall, an explosion or from lack of oxygen, the tissue within it does its best to compensate for the injury. Ideally, by rewiring neurons and growing new cells, the brain will return itself to a state similar or identical to that of before the injury. But, because the brain receives a finite amount of oxygen, it can only devote so much energy to rewire the neurons.

This is where NBOT or HBOT become useful. By placing a patient either in an individual or group chamber with individual hoods, doctors can increase the amount of oxygen taken in by the lungs, making more oxygen available for the brain to use to heal itself. While hyperbaric treatment does not allow the brain to receive more blood, it permits the blood that the brain does receive to be maximally saturated with oxygen, so the brain has more energy to divert towards compensating for the recently acquired injury. This logic applies to the rest of the body, but for the interest of the article, we are looking solely through the lens of neurology.

Dr Paul Harch from the Louisiana State University School of Medicine in the USA is currently at the forefront of neuroplasticity research, thanks to his work with hyperbaric therapy. A recent case study published by Harch and his team serves as a prime example of how hyperbaric oxygen therapy can be so vital in saving a patient's brain.

In the case study, the patient was a two-year-old girl who experienced a near-drowning event. After falling into her family pool, she had been underwater for around 10-15 minutes. First responders spent 45 minutes using CPR, attempting to find a heartbeat before transferring the patient to the local hospital, where emergency medical personnel spent the next hour using CPR and other resuscitation methods before finding a heartbeat. The patient had spent a total of approximately two hours with no heartbeat.

Authors


IAN BOGDANOWICZ *is a pre-med sophomore studying Human Physiology at Boston University*


CARLY ESTEVES *MS, AGACNP, CCRN is the Lead Trauma Nurse Practitioner at Vassar Brothers Medical Center*


IAN PORTELLI *BCDM, PhD, is AVP, Medical Research and Operations at HealthQuest Systems Inc; AVP for Trauma at Vassar Brothers Medical Centre; and Associate Professor Emergency Medicine New York University School of Medicine. Dr Portelli is* CRJ*'s Chief Scientific Editor*

After 35 days of intense medical treatment, the patient was discharged. She had little to no cognitive ability: she was unresponsive to all stimuli, she had no use of her arms or legs and her speech skills were destroyed. She was also constantly shaking her head and squirming. MRI of her brain showed a thalamic injury and generalised atrophy with degeneration of both the grey and white matter within her brain. It was unlikely that she would ever walk or talk again, much less recover to normal functioning from before the drowning event.

Following a consultation, Harch started the patient on NBOT, as her local facility had neither the equipment nor the ability to use HBOT. After 23 days of treatment, the patient was able to move her arms and legs, begin feeding, and was even laughing at times. Finally, she was able to travel to Harch's facility and begin hyperbaric oxygen therapy at 78-days post-drowning.

"Within hours," says the case-report, "the patient experienced decreased tone, increased gross motor activity, vocabulary, and alertness." Emboldened, both the family and the medical team decided to press on with a full 40 days of treatment. Incredibly, MRI scans taken 27 days after the conclusion of HBOT treatment showed only a mild residual brain injury and almost a complete reversal of cortical and white matter degeneration.

Resilient properties

We must consider the fact that the patient was so young, and thus was able to take advantage of the extremely resilient properties of the growing brain. Children's brains have extremely 'plastic' properties, which is important for normal learning and development. Often, a mild injury to a young brain will cause the neurons within the brain to 'rewire' themselves in order to overcome the injury and continue working normally. So, the idea of neuroplasticity is amplified in the brains of children and young people.

Harch attributes some of the treatment's success to using HBOT in a: "Hormone-rich childhood cerebral milieu." That said, the use of HBOT was the key step in the patient's recovery. Without this intervention, it is unrealistic and irresponsible to assume that the patient would have recovered at all, let alone recover nearly 100 per cent of brain volume loss.

As always, more research is needed in the field of hyperbaric medicine, neurogenesis, and the plastic properties of the brain. The technology needs to become cheaper and more efficient. After one treatment, a typical HBOT chamber is out of commission for nearly an hour, making treatment of multiple patients unrealistic. More work needs to be done to find the optimal level of oxygen and pressure for each condition and patient. But there is no denying the incredible implications HBOT has for both the field of emergency medicine and crisis response.

If we already know that HBOT can be useful for the treatment of brain injury, could it be helpful in the treatment of PTSD symptoms? With more and more drama surrounding the brains of sportspeople and athletes with chronic traumatic encephalopathy (CTE), could NBOT or HBOT be useful in treating or slowing the advance of the brain degeneration?

It is possible that hyperbaric treatment will have no effect and that the answer to some of these questions will be 'no', but they need to be asked. If there is even a slim chance that HBOT or NBOT will be useful for just one of these conditions, work needs to be carried out in order to find out.

HBOT is not a miracle treatment that will fix any brain defect. In fact, the FDA has not approved it for widespread treatment of brain injury or spinal cord injury, nor has it been approved to treat any mental conditions like autism, Parkinson's or Alzheimer's disease. But with a growing base of hard evidence supporting its positive effect on generalised brain injury and stroke, who is to say that more time and research will not lead to similar breakthroughs with these and other conditions?

The field of hyperbaric therapy has done amazing things for medicine. From helping to treat crush injuries to helping make skin grafts as seamless as possible, NBOT and HBOT have become a medical tool of great importance. But there is potential to do even more. It could possibly change the landscape of emergency medicine and crisis response. C•RJ

There has been a hesitancy to move the field of hyperbaric medicine forward to treating more serious medical cases

Narin Phapnam | 123rf