HISTORY

The use of hyperbaric air began **in 1662,** when Henshaw, a European physician, used it to treat respiratory ailments and to "cool the fires of the heart" (circulation had not yet been discovered). In the course of time, many European spas opened hyperbaric facilities and all sorts of wondrous claims of therapeutic benefit were made. After the discovery of oxygen, the hyperbaric practitioners enriched the air with oxygen and many more benefits were claimed, but all were unfounded.

Modern hyperbaric oxygen therapy is an outgrowth of the medical activities of physicians and researchers who dealt with compressed air workers and divers in the mid 1800's. By then, pumps had been produced which could pressurize air to high pressures and this was used in diving and compressed air work. In the former, the compressed air allowed deeper and longer exposures under water. In the latter, it was used in pressurized tunnels and caissons to keep water out of the work area. As pressure and length of exposures increased, the exposed divers and workers began to show signs of disease. This disease could be relieved if they were returned to pressure. A French mining engineer named Triger first described this diseased as '*maladie du caisson'* and suggested recompression as the treatment. No one understood the connection between the disease, the pressure and time of exposure but physicians Pol and Watelle returned the victims of maladie du caisson to pressure, thus initiating the first recompression treatments with good results.

At the end of the **18th century**, Paul Bert, the French physiologist presented his many discoveries about atmospheric pressure effects, including the revelation that oxygen was poisonous at high pressure. As a result, virtually all the hyperbaric facilities at spas disappeared. The use of air or oxygen at increased pressure was actually banned by medical organizations. Ironically, Bert had also investigated "*maladie du caisson"* and concluded it was due to bubbles or nitrogen caused by rapid decompression. He also suggested the use of oxygen for decompression and for the treatment of the disease.

However, investigation of pressure effects and treatment of compressed air workers and divers continued as legitimate practice, because engineers continued to build bridges and tunnels where caissons or compressed air were needed and the Navies of the World continued to dive.

Haldane, the British physiologist was asked to develop diving tables for the Royal Navy so that divers would no longer get sick with the 'bends' and other ailments. He did so, using goats as his experimental animal model and extrapolated the results to humans. How valid this extrapolation is may be debatable. Interestingly, he used goats as his second choice. Dogs were used first, but when they got decompression sickness, they whimpered and lay down. They learned that by whimpering and lying down, the experiment would be stopped and they would not get hurt. In other words, the dogs were smart enough to prevent the researchers from giving them decompression sickness. The goats were not. They consistently fell down when they got decompression sickness.

Haldane's resulting tables continued to be used, in various modifications until the early '70s. They are still the basis for the U.S. Navy decompression tables and some of the derivatives of them such as the PADI Tables and some diving computers.

Despite the general medical ban on hyperbaric treatments, some individuals persisted in using HBO, including an American physician named Orval Cunningham:

In 1918, he was professor of anaesthesiology at Kansas University Medical School in Kansas City. He had quite an inventive mind. He had observed that at high altitude, patients with pneumonia and heart diseases did much more poorly than at higher pressure at sea level. He reasoned that pressure above sea level shou ld be even better. After getting approval from the medical school to do some experiments with animals, he started treating patients with pneumonia from the 1918-1919 influenza pandemic. He did so at the request of desperate colleagues who were seeing their patients die and Cunningham treated many successfully with hyperbaric air. His first chamber was patterned on the design of caisson chambers and was 10 feet in diameter and 30 feet long. With his initial success, he raised funds and built a second chamber next to his house. This was 10 feet in diameter and 80 feet long with individual compartments as in Pullman train cars. The 36 patients it could house could move about freely and use the toilet and shower facilities inside.

He treated not only pneumonia but also heart disease, hypertension, rheumatic fever, arthritis, diabetes mellitus and syphilis. He never did any of the animal experiments he had initially planned. In 1923 the interior or the "Pullman" chamber caught fire. This was due to the open gas burners used to heat the chambers. Fortunately, no one

was injured. The chamber was repaired and the heating system altered. Cunningham had so many patients that he had to buy a house to accommodate them, and built a second chamber. He was now making a lot of money, of the order of $100,000 per year. He then had a stroke of luck. The multi-millionaire Henry Timkin, of ball bearing fame, was ill with a kidney infection and uremia. His daughter brought him to Cunningham who put him in his chamber and began aero-therapeutic treatments. Though lapsing in and out of coma, Timkin eventually recovered. Timkin later offered to build Cunningham a multi-story hyperbaric hospital. This was built in Cleveland, Ohio and was in the shape of a sphere, 64 feet in diameter with 5 floors. There were 36 double bedrooms, a dining room on the ground floor and a game and recreation room on the top floor. Trouble began in 1925, when the Kansas University medical School asked Cunningham to resign because he was no longer practicing anaesthesia. He was offered a position in the department of Medicine but his antagonist, the chairman of the department, believed he was using aero-therapy without sufficient experimental foundation. Cunningham resigned from the university. The American Medical Association began an investigation of his aero-therapy because of the many inquiries they received. Cunningham did not answer questions to their satisfaction and they concluded there was no evidence to support his claims of therapeutic benefits. They stated that he seemed more interested in economics than scientific medicine. The Cleveland facility was finished in 1928 and Cunningham closed down the Kansas chambers and moved to Cleveland. There, hyperbaric treatments in his new hospital flourished. The sphere had two adjacent chambers, 16 feet in diameter and 35 and 70 feet long. Unfortunately, the economic crash on 1929 fell on the hospital too; patients could no longer afford the treatment fees and independent financing such as that from Timkin disappeared. Cunningham turned the hospital over to a young assistant because his health was also failing. One year later the hospital was closed. In 1937, Cunningham died. In 1942, the steel sphere was dismantled for scrap for use in the war effort.

In the '30s, some experimental work was done by Dr. Albert Behnke, using oxygen to improve decompression of divers and also to treat decompression sickness. He found that the toxic effects of oxygen were pressure and time dependent. A subject could be given oxygen at high pressure for an ' envelope' of pressure and time. At the same time Dr. Edgar End in Milwaukee treated carbon monoxide poisoning victims with hyperbaric oxygen therapy with good results. It took over 20 years before anyone paid attention to this work. During the second World War, there was little hyperbaric research. However, considerable work on oxygen toxicity was done to redefine the pressure and time envelope in which toxicity would not occur, or could be avoided. This was because the navies used clandestine swimmers to attack enemy ships and sink them. These swimmers used oxygen rebreather sets under water down to 40 feet and were undetectable because the sets gave off no bubbles.

In the **late 1950's**, Boerema and Brummelkamp, two surgeons in Amsterdam, Holland, acquired a hyperbaric oxygen chamber to use in cardiovascular surgery. They theorized that open heart surgery could be done if the patient was 'super oxygenated' and brief circulatory arrest was induced. They successfully accomplished this before the advent of heart-lung bypass machines. They also treated cases of carbon monoxide poisoning and gas gangrene in their chamber and reported good results. The modern era of hyperbaric oxygen therapy had begun.

Diving research also plunged foreword with some of the far-sighted concepts about living under the sea in habitats. Cousteau and the French undertook the Conshelf experiments. Dr. George Bond and the US Navy began the SEALAB series. Private habitats such as Tektite and Hydrolab also played a role in understanding the effects of living under pressure for long periods. Then, with the discovery of subsea oil, a virtual explosion of diving activity, deeper diving and saturation diving began. This latter activity saw its heyday in the **1960-70's** and was a necessary requirement of offshore drilling platform construction and maintenance. Since that time oil exploration has continued, however this activity tapered off significantly, and with it, the need to develop associated engineering technology. Some interesting diving experimentation has however continued:

- armoured diving suits pressurized at atmospheric pressure (1ATA) which in fact amount to one man submarines have enjoyed an ever expanding list of industrial applications.
- recreational diving has developed a hybrid aspect called "technical diving" which generally attracts the financially well endowed diver who is keen to push the use of the technology to the limit. This group may inadvertently have become the current and ongoing experimental

zone of human pressure physiology (and pathology).

Applications of a non-diving nature but utilizing manned pressurized chambers have dominated this applied science of in a variety of ways:

- expansion of human high altitude exposure tolerance using inflatable hyperbaric systems are routinely utilized by climbers.
- medical applications and associated human physiology knowledge has allowed the elegant application of subtle biochemical principles progressively over the past 2 decades (in the **1980-90's**) as is to be discovered in the sections which follow. Challenges to these novel concepts have, of course, occurred, in many applications we continue to see better experimental designs which demonstrate how we can take advantage of the many subtle shifts in biochemical equilibrium which are a consequence of pressure and /or oxygen provided under pressure. Some frontiers currently being explored along this journey include augmented healing of tissues from a variety of insults: cardiac, neurologic,, cosmetic and musculoskeletal.
- Loopholes in regulations of the use of pressure vessels for human occupancy resulted in broadly marketed concept of treating fixed neurological disability with low intensity hyperbaric oxygen led to establishment of multiple private clinics as well as home installations. In Feb 2001 a large placebo controlled RTC in Quebec .[1] which examined whether any additional benefit was provided to children with cerebral palsy by HBO over a control. The study was negative – ie no difference between the groups who both improved.

–This has lead to recommendations by an outside group of specialist physicians that such experimentation in children with these problems should cease.[2] *It has also opened the door to further optimize the potential of these children. Regulatory issues remain unresolved.*

Summary - History Of Medical Use Of Hyperbaric Oxygen

1662	Henshaw	- compressed air
1700's	Priestly	- discovery of O_2
1800's	Triger	- described DCI
	Pol & Watelle	- recompression Rx
	Paul Bert	- O_2 toxic
		- N_2->DCI
		- O_2 Rx for DCI
1908	Haldane	- tables, goats
1918	Cuningham	- Mr. Promoter
1930's	Edgar End	- HBO for CO poisoning
1940's	military	- O_2 toxicity
1950's	Boerema & Brummelkamp	- HBO open heart surgery
		- HBO for gas gangrene
	offshore petroleum	- Saturation diving heyday
1960's	Cousteau	- undersea habitats
1970-80's	Undersea & Hyperbaric Medical Society	- validation of HBO
	Marx	- O_2 gradient growth stimulation
1990's	Thom / Zamboni / Gorman	- HBO inhibition of injury cascade
	Bouachour	- HBO for crush injuries
	sports injuries	- under investigation
2000	Collet	- negative multicentric RCT on CP