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Short Communication

Safety of the Hyperbaric Oxygen Therapy in the Treatment of Different Pathologies in Horses: Preliminary Study

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Hyperbaric oxygen therapy (HBOT) involves inhalation of oxygen under pressure greater than 1 absolute atmosphere (ATA). The therapeutic effect is achieved by having the patient breathe 100% oxygen inside a pressurized hyperbaric chamber. Hyperbaric therapy, although a relatively old therapy, is increasingly being used as a treatment option in both human and veterinary medicine as more chambers become available and awareness of its benefits increases (Edwards, 2010).

At Equine Performance Innovative Center, we have a vertical hyperbaric chamber, made by "Equineox Technologies Ltd" (Figure 1).

Figure 1: *Vertical hyperbaric chamber, made by "Equineox Technologies Ltd".*

Treatment pressure can range from 1 to 3 ATA to drive a significant increase in arterial oxygen concentration and thus induce a number of physiological, cellular, and biochemical effects (Slovis, 2008).

To understand the physiological effect of this treatment, we will start with a short review. Oxygen is transported by the blood from the lungs to the tissue by two methods: bound to hemoglobin or physically dissolved in plasma.

Oxygen bound to hemoglobin

At normal pressure at sea level, where the alveolar oxygen pressure is approximately 100 mmHg, hemoglobin is already 97% saturated (oxyhemoglobin) and produces an oxygen content of approximately 19.8 mL of oxygen per dL of blood. When the alveolar partial pressure of oxygen (PAO_2) reaches 200 mmHg, hemoglobin becomes completely saturated with oxygen. Therefore, further increases in pressure will not increase the amount of oxyhemoglobin; therefore, oxygen transported through hemoglobin is not improved by hyperbaric therapy.

Oxygen dissolved in plasma

Oxygen is dissolved in the plasma and is transported to the tissues in a physical solution. A person breathing air at sea level pressure has only 1.5% of the oxygen physically dissolved in the plasma. Plasma oxygen transport is the key to hyperbaric therapy, as even poorly perfused tissue can receive oxygen as hyper-oxygenated plasma filters through it (Adam., *et al*. 2020).

It is important to remember that the solubility of a gas is proportional to its pressure, therefore, as the atmospheric pressure of oxygen increases, so does the concentration of oxygen in the plasma. This concentration is increased fivefold with the administration of 100% oxygen alone at 1 ATA and is increased tenfold when oxygen is administered at 2 ATA. By facilitating tissue hyperoxia, hyperbaric chamber therapy exerts beneficial anti-inflammatory, immunomodulatory, antimicrobial, antigenic, and barometric effects, which collectively contribute to its myriad clinical applications in both human and veterinary medicine (Bookspan, 2000).

Over the past 3 years, we have treated more than 118 horses, performing more than 1200 hyperbaric oxygen treatments at Equine Performance Innovative Center. It is crucial to remember that if operated properly, hyperbaric oxygen treatment is extremely safe.

The biggest single risk to safety is fire. That is why is very important that operators always be aware when preparing, using, and completing a treatment in the chamber.

The chamber must be prepared to carry out the treatment following established security measures and protocol: 1) open the oxygen tank valves, 2) turn on the compressor, 3) turn on the console, 4) wet the entire chamber with water inside, ensuring that all walls are wet, 5) turn on the sprinkler for at least one minute, 6) ensure that the hyperbaric chamber door is working properly, 7) ensure that the chamber is clean, and ready to start a treatment.

The horse is prepared to enter the hyperbaric session (Figure 2). This preparation includes: 1) cleaning the hooves, 2) brushing and bathing the animal to remove any impurities that could cause incineration during treatment, 3) If the animal has horseshoes on its fronts, they are bandaged with non-flammable elastikon-type tape, horses with horseshoes on their hind are NOT accepted for treatment, the hind horseshoes must be removed before starting the procedure, 4) the horse is sedated with both intravenous and intramuscular Detomidine, 5) the horse enters the chamber, 6) the halter is removed, and 7) the door is closed.

Figure 2: *Horses getting ready to go inside the hyperbaric chamber, the door is open, and will be closed to start a treatment.*

The animal enters the hyperbaric chamber (Figure 3).

Figure 3: *Horses inside the hyperbaric chamber, the door is open, ready to be closed and start a treatment.*

There is a 20-minute initial compression period for the chamber to reach the appropriate pressure. Once the chamber has reached the appropriate pressure, the treatment begins, which usually lasts 45 minutes. Once the established therapeutic period has been reached, decompression begins, which takes another 20 minutes. During all this time, the horse is monitored from the console. Every 5 minutes, the time, oxygen level, ATA of treatment, and horse behavior is recorded (Figure 4).

Figure 4: *Horse inside the HBOT, being monitored from the console.*

Once the procedure is finished, the door is opened and the animal returns to its stall. The chamber is then cleaned and prepped for another treatment.

Some of the most important cases that we have been treating with our hyperbaric chamber are include in the table 1.

Injury	Number of treatments performed	Cases treated	ATA	PSI	Treatment time at full pressure	Treatments per horse AVG
Laminitis	133	9	2 – 2.5	14.7 – 22	50 min	14.78
Bone Fracture/ infection	71	6	2 – 2.5	14.7 - 22	42.5 min	11.83
Cellulitis	89	11	2 – 2.5	14.7 - 22	42.27 min	8.09
Non-Healing wounds – Skin infections	224	20	2 – 2.5	14.7 - 22	42 min	11.2
Skin burn	17	1	2	14.7	45 min	17
Snake bite	6	1	2.5	22	45 min	6
Anaphylactic reactions	10	3	2	14.7	40 min	3.33
Septic bursitis	103	2	2.5	22	45 min	51.5
Upper respiratory diseases	114	8	2 – 2.5	14.7 - 22	46.8 min	14.25
Lower respiratory diseases	191	23	2 – 2.5	14.7 - 22	44.6 min	8.3
Kidney failure	64	1	2 - 2.5	14.7 - 22	45 min	64
Dummy foal	5	3	2	14.7	40 min	1.67

Table 1: *Some of the most relevant cases we have been treating with our hyperbaric chamber at Equine Performance Innovative Center. Number of treatments performed, the cases treated for that injury, the absolute atmosphere (ATA), the pressure per inch square (PSI), the treatment time when the chamber reached full pressure and the average of treatment performed per horse per injury.*

We did a survey, using SurveyMonkey App, and we asked to the horse owners about their experience with the Hyperbaric Oxygen Treatment. When we asked how the horse is after receiving the HBOT treatment, 71% answered that their horses were better, 14% said that horse was about the same and 14% said that their horse was worse. We also asked if they would repeat the HBOT treatment, if money wasn't a limitation; 57% said very likely, 14% said likely, 14% neither likely or unlikely and 14% unlikely. Finally, we asked if they were satisfied with the results after their horse received HBOT; 57% were very satisfied, 14% was satisfied and 29% were neither satisfied nor unsatisfied (Figure 5).

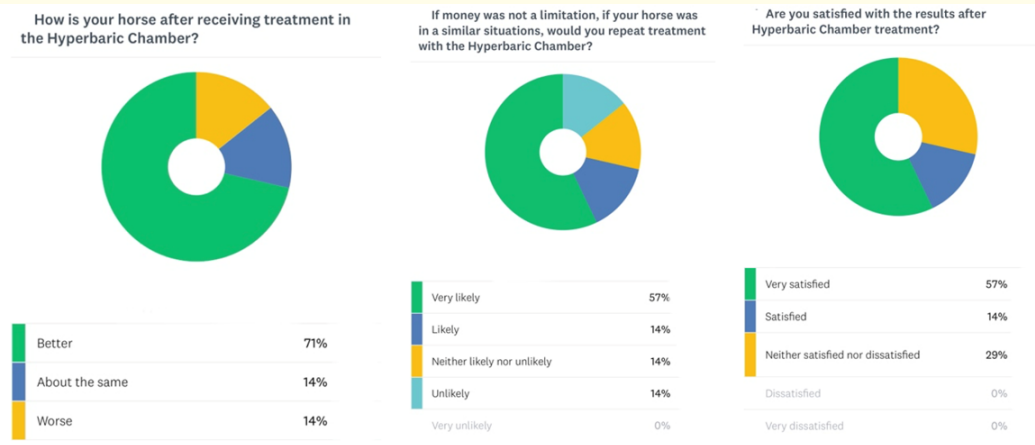

Figure 5: *Graphics showing the results of the survey performed with SurveyMonkey App.*

This preliminary information has been very useful to show that if the treatment is performed properly and the safety steps are followed, the hyperbaric oxygen chamber is a very safe therapy to treat different pathologies.

Our next goal is to perform research and analyze the data to determine the best treatment parameters for each pathology to help horses to recover more efficiently and effectively.

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