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Original article

Effect of hyperbaric oxygen therapy on the healing of postoperative wounds in bitches after hemimastectomy

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Abstract

The use of hyperbaric oxygen therapy (HBOT) is an accepted method of supporting wound healing in human medicine. Yet, because of the risk of complications associated with HOBT, a safer modification of the therapy, known as L-HOBT (lower pressure and lower oxygen concentration), is increasingly used nowadays. Therefore, due to the lack of literature reports regarding the clinical use of L-HBOT in animals, the authors decided to present the results of L-HBOT supportive treatment of postoperative wounds after hemimastectomy compared to classic treatment. The study group included 12 bitches divided into two groups: group A (assisted L-HBOT) and group B (classic treatment). In addition to conventional treatment, the supportive therapy included 1.5 hours of hyperbaric chamber therapy for 5 consecutive days, starting 24 hours after surgery (1500hPa pressure and 26% oxygen concentration in the chamber). The patients were followed and evaluated throughout the course of the treatment by two independent doctors. The results of the treatment revealed no negative clinical impact of L-HOBT supportive therapy on the body of the animals. At the same time, postoperative wounds after L-HOBT healed faster and with fewer postoperative complications compared to the control group. This resulted in a shorter treatment period, terminating with an earlier skin suture removal.

Key words: oxygen therapy; ventricle, mastectomy, wound, surgery

Introduction

Hyperbaric chambers in human medicine allow the breathing of oxygen at a pressure of 2 - 2.5 atmosphere absolute (ATA). Such a procedure is referred to as hyperbaric oxygen therapy (HBOT) (Sahni et al. 2004). According to the three laws of gases (Boyle, Henry, Fick), this allows supraphysiological oxygen levels to be obtained in a living organism (Kindwall 2008, Edwards 2010). This leads to favorable biological reactions such as improvement of tissue oxygenation (Meter Van 2005), increase of antimicrobial activity of immune cells (Mendel et al. 1999), improvement of angiogenesis (Muhonen et al. 2004) and contraction of blood vessels (Ostrowski et al. 2005).

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The most common indications for a treatment in a hyperbaric chamber are: carbon monoxide poisoning, gas embolism, necrotic tissue infections, thermal burns, musculoskeletal injuries, acute soft tissue ischemia, ulcers, osteomyelitis, idiopathic osteoarthritis and multi-organ injuries. Unfortunately, apart from a long list of indications for the use of hyperbaric oxygen therapy (HBOT), or more precisely high pressure and high oxygen concentration hyperbaric oxygen therapy (H-HBOT), several contraindications to its use may be found in the literature. Among others, these include pneumothorax, chemotherapy, acute respiratory infections, pregnancy, emphysema or high body temperature, which lowers the seizure threshold.

There are also reports in the literature of the negative effects of HBOT treatment such as barotraumatic injuries (Bantseev et al. 2004) or oxygen poisoning (Mensack and Murtaugh 1999). This mainly applies to H-HBOT, that is the therapy in which high pressure combined with high oxygen concentration in the chamber is used. Therefore, it is currently recommended to use HBOT therapy in the form of lower pressure and lower oxygen concentration, which is referred to as L-HBOT. The main difference consists in the use of lower pressure (1.2 – 1.3 ATA) and lower oxygen concentration (about 30%). Due to the lower cost of the L-HBOT chamber and fewer potential complications during its use, such therapy is increasingly used in veterinary medicine.

Surgical removal of the mammary gland is currently considered a standard in the treatment of tumors of this organ with the obvious exception of inflammatory cancer (Chang et al. 2005, Papazoglou et al. 2014). The most common complications after mastectomy include seroma formation, wound infection, wound dehiscence, ischemic necrosis, hemorrhage, pelvic edema and postoperative recurrences (Papazoglou et al. 2006, Papazoglou et al. 2014). Necrosis and dehiscence of postoperative wounds most often occur as a result of non-compliance with Halsted's basic principles in tissue management during surgery (Papazoglou et al. 2014). The wound dehiscence can also be a result of tissue suturing in wounds under higher tension, e.g. after total mastectomy (Papazoglou et al. 2006). A disorder in healing processes leads to prolonged treatment and an increased risk of infection of the postoperative wound.

The use of hyperbaric oxygen therapy (HBOT) in the treatment of wounds has been described in both humans and animals. The beneficial effects of this therapy have also been experimentally demonstrated in animals (Hosgood et al. 1992). Despite the fact that there are numerous publications on the use of HBOT in human medicine, there are only a few reports presenting the clinical use of L-HBOT in the treatment of wounds in animals. Therefore, this article presents the results of L-HBOT supportive treatment in healing postoperative wounds after hemimastectomy in bitches. At the same time, it is the first Polish report presenting the possibilities of using hyperbaric oxygen therapy in dogs as clinical patients.

Materials and Methods

The work presents the results of treatment of clinical patients and, according to the Animal Protection Act, does not require the consent of the local ethics committee. Clinical cases presented in the study concerned bitches with mammary gland tumors. Hemimastectomy was indicated in all of the cases. The study included 12 bitches with an average age of 9.5 years (range 6 to 11.5) and an average body weight of 23 kg (weight range 11 to 32). Each of the dogs underwent a thorough clinical examination and basic blood test before the surgery. Hemimastectomy was performed in all of the operated bitches. The operated tumors were medium and small in size and/or scattered over several nipples on the operated site. All procedures were performed by the same surgical team. After the surgery, the dogs were divided into two groups which differed in postoperative management. In group A, comprising 6 bitches, L-HBOT therapy was introduced in addition to a standard postoperative therapy with the owners' consent. Group B included 6 bitches whose owners did not agree to L-HOBT supportive treatment.

Anesthesia and postoperative management

After conducting the clinical examination, taking into account the results of current blood tests, there were no contraindications for general anesthesia. Patients were given intramuscular premedication with a mixture of dexmedetomidine (Dexdomitor, Orion Pharma) at a dose of 0.1-0.2 mg/kg with methadone (Comfortan, Dechra) at a dose of 0.2 mg/kg. General anesthesia was then induced with propofol (Scanofol, ScanVet) dosed according to the effect (usually 1 mg/kg), followed by intubation. After inserting a cuffed endotracheal tube and connecting the animal to the Datex Ohmeda S5 inhalation anesthesia apparatus, anesthesia was maintained with isoflurane (Isovet, Piramal Healthcare).

Intra-operative painlessness was obtained by the administration of fentanyl (Fentadon, Dechra) through continuous infusion of 0.2 µkg/ kg/min after previous bolus administration of 2 µkg/kg. In addition, local epidural anesthesia was induced by sterilely injecting lignocaine (Lignocainum Hydrochloricum WZF 2%,

Polfa Warszawa) at a dose of 4 mg/kg (max 5 ml) into the epidural space through a puncture in the lumbosacral space. The treatment of postoperative pain included administration of buprenorphine (Bupaq Multidose, Orion Pharma) at a dose of 20 µkg/kg and every 8 h for the next 4 days, and meloxicam (Metacam, Boehringer Ingelheim) for 5 days – initially at a dose of 0.2 mg/kg, then 0.1 mg/kg. Additionally, on the first day, patients received metamizole (Pyralgivet, Vet-Agro) at a dose of 20-50 mg/kg every 8 hours.

After the surgery, all dogs were given an antibiotic, namely amoxicillin with clavulanic acid (Synulox, Zoetis) at a dose of 12.5 mg/kg, every 12 hours for 5-7 days. The first dose of antibiotic was given by subcutaneous injection. The following doses were administered orally in tablets.

Surgical procedure

The surgical procedure was started after placing the animal in dorsal recumbency and preparation of the operating field in accordance with the principles of general surgery. After covering the surgical field with sterile drapes, an elliptical incision was then made around the mammary glands which were to be removed. After incision of the skin with a scalpel, further preparation was carried out with scissors and an electric knife (Erbe VIO 3). At the same time, the bleeding vessels were coagulated using bipolar forceps (Erbe VIO 3), and larger blood vessels were ligated with absorbable suture material (Monosyn, size 0, Braun). After removal of the mammary glands, the wound was sutured in layers using single interrupted sutures in subcutaneous tissues. Single sutures made of non-absorbable suture material (Dafilon 2-0, Braun) were applied to the skin. Skin sutures were removed after complete healing of the postoperative wound, depending on the group studied and the clinical assessment of the wound between the sixth and fourteenth day after surgery.

L-HOBT supportive treatment

L-HOBT supportive treatment in group A was started 24 hours after the surgery. For 5 consecutive days, the treated animal was placed in a hyperbaric chamber once a day for a duration of 1.5 hours. The duration of slow compression and decompression was 5 minutes in each case. This resulted in a 26% oxygen concentration with simultaneous increase of the pressure inside the chamber to 1500 hPa.

Postoperative evaluation

All the dogs and their postoperative wounds were independently evaluated by two doctors every 24 hours throughout the treatment period (up to 14 days after surgery). The clinical evaluation comprised assessment of the general condition of the animal and the wound itself. The wound was inspected for the presence of postoperative exudate and signs of a possible wound infection. Factors such as the time needed for the wound to heal and the possibility of safe suture removal were also taken into account in the evaluation. Additionally, the dogs from group A were monitored and evaluated during and immediately after supportive L-HBOT treatment. The assessment concerned the presence of possible systemic changes, such as neurological disorders or respiratory problems.

Results

Clinical evaluation in group A (i.e. dogs undergoing L-HOBT supportive therapy) did not reveal any negative clinical signs of either respiratory or nervous system disorders. During hyperbaric oxygen therapy, all the dogs from group A lay quietly in the chamber with no signs of anxiety. None of the animals from group A required discontinuation of hyperbaric oxygen therapy.

On the first day, postoperative wounds in all dogs from both groups looked very similar. A slight serous-bloody discharge was visible on the surface of the incision line. All wounds showed minor swelling with slight redness along the incision line. Significant differences in the wound healing process between the examined groups were found from the third day after surgery, which corresponded to two hyperbaric oxygen therapies in group A. The differences related mainly to the decrease in the amount of discharge in dogs of group A combined with a significant reduction of swelling and redness of the wound. In the dogs from group B, these symptoms were observed up to 4-5 days after surgery.

The decision to remove skin sutures was made on the basis of clinical symptoms. Thus, in group A, sutures along a significant length of wound (3/4 of the cranial part of the wound) were removed on the fifth – sixth day after the surgery. In the caudal part, due to an increased mobility of the operated area, sutures were removed on the eighth day after surgery. The situation was different in group B in which, due to a clinically observed slower healing process, every second suture was removed on the eighth day after the surgery. The rest of the sutures were removed on the 12^{th} or 14^{th} day after surgery (caudal part). In one bitch in group B the borders of the wound split open at the height of the last two sutures, located at the caudal corner of the wound. Loose sutures were removed and the wound was healed through granulation process. This resulted in closure of the wound 14 days after surgery. Two

weeks after surgery, in bitches from group A, a barely visible scar completely covered with epidermis along the incision line was observed.

Discussion

The authors of this study did not observe any negative impact of L-HBOT supportive treatment in dogs. This is also confirmed by the results of the experimental work presented by Ishibaschi et al. (2015). They demonstrated a reduced effect of L-HBOT in comparison with H-HBOT on the blood gas parameters in experimental dogs. At the same time, they showed a positive effect of the therapy on oxidative stress and the function of the autonomic nervous system, which, according to the authors of the cited work, has a beneficial effect on the homeostasis of the whole body.

Based on the authors' knowledge, there are only a few reports in the literature presenting the use of L-HBOT in animals. At the same time, the authors of the presented works perceive the beneficial effect on the treatment of specific disorders, including wound healing, a result of the mechanisms of action occurring during the use of H-HBOT treatment. Such an assumption stems from well-known mechanisms of action of hyperbaric oxygen therapy on the living organism (Ishibaschi et al. 2015). Latimer et al. (2018) experimentally demonstrated no significant effect of H-HBOT in the treatment of uncomplicated pure wounds in dogs. This finding applied to both surgical wounds after suturing and surgical wounds treated by granulation. The lack of differences between the study groups concerned subjective assessment in the scope of wound contraction and epidermis formation, as well as histopathological and microbiological assessment of the scar. However the authors of the study emphasized the fact that the small number of animals included in the study could have had an impact on the results.

The authors of the present study, despite small study groups, found a beneficial effect of supportive treatment of surgical wounds after hemimastectomy. However the authors are aware of the fact that some of the results presented, such as evaluation of the edema or the degree of redness of wounds, are subjective assessments. However, it should be noted that the wound assessment was carried out by two people who did not share their insights during the study. Additionally, it is worth noting that the dogs in the L-HBOT treated group had most of the sutures removed as early as on the sixth day after surgery, whereas in the group of dogs without L-HBOT, partial suture removal began two days later. There was also a difference in the appearance of postoperative scars. Two weeks after surgery, scars were barely visible in group A compared to those in group B.

In conclusion, it should be stated that, based on the results of the present study, the use of L-HBOT does have a positive effect on the treatment of postoperative wounds. However the authors are aware of the small number of animals in the study groups. Therefore, further expanded research into the effectiveness of hyperbaric oxygen therapy in wound healing is needed.

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