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CASE REPORT
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Hyperbaric Oxygen Therapy in Bitches with Dioctophymosis

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ABSTRACT

***Background*:** Hyperbaric oxygen therapy (HBOT) is a therapeutic modality in which pure and pressurized oxygen is delivered to the patient, causing tissue hyperoxygenation and consequent improvements in the inflammatory state, immune defense capacity, and healing. It is performed in pressurized chambers with oxygen, specific for the therapy. *Dioctophyme renale*, a nematode, is a parasite in mammals that causes severe, chronic, and progressive kidney damage. It is usually diagnosed through abdominal ultrasonography. Most cases are asymptomatic, and the treatment of choice is surgery. This report concerns 2 cases of conditioning with HBOT before laparoscopic right nephrectomy.

***Cases*:** Two adult bitches, both of mixed breed, parasitized naturally by *Dioctophyme renale* in the right kidney, and were treated at the Veterinary Hospital. The bitch in case 1 had no clinical signs of the disease, whereas the bitch in case 2 had hematuria for 3 years. Parasite eggs were not found in the urine of either dog. Both dogs underwent 2 presurgical HBOT sessions, 24 h apart, at a pressure of 2 absolute total atmospheres for 30 min. Immediately after the 2nd session, general anesthesia was induced, and the dogs underwent laparoscopic right nephrectomy in the left lateral decubitus position, and surgical access was through 3 portals in the right flank. Hemostasis was achieved with titanium clips in case 1 and with bipolar forceps with impedance control in case 2. The parasitized kidneys were placed in a tissue extractor bag and removed from de cavity, and the surgical wound was sutured in 3 layers. Three male parasites were removed from the kidney in case 1 and one male parasite from that in case 2. Neither patient had free parasites in the abdominal cavity. No intraoperative or postoperative complications occurred. Hematological examinations revealed improvement in the red blood cell count and a decrease in the serum fibrinogen level in case 1 and a decrease in the red series and an increase in the serum fibrinogen level in case 2. Both patients had decreased total numbers of leukocytes and platelets.

***Discussion*:** Studies have shown that presurgical hyperbaric conditioning improves renal and hepatic response to ischemia-reperfusion disorders, such as those that may occur during laparoscopies. Such disorders result from the creation of a pneumoperitoneum during the procedure, which increases intra-abdominal pressure. These tissues may receive cytoprotection mediated by the expression of heme-oxygenase 1, an anti-inflammatory substance induced by HBOT. Although the red series was reduced in case 2, it remained within the harmless reference range for the species. The increase in the red series in case 1 demonstrates the potential benefit of HBOT, inasmuch as many animals with *D. renale* have anemia. Because dioctophymosis leads to chronic kidney damage, a mild inflammatory response is expected. Thus, therapies that reduce systemic inflammation, such as HBOT, are beneficial to patients. Preoperative oxygenation is also recommended in animals undergoing long procedures. The results obtained in these 2 cases were different, but the benefits already proven by the consulted literature indicate that hyperbaric therapy can be advantageous in animals undergoing surgery. HBOT proved to be beneficial in the preoperative conditioning of 2 bitches with *Dioctophyme renale*, and both animals tolerated very well the therapy.

Keywords: hyperbaric oxygen therapy, dioctophymosis, parasitology, giant kidney worm.

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INTRODUCTION

Hyperbaric oxygen therapy (HBOT) is the delivery of 100% oxygen in specific patient chambers, with proper pressurization and gas exchange [6]. HBOT is usually tolerated by dogs and cats [4]. The main benefits of HBOT are tissue hyperoxygenation, optimization of white blood cell (WBC) activity, and improved wound healing [6]. Several studies have shown that presurgical hyperbaric conditioning in rats improves responses to renal ischemia-reperfusion injuries, decreases blood urea nitrogen (BUN) levels, and attenuates oxidative stress [11,16,20].

Dioctophymosis is a parasitic zoonosis caused by a cosmopolitan nematode, *Dioctophyme renale*, 1st described by Goeze in 1782 [14]. *D. renale* stimulates tropism in 1 kidney and, if untreated, usually causes complete destruction of the affected organ [9,14,18]. Parasitism may cause chronic renal disease, anemia, azotemia, and hematuria [8,10,14,17]. The treatment of choice is surgery: nephrectomy [8,9,14], nephrotomy [10], or parasite removal from other anatomic sites [9].

This report concerns hematological findings in 2 dogs with *D. renale* parasitism that underwent HBOT conditioning before right-sided laparoscopic nephrectomy.

CASES

Case 1. A 12-year-old bitch, weighing 12.8 kg, was undergoing a routine assessment at the University Veterinary Hospital of the Federal University of Santa Maria (UFSM). Abdominal ultrasonography revealed the presence of several tubular structures with hyperechogenic margins filling the renal parenchyma of the right kidney, which was compatible with findings of *D. renale* parasitism. The bitch did not show any clinical signs of renal parasitism, and no parasite eggs were found in the urine.

Case 2. A 8-year-old bitch, weighing 4.6 kg, had been admitted with mild signs of liver disease. Dioctophymosis was diagnosed during abdominal ultrasonography, which revealed parasite structures within the right kidney. The bitch had experienced episodes of hematuria for 3 years. However, no *D. renale* eggs were seen in the urine.

Each dog underwent presurgical HBOT (Figure 1A & B) individually in a veterinary hyperbaric chamber (HVM-H1[1]). The chamber was pressurized with 100% oxygen for 15 min, until a pressure of 15 PSI (2 absolute total atmospheres [ATA]) was reached. After 30 min under hyperbaric conditions, the chamber was depressurized for 15 min, until a normobaric environment was reached. Each bitch underwent 2 HBOT sessions, with a 24-h interval between sessions. One bitch (*case 1*) remained quiet during the HBOT sessions, but the other (*case 2*) vocalized during the sessions, although without respiratory distress or any evidence of barotrauma (Figure 1A).

Hematologic assessment before and after HBOT revealed opposite results for the bitches (Table 1). In *case 1*, the red blood cell (RBC) parameters improved and the serum fibrinogen level decreased, whereas in *case 2*, the RBC count decreased and the serum fibrinogen level increased. In both cases, total plasma protein and albumin levels increased, and the inflammatory response decreased, as indicated by WBC counts. BUN and serum creatinine levels also changed in both cases. In *case 2*, levels of the hepatic biomarkers alanine aminotransferase (ALT) and alkaline phosphatase (ALP) also improved.

Both bitches underwent surgery immediately after the 2nd HBOT session. After induction of general anesthesia with a balanced anesthetic protocol, the dogs were placed in the left lateral recumbent position, and the right paralumbar fossa was aseptically prepared. An 11-mm port was established in the right flank, at the level of the inguinal fold. Then access to the abdominal cavity was properly checked, and a pneumoperitoneum was created with CO_2. Two additional working ports (11 mm and 6 mm) were placed in triangulation with the camera port (Figure 1C). In *case 1*, the right renal hilus was bluntly dissected for placement of a hemostatic titanium clip at the renal artery; in total, 5 clips were placed at the renal vein (3 proximally and 2 distally). Then the vein was transected. Next, 5 clips were placed at the renal artery (3 proximally and 2 distally), and the artery was severed. The ureter was identified, clipped, and severed as close to the bladder trigone as possible. The perirenal tissue was divided with a mixture of blunt dissection with Kelly forceps and bipolar diathermy.

In *case 2*, dissection of the renal hilus was dramatically impaired by the presence of several strong adhesions between tissues surrounding the kidney and the vena cava and abdominal wall. Dissection was performed with Kelly forceps and scissors, and a vessel-sealing device (LigaSure™[2]) was used for prophylactic hemostasis of the renal artery and vein,

as well as for occlusion of the ureter. In both bitches, the right kidney was withdrawn from the abdominal cavity with a tissue retrieval bag (Figure 1D). The wounds were closed by a routine method.

Inspection of the renal content revealed the presence of 3 live male *D. renale* nematodes, 19.5 cm, 25 cm, and 30 cm in length (Figure 1E), in *case 1* and 1 dead male *D. renale* nematode, 12.3 cm in length, in *case 2* (Figure 1F). In both cases, the resected kidneys were found to be filled with parasites and fluid, with severe parenchymal destruction.

DISCUSSION

Anemia is a frequent complication in patients with *Dioctophyme renale* parasitosis [7,9,15]. Thus, a consistent increase in RBC counts, as in *case 1*, is beneficial and desirable. Although the RBC counts decreased perioperatively in *case 2*, it remained within the reference range for the canine species, with no detriment to the patient. Increases in hemoglobin have been reported in humans undergoing HBOT [5], but extended HBOT has been associated with a decrease in RBC counts [19]. A single long-term HBOT session (6 h) raised the volume of globular protein in rats, which returned to baseline values after 24 h [1]. The exact mechanisms involved in those changes in RBC counts were not completely clarified.

Platelet counts decreased in both animals in this study, in contrast to another study [1]. The bitch in *case 1* had increased serum fibrinogen levels at admission, which decreased to the reference range for the canine species after the HBOT sessions. The difference in results may be related to Amin *et al*.'s use of longer HBOT sessions [1]. HBOT affects the regulation of several cytokines, which was reflected in the attenuation of the inflammatory response [21]. This theory explains the decrease in WBC counts observed in both animals in this study.

Table 1. Hematologic and biochemical changes in dogs with *Dioctophyme renale* parasitism before and after presurgical conditioning with two 30 - min HBOT sessions at 2 ATA.

	Case 1		Case 2		
Parameter	Before HBOT	After HBOT	Before HBOT	After HBOT	Reference range*
Red blood cell count (10^6/μL)	6.23	6.98	6.99	6.35	5.7 - 8.5
Hemoglobin (g/dL)	14.2	15.5	17.6	15.9	14.1 - 20.1
Hematocrit (%)	40	45	52.8	47.8	41 - 58
Mean corpuscular volume (fL)	64.2	64.5	75.1	75.3	64 - 76
MCHC (%)	35.5	34.4	33.3	33.2	33 - 36
RDW (%)	12	11.7	14	12.8	10.6 - 14.3
Total plasma proteins (g/dL)	7.2	8	6.8	7.6	5.9 - 7.8
Platelet count (10^3/μL)	381	364	576	495	186 - 545
Fibrinogen (mg/dL)	600	200	200	400	200 - 400
White blood cell count (10^3/μL)	8.5	8.0	13.8	10.9	5.7 - 14.2
Neutrophils	6,460	5,680	8,970	7,085	2.7 - 9.4
Lymphocytes	1,445	1,200	4,002	2,507	0.9 - 4.7
Monocytes	170	720	690	436	0.1- 1.3
Eosinophils	425	400	138	872	0.1 - 2.1
Albumin (g/dL)	2.8	3	3.3	3.3	3.2 - 4.1
Creatinine (mg/dL)	0.8	0.7	0.8	0.8	0.6 - 1.4
Blood urea nitrogen (mg/dL)	46	52	36	33	9 - 26
Alanine aminotransferase (U/L)	–	–	174	136	17 - 95
Alkaline phosphatase (U/L)	–	–	248	216	7 - 115

*Reference ranges for the canine species according to the Cornell University College of Veterinary Medicine. ATA: absolute total atmospheres; HBOT: hyperbaric oxygen therapy; MCHC: mean cospuscular hemoglobin concentration; RDW: red blood cell distribution width.

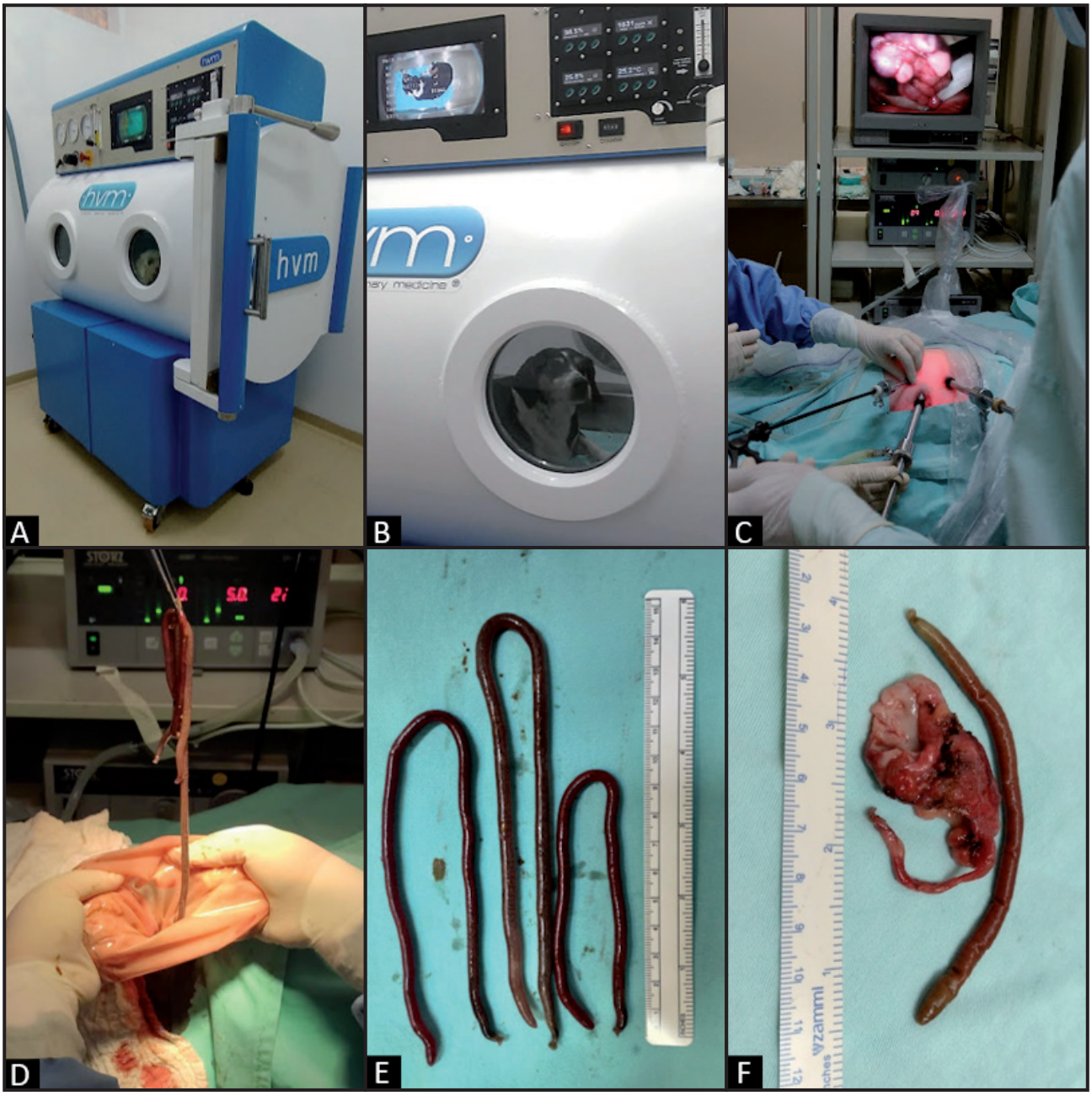

Figure 1. Findings from 2 bitches with *Dioctophyme renale* parasitism of the right kidney, both of which underwent hyperbaric oxygen therapy (HBOT) before laparoscopic nephrectomy. A & B- Patients inside the hyperbaric chamber (HVM™) during a HBOT session. C- Laparoscopic nephrectomy by a 3-port approach in the right paralumbar fossa. D- Retrieval of parasites from the right kidney, into the laparoscopic specimen retrieval bag. E- Three male parasites withdrawn from the right kidney in *case 1*. F- Right kidney and male parasite retrieved in *case 2*.

HBOT has been associated with the preservation of renal function in ischemia–reperfusion (I/R) models, with improvement in BUN values, even when HBOT is used for presurgical conditioning [11,16,20]. A HBOT protocol identical to that used in these 2 cases improved liver protection mechanisms, with an increase in mitochondrial function and a decrease in serum biomarkers of liver injury after onset of I/R disorders [13]. In *case 2* in this study, the bitch had mild liver disease, with biliary sludge within the gallbladder, and liver biomarkers improved after HBOT sessions, as in the previous report [13].

Heme oxygenase-1 (HO-1) is a potential antioxidant enzyme that can catabolize the heme group. Heme is a pro-oxidant that promotes toxic effects over several cell targets, which was widely reported in studies on kidney and liver I/R injury [11,12]. In an animal model, HBOT increased kidney expression of HO-1, which resulted in less tissue injury and improved renal function in animals undergoing presurgical

conditioning [11]. Moreover, HBOT protects the liver from I/R injury. Such a protective effect is mediated by the expression of HO-1 [12].

I/R injury occur during laparoscopy as a consequence of the pneumoperitoneum created to insufflate the abdominal cavity [2]. I/R injury are one of the most significant causes of oxidative stress and inflammation during laparoscopic procedures [3]. The minimal changes in BUN and serum creatinine levels in the 2 bitches in this study may have occurred because the analyses were performed before laparoscopic nephrectomy. Nonetheless, improvement in liver biomarkers in *case 2* may be attributed to improvement in HO-1 expression after presurgical hyperbaric conditioning. However, more studies of the postoperative effects of presurgical HBOT conditioning are warranted.

Both patients presented with only limited hematological changes. In fact, HBOT alleviated these changes, which led to normalization of hematocrit and serum fibrinogen level, as well as improvements in albumin, ALP, and ALT levels in *case 2*. These results indicate that tissue hyperoxygenation may cause positive effects in certain pathological conditions.

Although levels of some parameters decreased, all parameters remained within the reference intervals for the canine species, and the dogs were not negatively affected by the therapy. With regard to the benefits of HBOT reported in the literature, the authors recommend hyperbaric conditioning in dogs with *D. renale* parasitism or liver disorders, or both, before laparoscopic surgery.

In conclusion, presurgical hyperbaric conditioning may cause different effects in the RBC parameters of bitches with *Dioctophyme renale* parasitism. HBOT may be considered for presurgical clinical intervention in canine patients with dioctophymosis. Overall, therapy was tolerated by both bitches in this study, with no adverse effects, in two 30-min sessions with 2 ATA of pressure.

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