Right Atriotomy Using Total Venous Inflow Occlusion for Removal of Heartworms in a Cat

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ABSTRACT. Heartworm infection with caval syndrome was detected in a thirteen-year-old male cat. However, removal of the heartworms via a jugular venotomy was infeasible because the size of the jugular vein limited our ability to use flexible alligator forceps. Therefore, a right atriotomy using total venous inflow occlusion was performed to remove the heartworms. The procedure was accomplished successfully, and the cat recovered from its symptoms. The present case suggests that right atriotomy using venous inflow occlusion is practical for removal and prevention of rupture of heartworms.

KEY WORDS: atriotomy, feline, heartworm, total venous inflow occlusion.

Cats are more resistant to infection with adult heartworms than dogs. The asymptomatic cat can recover spontaneously because heartworms have a shorter life span in the cat. However, a small number of heartworms may cause clinical signs like dyspnea, anorexia, vomiting and sudden death [4, 11]. When cats exhibit acute respiratory signs, life supportive care is necessary. Some surgical procedures have been used to successfully remove heartworms [2, 5, 6, 9]. To our knowledge, total venous inflow occlusion, however, has not been reported for removal of heartworms from an infected cat. The present report describes a feline case in which retrieval of heartworms was performed via right atriotomy using total venous inflow occlusion.

A 13-year-old 4.4 kg male domestic shorthair cat was referred to Sakata Animal Hospital due to an episode of anorexia and lethargy. The cat had received annual vaccinations, but no heartworm preventive medications. Feline immunodeficiency virus was positive, but feline leukemia virus was negative. In addition, the cat was allowed to go outside freely and had been treated for bite wounds several times. On physical examination, the cat presented dyspnea and systolic heart murmur (Levine 3/6). The results of CBC indicated moderate anemia (PCV, 28.3%). Biochemical tests revealed an increase in BUN (94.6 mg/dl), alanine transaminase (291 IU/l) and total bilirubin (0.6 mg/dl). On thoracic radiography, the cardiac silhouette was obscure due to accumulated pleural effusion (Fig. 1). Abdominal radiography showed what appeared to be ascites, but abdominal ultrasonography was not performed. Two-dimensional echocardiography demonstrated enlargement of both the right atrium and right ventricle and echogenic parallel linear structures in the right ventricle. Tricuspid regurgitation was evidenced by color flow doppler echocardiography. However, the pressure gradient across the tricuspid valve was not estimated at the time. An antigen test for adult heartworm was positive, although microfilariaemia was not detected. These results were coincident with caval syndrome attributable to heartworm infection.

Because of possible complications associated with adulticide therapy, removal of heartworms via jugular venotomy was proposed. The cat was premedicated with atropine (0.04 mg/kg, SC) and midazolam (0.2 mg/kg, IV). General anesthesia was induced using ketamine (0.6 mg/kg, IV) and fentanyl (10 µg/kg, IV). Anesthesia was maintained with isoflurane in oxygen delivered via a vaporizer with simulta-

![Fig. 1. Ventrodorsal thoracic radiography at the initial examination. Pleural effusion makes the cardiac silhouette obscure.](image)
Simultaneous constant rate infusion (CRI) of ketamine and fentanyl (0.6 mg/kg/hr and 10 μg/kg/hr, respectively). Cefazolin was administered prophylactically after induction of anesthesia. Both heparin (100 IU/kg, IV) and dexamethasone (0.4 mg/kg, IV) were administered perioperatively. Since thoracentesis without sedation was a challenge in this case, it was performed following induction of general anesthesia to drain the serosanguineous fluid. The cat was then placed in right lateral recumbency, and we attempted to expose the left jugular vein by cut down. However, the jugular vein was too small to insert flexible alligator forceps; the region was dominated by granulation tissue and numerous collaterals. The right jugular vein was similar to the left side. Therefore, we decided to conduct retrieval of the heartworms via right atriotomy five days later.

Anesthesia was performed in the same manner, and succinylcholine (0.2 mg/kg, IV) was administered during thoracotomy. Right thoracotomy was performed in the fifth intercostal space with controlled respiration. The azygos vein, cranial vena cava and caudal vena cava were isolated and snared with umbilical tapes passed thorough silicon tubes as tourniquets. Total venous inflow occlusion was accomplished by tightening the tourniquets at normothermia, and ventilation was discontinued during inflow occlusion and resumed on loosening of occlusion. Following inflow occlusion, the right atrium was incised transversally, and eight adult heartworms (three males and five females) were removed from the right ventricle (Fig. 2). After confirmation of the absence of worms in the right atrium and ventricle, the incision was closed by vascular occlusion clamp, and inflow occlusion was then released. The total occlusion time was 90 sec. The clamped incision was sutured in a simple continuous suture pattern with 5-0 polypropylene. Since the cat’s arterial blood pressure decreased during cardiac resuscitation, epinephrine (0.01 mg/kg IV) and dopamine (5 μg/kg/min CRI) were administered. After cardiac resuscitation, two drain tubes were placed to remove air and fluid from the thorax postoperatively, and the thoracotomy was closed routinely.

The cat awakened without any event, and fentanyl infusion (2 μg/kg/hr CRI) was continued. Serous and faintly bloody fluid from drainage tubes at a rate of over 50 ml/day for the first two postoperative days. From postoperative day 3 on, the mean volume of effusion decreased to about 24 ml/day; however, no more decrements were observed. Furthermore, the drainage became chylous, but fluid analysis was not performed. On postoperative day 15, the drainage tubes were removed, although the amount of drainage had scarcely changed, and the cat was discharged. On postoperative day 28, the cat was alert and no longer dyspneic, and no pleural effusion was recognized on thoracic radiography (Fig. 3). In addition, no ascites was detected on abdominal radiography. However, the systolic heart murmur was still detected (Levine 3/6), and tricuspid regurgitation was evident on echocardiography. The cat was thought to have pulmonary hypertension because the systolic pressure gradient between the right ventricle and right atrium exceeded 30 mmHg, as calculated by peak regurgitant jet flow velocity using the modified Bernoulli equation [1]. No heartworms were detected in the right atrium, right ventricle or main pulmonary artery. Two months later, the results of a heartworm antigen test were negative, and the cat remained in good condition.

Adulticide therapy has the risk of complications associated with dead worms [4, 11]. Moreover, our case was affected caval syndrome, which is an indication for surgery [11]. A few cases of jugular venotomy have been reported.
in the cat [2, 5]. We attempted jugular venotomy using flexible alligator forceps because of their availability at our hospital [6]. However, the jugular vein of this cat had been almost completely replaced by granulation tissue and collaterals, which were probably caused by previous bite injuries. A venotomy would have failed even if a small devise had been available, such as a string-type horseshair brush [5]. Therefore, thoracotomy was required to remove the heartworms from the right side of the heart.

According to the guidelines, instruments like alligator forceps can be inserted through a right ventricular purse string incision for removal of heartworms [11]. A modified atriotomy using a cannula has also been reported [9]. These procedures can be performed on the beating heart without specialized equipment. On the other hand, total venous inflow occlusion is a technique for open-heart surgery that entails complete circulatory arrest and is more invasive [12]. However, this technique is superior in terms of favorable visualization of intraventricular cavity, which is advantageous in prevention of trauma from heartworms. It is important to note that rupture of a heartworm evokes circulatory collapse associated with a shock-like reaction caused by the worm’s body fluids [8, 10]. Therefore, heartworms must be kept intact during surgery. However, intact removal of heartworms using alligator forceps through a right atrial or ventricular purse string incision may be difficult, especially when the heartworms are tangled or coiling around the tricuspid valve chordae tendineae [7]. Moreover, alligator forceps may injure not only heartworms but also intraventricular structures, including the tricuspid valve apparatus, in this situation. Although the heartworms were not tangled in the present case, right atriotomy using total venous inflow occlusion was a suitable approach to avoid trauma from the heartworms and to intraventricular structures.

Since the present cat showed tricuspid regurgitation and pulmonary hypertension, right-sided heart failure is the presumed reason for the pleural effusion. The residual regurgitant flow was probably the result of irreversible disturbance of the tricuspid valve apparatus caused by the heartworms or tricuspid valve orifice dilation associated with enlargement of the right ventricle. In dogs with chronic heartworm disease, hypertrophy and consolidation of the tricuspid valve have been reported [7]. Because the right atrial pressure was not measured and the lack of detailed perioperative doppler echocardiography data in the present case, other factors cannot be excluded as the cause of the pleural effusion. Regarding the postoperative chyloous effusion, surgical complications should also be taken into consideration. Thoracic duct injury is a potential cause of chylothorax, but this occurs in humans and is uncommon [3]. Although chylothorax associated with inflow occlusion has not been reported in small animal practice, it is possible that the thoracic duct or tributary was injured during isolation of veins for inflow occlusion in the present case. Lymphangiogram of the thoracic duct may be useful in making a clear determination [13]. Fortunately, the amount of drainage was relatively small from postoperative day 3 onward, and no pleural effusion was detected on thoracic radiography at a follow-up examination; we were unable to find a reason for the chyloous effusion.

The present case suggests that right atriotomy using total venous inflow occlusion is practical for removal of intact heartworms. However, careful observation should be continued because tricuspid regurgitation and pulmonary hypertension, as seen in the present case, can potentially cause recurrence of pleural effusion.

REFERENCES