A creative concept for transvenous extraction of *Dirofilaria immitis* in dogs with heartworm caval syndrome: a case report

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**Abstract.** Heartworm disease (cardio-pulmonary dirofilariosis), caused by the filarioid mosquito-borne nematode *Dirofilaria immitis*, is a serious and potentially fatal condition in dogs. Caval syndrome (CS) is a life-threatening manifestation in the late stage of the disease; surgical removal of worms is the only treatment option for dogs in this condition. Given that risks associated with heartworm surgical removal have been registered, various minimally invasive techniques and better instruments continue to be designed.

Here, we describe a case report on heartworm surgical removal in a 3 years old Belgian Shepherd dog with CS, using a minimally invasive procedure based on a creative device. The device consists of a string type horse hair brush that lies behind the surgical utensil. The transvenous right jugular approach was employed under echocardiographic guidance.

A total number of 28 worms were removed by the procedure, but the echocardiogram showed that some worms still remained. Regardless, the goal was to remove as many intact worms and to re-establish the blood circulation, relieving in this way some of the heart failure condition symptoms. Next day following the procedure, the dog had reversed to stage III of the disease, and the echocardiographic evaluation revealed that the initial remaining worms could no longer be detected in the heart; it was hypothesized that they have returned back into the pulmonary arteries due to haemodynamic forces of the blood flow. Marked improvement was achieved in the treatment of right-sided congestive heart failure. The dog had recovered and was discharged 10 days after worm removal; a protocol treatment including Doxycycline (10 mg/kg) for 30 days and Ivermectin (6 μg/kg every 2 weeks) for six months was recommended. One year later, the dog became antigen free.

In conclusion, the surgical technique presented here exceeded the initial goal of being minimally invasive, but also demonstrated the efficacy of this two-pieces device, which can be easily assembled and be used for the heartworm extraction in dog with CS.

**Keywords:** Dirofilariosis; Caval syndrome; Echocardiography; Tayama String horsehair brush; Dog.

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Introduction

Heartworm disease (HW) (cardio-pulmonary dirofilariosis) is caused by the filarioid nematode *Dirofilaria immitis* (Nematoda; Filarioidea). It is transmitted through mosquitoes’ bites which act as vector and intermediate host (Mitrea, 2011). Adults live in the pulmonary arteries and could invade the right heart chambers. The disease has a fatal progression if left untreated (Genchi et al., 2005).

Caval syndrome (CS) or "liver failure syndrome" appears in the end stage of the disease (stage IV), as a consequence of cardio-pulmonary dirofilariosis progression. This was first mentioned by Adams (1956) which described an acute form of heartworms associated with a large number of worms into the venae cavae and right atrium in a dog.

CS consists in the migration of heartworms against the blood flow from the pulmonary arteries to the right ventricle, right atrium and venae cavae (Strickland, 1998). This occurs because the heartworms lack the ability to adhere or to submerge to the endothelium and also to freely move, causing an increased vascular resistance within the circulation at the distal end of pulmonary arteries thus entering the heart (Jones, 2016). Once the chambers of the heart and venae cavae are occupied, the heartworms disrupt the proper functioning of the tricuspid valve, causing pulmonary hypertension and reduced pulmonary output (Strickland, 1998). In summary, stratifying the likely course of this condition by creating a framework of the following events are registered: a retrograde migration of a large worm burden, a haemodynamic alteration with acute pulmonary hypertension, reduced cardiac output and right ventricular dysfunction with tricuspid regurgitation (Strickland, 1998; Bové et al., 2010).

In order to re-establish adequate cardiac function and prevent critical consequences for affecting the body, CS must be immediately treated. Surgical removal of worms is the only treatment option for dogs in this condition otherwise it will end up fatally. However, many risks associated with heartworm surgical removal have been registered. Therefore, minimally invasive techniques and better instruments continue to be designed. These were described since the 1980 as catheterizations with flow-directed catheters fluid (Atkins et al., 1988), Ishihara’s flexible alligator forceps (Ishihara et al., 1986), basket retrieval devices (Yoon et al., 2011), modified red rubber feeding tubes (Jones, 2016) or "snare" guided catheters (Alho et al., 2016). These devices are very diverse, but all are designed in order to reduce intravascular trauma and damage of worm cuticles during surgical extraction (Strickland, 1998; Garner, 2011; Yoon et al., 2011; Alho et al., 2016).

Here, we describe a case report on heartworm surgical removal in a dog with CS, using a minimally invasive procedure based on a creative device.

Materials and methods

Case presentation

A 3 year-old male Belgian Shepherd dog mixed breed, weighing 19 kg was presented to the Clinics of the Faculty of Veterinary Medicine in Bucharest with a history of a recently depreciated health condition, lack of appetite, diarrhea and persistent cough after which he suddenly collapsed. The dog originated from a household in which another female dog showed a similar clinical episode three weeks prior, after which he suddenly died. The dog had not received heartworm prevention or vaccination a year ago to this visit, as the owner stated.

On physical and clinical examinations, the dog showed acute anorexia, abdominal distension, and pale mucous membranes with a delayed capillary refill time, weak peripheral pulse, grade III/VI right-sided heart murmur at the level of the tricuspid projection area, jugular distention and bounding jugular pulse (figure 1).

Laboratory investigations

Blood samples were collected and subjected for routine hematological and biochemical investigations and for parasitological laboratory analyzes.
Imagistic investigation using Focused Assessment with Sonography for Triage (FAST) to assess an underlying cause has been performed applying the Abdominal FAST (AFAST) and Thoracic FAST (TFAST) procedures (Boysen et al., 2004).

Parasitological investigations, by using of a commercial immuno-chromatographic rapid test (SNAP®4DX® Plus, IDEXX Laboratories, 2017) for detecting circulating female antigen of *D. immitis* and a modified Knott technique for detecting circulating microfilariae (Georgi and Georgi, 1992; Mitrea, 2011) were performed.

**Results**

*Paraclinical investigations*

The serum biochemistry profile (table 1) performed prior to the surgical procedure, pointed out pre-renal azotemia and increased hepatic enzymes due to the passive congestion following right cardiac enlargement. The SNAP®4DX® Plus test showed positive results for Ag of *D. immitis*.

The modified Knott technique showed microfilariae with a characteristic morphology of straight tail and a spindle-shaped cephalic extremity, compatible for *D. immitis* (Genchi et al., 2005) (figure 2).

The AFAST technique revealed splenomegaly, hepatomegaly with hepatic congestion and free intra-abdominal fluid (figure 3). TFAST pointed out a mass of heartworms across the tricuspid valve and a dilated right ventricle, which correspond to CS (figure 4) (Kittleson and Kienle, 1998; Venco and Vezzoni, 2001).

**Diagnostic**

By corroborating all the above results the diagnostic was assumed as dirofilariosis, stage IV, which is consistent with CS.
**Table 1.** Serum biochemistry values in a 3 year old Belgian Shepherd mixed breed with caval syndrome (dirofilariosis stage IV)

<table>
<thead>
<tr>
<th>Serum biochemistry parameters</th>
<th>Results</th>
<th>Reference value (Boon and Rebar, 2010)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Albumin (ALB)</td>
<td>2.3</td>
<td>2.2-4.0 (g/dl)</td>
</tr>
<tr>
<td>Phosphatase Alkaline (ALKP)</td>
<td>↑ 677</td>
<td>23-212 (u/L)</td>
</tr>
<tr>
<td>Alanine Aminotransferase (ALT)</td>
<td>↑ 340</td>
<td>10-100 (u/L)</td>
</tr>
<tr>
<td>Amylase (AMYL)</td>
<td>↓ 412</td>
<td>500-1250 (u/L)</td>
</tr>
<tr>
<td>Blood Urea Nitrogen (BUN)</td>
<td>↑ 121</td>
<td>7-27 (mg/dl)</td>
</tr>
<tr>
<td>Calcium (Ca)</td>
<td>10.8</td>
<td>7.9-12 (mg/dl)</td>
</tr>
<tr>
<td>Creatinine (CREA)</td>
<td>↑ 3.5</td>
<td>0.5-1.8 (mg/dl)</td>
</tr>
<tr>
<td>Gamma Glutamyl Transferase (GGT)</td>
<td>↑ 50</td>
<td>0-7 (u/L)</td>
</tr>
<tr>
<td>Glucose (GLU)</td>
<td>↓ 55</td>
<td>70-143 (mg/dl)</td>
</tr>
<tr>
<td>Lipase (LIPA)</td>
<td>1672</td>
<td>200-1800 (u/L)</td>
</tr>
<tr>
<td>Total Bilirubin (TBIL)</td>
<td>↑ 4.5</td>
<td>0-0.9 (mg/dl)</td>
</tr>
<tr>
<td>Total Proteins (TP)</td>
<td>↓ 2.2</td>
<td>2.5-4.5 (g/dl)</td>
</tr>
<tr>
<td>GLOBULINS (GLOB)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Table 2.** Hematological results in a 3 year old Belgian Shepherd mixed breed with caval syndrome

<table>
<thead>
<tr>
<th>Hematological parameters</th>
<th>Results</th>
<th>Reference values (Hart and James, 2006)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hematocrit (HCT)</td>
<td>↓ 33.6%</td>
<td>3.7-55.0%</td>
</tr>
<tr>
<td>Hemoglobin (HGB)</td>
<td>↓ 10.7 g/dL</td>
<td>12.0-18.0 g/dL</td>
</tr>
<tr>
<td>Mean Corpuscular Hemoglobin</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Concentration (MCHC)</td>
<td>34.8 g/dL</td>
<td>30.0-36.9 g/dL</td>
</tr>
<tr>
<td>White Blood Cells (WBC)</td>
<td>↓ 5.90 K/µL</td>
<td>6.00-16.90 K/µL</td>
</tr>
<tr>
<td>Granulocytes (Grans)</td>
<td>4.20 K/µL</td>
<td>3.50-12.00 K/µL</td>
</tr>
<tr>
<td>% (GRANS)</td>
<td>71.2 %</td>
<td></td>
</tr>
<tr>
<td>Lymphocytes/ Monocytes (L/M)</td>
<td>1.7x10^9/L</td>
<td>1.1-6.3x10^9/L</td>
</tr>
<tr>
<td>(%/L/M)</td>
<td>29 %</td>
<td></td>
</tr>
<tr>
<td>Platelets (PLT)</td>
<td>↓ 160 K/µL</td>
<td>175-500 K/µL</td>
</tr>
</tbody>
</table>

**Figure 2.** Microfilariae of *Dirofilaria immitis* by the modified Knott test
**Treatment**

A surgical approach for removing of worms has been chosen as treatment option for the dog, by using a minimally invasive procedure based on a creative device (figure 5).

For the beginning, an emergency therapy was initiated to stabilize the patient. A peripheral catheter was placed on the cephalic vein and aggressive shock therapy was initiated with crystalloid fluids, to compensate for intravascular volume deficiency expressed by the following clinical signs: prolonged capillary refill time (>2 seconds), tachycardia (heart rate 100 beats/minute), pale mucous membranes and a low systolic blood pressure of 80 mm Hg. Supplemental oxygen via face mask has been delivered.

Taking in consideration the risk associated with possible thromboembolism following the heart catheterization, the dog was premedicated with Prednisolone (1 mg/kg, subcutaneously [SC]) once daily and Ceftriaxone (25 mg/kg intravenously) [IV] twice daily (b.i.d.).

**Surgical procedure**

The basis of the instrument adapted consists of a string type horse hair brush, named Tayama. The device, respectively, a “heartworm extraction brush” was assembled in the operating theater, from a flexible guidewire of a 7-French central venous catheter, to which was attached a non-absorbable monofilament suture - Polypropylene 2/0 and 0 (Kittleson and Kienle, 1998; Strickland, 1998; Yoon et al., 2011). The straight edges of polypropylene suture were inserted with alternating loops fixed to the proximal end of the flexible guide-wire.

The striations of the flexible guide-wire prevent the suture from sliding and, at the same time, allow the knots to be tightened as much as possible.
Figure 4. Two-dimensional long axis view from the left parasternal window revealing hyperechoic heartworms across the tricuspid valve and a dilated right ventricle.

Figure 5. "Tayama" brush consisting in a combination of a flexible guidewire, a 7-French central venous catheter and a non-absorbable monofilament suture.
The surgical procedure was guided by ultrasonography taking advantage of the fact that the heartworm’s cuticular wall is reflective and easily visualized by ultrasonographic examination (Jones, 2016). The anesthesia was inducted using initially Diazepam (0.2 mg/kg), followed by Ketamine, approximately 3 mg/kg tapered to the desired effect. Intubation was performed using an endotracheal tube number 8.5. Anesthesia was maintained using Isoflurane (1.5%) and a local infiltration of Lidocaine 2%. The dog was positioned on left lateral recumbence on a special table with a cut to allow for the ultrasound probe to be in contact to the patient’s chest wall.

Heartworm embolectomy was accomplished by approaching the right external jugular vein with an extemporaneous device. By holding the handle, the surgeon slowly, rotated the device and gently pulled out repeatedly in a delicate and gradual manner.

Using echocardiographic guidance we were able to follow the surgeon’s trajectory and passage through the right heart chambers; also, the characteristic, hyperechoic cuticular heartworm was easily identified as two parallel lines (Jones, 2016) similar in appearance to the “=” (equal sign) and a hypoechoic center (Alho et al., 2016) confirming the presence of heartworms.

A total number of 28 adult heartworms were removed by the procedure (figure 6), in a total of four attempts, but the echocardiogram showed that some worms still remained. Two hours after surgery the animal completely regained consciousness.

**Follow-up**

Next day following the procedure, the dog had reversed to stage III of the HW disease and the echocardiographic evaluation revealed that the initial remaining worms could no longer be detected in the heart. It was hypothesized that they have returned back into the pulmonary arteries, presumably, due to haemodynamic forces of the blood flow.

![Figure 6. Surgical extraction of adult helminths from the right jugular approach in a 3 year-old mixed Belgian Shepherd dog with Cavallet syndrome](image-url)
Marked improvement was achieved in the treatment of right-sided congestive heart failure using Pimobendan 0.25 mg/kg (b.i.d.), Benazepril 0.5 mg/kg (s.i.d.), Furosemid 2 mg/kg (b.i.d.) and Cardio Strength (Vetri Science®) 2 capsules (s.i.d.). The dog had recovered and was discharged 10 days after worm removal.

A protocol treatment including Doxycycline (10 mg/kg) for 30 days and Ivermectin (6 μg/kg every 2 weeks) for six months was recommended (Grandi et al., 2010). The dog was evaluated at each 3 months post treatment for parasite microfilaremia and antigenemia. At first evaluation p.t., the dog was negative for microfilariae, but still remained Ag positive. One year later, the dog became antigen negative.

Discussion

Here we describe a case report on heartworm surgical removal in a dog with CS, using a minimally invasive procedure based on a creative device.

The removal of the heartworms had resulted in the cessation of the tricuspid valve regurgitation, allowing for an increased cardiac output and a decrease in the pulmonary arterial pressure. Despite of the fact that not all the worms were removed, the goal was to extract as many intact worms as possible and to re-establish the blood circulation thus reduces the symptoms of the heart failure condition.

Nevertheless, a complete remission of the symptoms of CS is not possible. One study performed by Kittleson and Kienle (1998) examined dogs with a large worm burden, and showed that the group that had the mean pulmonary artery pressure of 60 mmHg, developed CS while another group, with similar worm burden but a mean pulmonary arterial pressure of 30 mmHg, did not develop the syndrome. Therefore, a reliable prediction of CS occurrence is doubtful.

This combination of treatment based on doxycycline and ivermectin abolish the Wolbachia endosymbiont population which is vital for worm development and fertility. One study performed by Bazzocchi et al. (2008) showed uterine injury of adult Dirofilaria females after doxycycline and ivermectin treatment.

Before attempting any surgical procedure, it is critical that the patient is in stable condition. In order to do so, fluid therapy along with medication is recommended, before and after the surgery, to prevent the occurrence of serious complications (Nelson, 2015). Often, after the death of one or more adult worms, the onset of clinical signs occurs due to the release of vasoactive substances that cause inflammation. The decrease in parenchymal and arterial wall damage is attributed to the effects of Prednisolone (Atwell and Tarish, 1995) which reduces pulmonary inflammatory lesions at a tapering dosage (Atkins and Seaks, 2018).

Several anesthetic procedures for heartworms removal have been suggested, including alpha2-receptor agonists premedication (Chiavaccini et al., 2014) but these are related with a reducing of cardiac output and increasing in pulmonary pressure which aggravates pulmonary hypertension (Flacke et al., 1993). Anticholinergics used in premedication such as Atropine suggested by Yoon et al. (2011) cause a significantly higher heart rate. This slows coronary blood flow and myocardial oxygenation which happens during diastole (Greene, 2001). Ketamine was used because, as a dissociative agent, stimulates indirectly the cardiovascular system by enhancing the sympathetic tone, thus causing an increase in heart rate, cardiac output and mean arterial pressure (Waxman et al., 1980). The benzodiazepines, when used alone, have a minimal cardiopulmonary depressant effect (Greene, 2001) and this association between Diazepam and Ketamine has been reported to maintain good cardiovascular performance in high-risk patients (Waxman et al., 1980). This is preferred to Propofol induction which can cause myocardial depression, peripherally vasodilation and hypotension (Macintire et al., 2012). Isoflurane do not sensitize the heart to the effect of catecholamines and cause no heart rhythm disturbances (Brock, 2001).
This surgical technique presented here, exceeds the initial goal of just being less invasive, but also efficient and easy to perform compared to the alligator forceps or basket retrieval devices and can be easily assembled and be used for the extraction of *D. immitis* helminths from the heart chambers and venae cavae. The feature of the soft and curved tip, allows a convenient passage through the jugular vein and its easy lowering into the right atrium and right ventricle. As opposed to the alligator forceps which are rigid instruments that can perforate the blood vessels and cardiac chambers while with its jaws could macerate the worms, the soft and curved tip of Tayama string allows for an easy passage through the jugular vein and smooth lowering into the right atrium and right ventricle (Kittleson and Kienle, 1998). Furthermore, the movements of the heartworms can cause inconvenient challenges in grabbing the worms using forceps. Standard red rubber feeding tubes can be modified and used instead of the flexible guidewire of the central venous catheter, but there is big disadvantage in using it because the tubes can become lost during surgery (Jones, 2016).

Acute pulmonary thromboembolism can be inevitable, but attempting to decrease the risk is essential. Worm fragments as well as platelet aggregation and inflammation can form thromboemboli that block circulation, especially in caudal lobes of the lungs (Greene, 2011). It is important to be aware and manage the risk as much as possible, because fatal outcomes is possible even the patient starts to feel better after the surgery; therefore exercise restriction is mandatory.

In conclusion, this minimally invasive technique has been proven successful in this trial and appropriate for handling the movements of heartworms while providing a rapid recovery time and better prognosis for the patient. The significance of this approach lies also in the fact that is offering a new insight and a creative approach for using a common and an easily available instrument.

**References**


