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NOTE

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# Laparoscopic nephron-sparing surgery for the treatment of canine dioctophymosis

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**ABSTRACT.** This paper reports on two cases of laparoscopic nephrotomy employed in the treatment of canine dioctophymosis, which is considered a unusual procedure and a new treatment proposal heretofore not performed in veterinary medicine. Two patients were treated, one with a history of hematuria and the other with incidental finding of the parasite in the abdominal cavity during elective ovariohysterectomy. Both dogs were subjected to abdominal ultrasound, which produced images indicating the presence of the parasite in the right side kidney, but with partial parenchymal preservation. The patients were therefore subjected to laparoscopic nephrotomy. The surgical procedure was effective in treating dioctophymosis and enabled minimum tissue invasion during surgery, in addition to preservation of the kidney.

**KEYWORDS:** canine, dioctophymosis, kidney, laparoscopy

Known as one of the world's largest nematode parasites, *Dioctophyme renale*, commonly called the "giant kidney worm" [7, 35], occurs worldwide and affects mainly domestic and wild carnivores [15, 23]. However, being a zoonotic parasite, it has also been reported in humans [35].

The life cycle of *D. renale* is complex and its transmission involves the elimination of eggs through the urine of infected definitive hosts, followed by larval development inside the eggs in aquatic environments. Next, the eggs are ingested by the intermediate host, an aquatic annelid oligochaetes worm [18], where they develop into L3 larvae that infect definitive and paratenic hosts (fishes and anurans) [24]. Finally, stray dogs usually become the main definitive hosts, given their easy access to contaminated areas, non-selective feeding habits, their ingestion of raw fish and of amphibians carrying the aquatic annelid [23].

In the definitive host, the parasite often migrates to the right side kidney, probably due to its anatomical proximity to the duodenum. In fact, most patients are asymptomatic and the disease is an incidental clinical finding [15]. However, apathy, anorexia, hematuria, dysuria, and lumbar pain may be observed in some cases [17, 34]. In addition to urinary sediment analysis, which reveals the presence of parasite eggs [24], abdominal ultrasound is also helpful in diagnosing the disease, as is the structural assessment of parasitized kidneys [30]. Unlike human patients with dioctophymosis, for whom nephrectomy is rarely recommended [35], this procedure is the therapy of choice for canine patients [7, 17] since most cases involve progressive destruction of the kidney parenchyma [30]. However, in cases where kidney function is preserved, the recommended treatment is nephrotomy [28].

Laparoscopic procedures are advantageous in such cases because they are minimally invasive and cause less tissue trauma and because they provide visual access to the structures, revealing anatomic alterations in the shape, color and pulsation of the kidney and thus underpinning the decision about the need for nephrotomy [6]. However, there are different reports about laparoscopic

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nephrectomy for the treatment of dioctophymosis [11, 12, 28]. To the best of our knowledge, so far only one abstract has been published concerning nephrotomy for the removal of *D. renale* through conventional surgery [4]. The authors of the present paper have made an oral presentation (not published) on the use of laparoscopic nephrotomy to this end on one of the patients mentioned herein. This paper aims to present the first report involving the laparoscopic nephron-sparing technique (nephrotomy) for the treatment of dioctophymosis with kidney preservation and successful postoperative evolution.

*Case 1*: Canine, male, mixed breed, seven months old, non-neutered, body weight of 7.2 kg, with a history of hematuria, was treated at the Veterinary Hospital (HCV) of the Federal University of Pelotas (UFPel). After a general physical examination revealed no alterations, the patient underwent complementary tests consisting of full blood count, liver and kidney profiles, urinalysis and abdominal ultrasound. The hematological and biochemical results were within the standards of the species, while

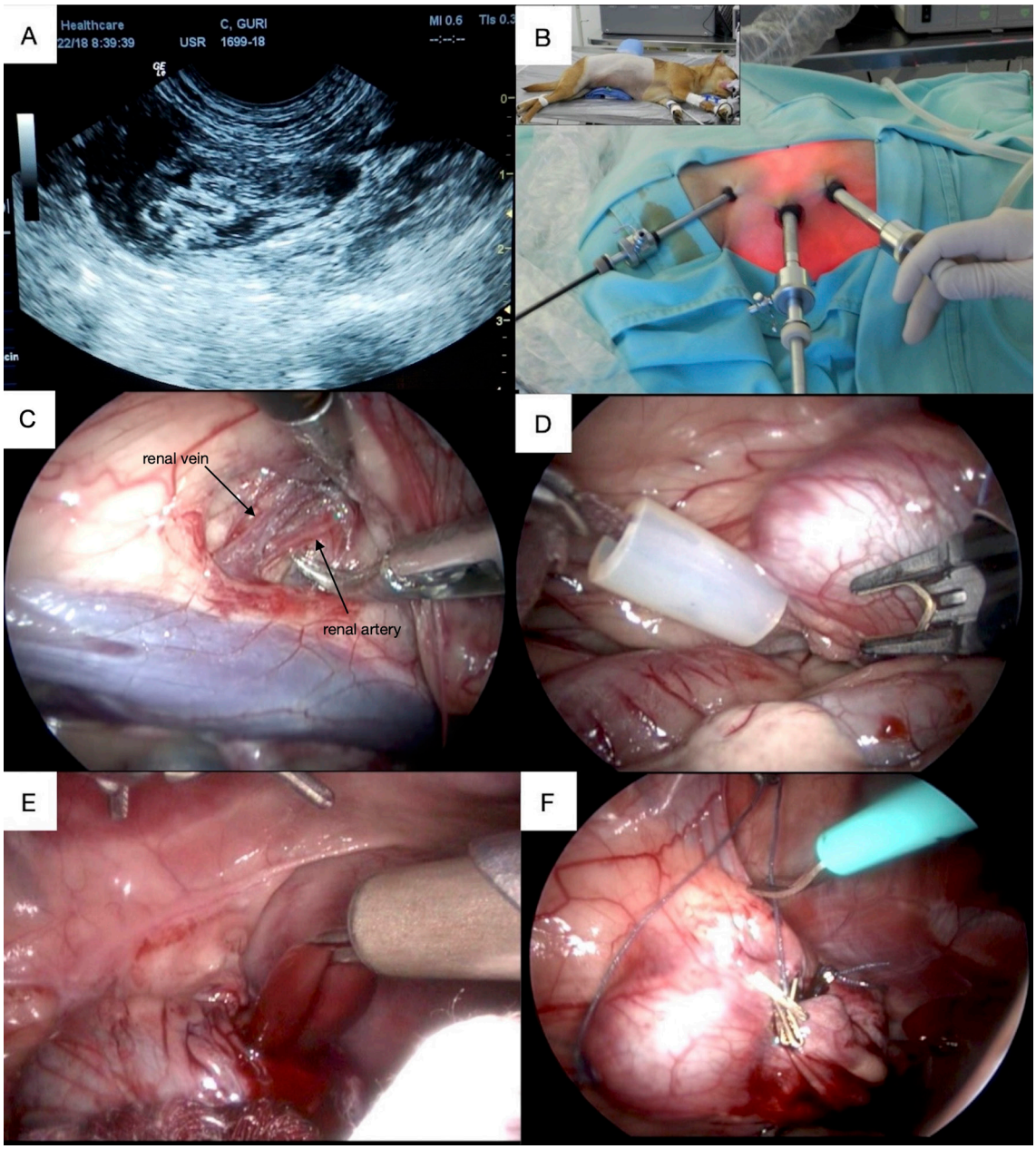


**Fig. 1.** (**A**) Ultrasound image of the right side kidney, showing structures compatible with *Dioctophyme renale* in Patient 1. (**B**) The inset image shows the left side lateral decubitus of Patient 1 and the flank elevated with folded cloth; the larger image shows the placement of the three portals in a triangular configuration. (**C**) Blunt dissection and isolation of vessels of the renal hilum (renal artery and vein are identified). (**D**) Application of Rummel tourniquet consisting of umbilical tape, a length of latex tubing, and titanium clips. (**E**) Parasite removal with the aid of Kelly forceps. (**F**) Final aspect of the nephrorrhaphy performed in an interrupted pattern using size 3–0 polyglycolic acid suture (Ácido poliglicólico 3–0®, Point Suture, Fortaleza, Ceará, Brazil) anchored at one end with titanium clips. Source: *Soluções Minimamente Invasivas Veterinárias* (SOMIV) −UFSM.

urinalysis revealed the presence of occult blood and the ultrasound found structures compatible with *D. renale* in the right side kidney (Fig. 1A). Nonetheless, the anatomical shape of the organ and part of the kidney cortex were preserved. The medullar region was not examined, but a positive Doppler signal was found in renal vessels. The anatomical shape of the left kidney was normal and free of parasites, with a regular contour, preserved dimensions, normal echogenic cortex and medulla regions, and preserved limits between them. In view of to the patient's clinical signs and ultrasound findings, he was subjected to a surgical procedure.

Acepromazine 0.01 mg/kg (Acepran® 1%, Vetnil, Louveira, São Paulo, Brazil) and methadone hydrochloride 0.4 mg/kg (Mytedom®, Cristália, Itapira, São Paulo, Brazil) were used intramuscularly as pre-anesthetic medications, and general anesthesia was induced intravenously with ketamine 1 mg/kg (Cetamin®, Syntec, Barueri, São Paulo, Brazil), lidocaine 2 mg/kg (Lidocaine hydrochloride®, HypoFarma, Ribeirão das Neves, Minas Gerais, Brazil) and propofol 3 mg/kg (Propovan®, Cristália, Itapira, São Paulo, Brazil). The patient was intubated with a size 6 endotracheal intubation tube (ETT) and anesthesia was maintained with 0.7–1 V% isoflurane (Isoforine®, Cristália, Itapira, São Paulo, Brazil) with 100% oxygen at a flow of 50 ml/kg/min and mechanical ventilation with a pressure of 12 $cmH_2O$ and a tidal volume of 12 ml/kg adjusting the respiratory rate to maintain normocapnia (35–45 mmHg). In addition, he received a continuous infusion of fentanyl citrate (Fentanest®, Cristália, Itapira, São Paulo, Brazil), lidocaine and ketamine (5 ml/kg/hr) during the maintenance of anesthesia. After stabilizing the anesthetic plane, the patient was placed in left side lateral decubitus and surgical field antisepsis was performed while maintaining the flank elevated with folded cloths (Fig. 1B). A right side lateral incision was made at the medial point between the iliac tuberosity and the costal margin slightly lateral to the height of the inguinal fold. Using the open technique, an 11 mm cannula (Karl Storz Endoskope®, Tuttligen, Germany) was inserted to pass through a rigid 10 mm endoscope (10 mm × 33.5 cm 0°, Karl Storz Endoskope®, Tuttligen, Germany), followed by insufflation of the abdominal cavity with medical $CO_2$ at 10 mmHg and 1.5 l/min (Electronic Endoflator®, Karl Storz Endoskope, Tuttligen, Germany). Two other trocars (11 mm and 6 mm) (Karl Storz Endoskope®, Tuttligen, Germany) were inserted in the right and left side lateral abdominal walls, respectively, to form a triangular arrangement among the portals (Fig. 1B). An examination of the abdominal cavity revealed the location of the right side kidney, which exhibited preserved anatomical shape and pulsation in the renal artery, enabling nephrotomy and thus the performance of nephron-sparing surgery.

Blunt dissection and isolation of the renal hilum were performed (Fig. 1C) for application of the Rummel tourniquet, which consisted of umbilical tape, a length of latex tubing, and 10 mm titanium clips (Europclip®, Ackermann Instrumente, Rietheim-Weilheim, Germany) (Fig. 1D) for temporary occlusion of the renal artery and vein. After that, nephrotomy was carried out in the dorsal pole region of the kidney, using Metzenbaum scissors to make an incision of approximately 0.5 cm to remove the parasite with Kelly forceps (Fig. 1E) through the reducer located in the second 11 mm trocar. Nephrorrhaphy was performed by means of intracorporeal suture in an interrupted pattern using size 3–0 polyglycolic acid suture (Ácido poliglicólico 3–0®, Point Suture, Fortaleza, Ceará, Brazil) anchored on one end with 10 mm titanium clips and finished with the placement of the same clip without prior application of knots (Fig. 1F). These clips are placed to apply tension upon closing, allowing the maneuver to be performed rapidly, as described by Choi *et al.* [5]. Kidney ischemia time was approximately 25 min, after which the tourniquet was removed with the aid of a bag made of a glove finger previously placed into the abdominal cavity through the second portal. Finally, the instrumentation was removed, the cavity was deflated, and the muscle and subcutaneous layers were sutured in an interrupted pattern with size-0 (Poliglactina 910 0®, Shalon, São Luís de Montes Belos, Goiás, Brazil) and 3–0 (Poliglactina 910 3–0®, Shalon, São Luís de Montes Belo, Goiás, Brazil) polyglactin suture, respectively. Cutaneous suture was carried out in a horizontal mattress pattern, using 4–0 monofilament nylon suture (Nylon 4–0®, Technofio, Goiânia, Goiás, Brazil).

The patient was prescribed postoperative tramadol hydrochloride 5 mg/kg (Tramadon®, Cristália, Itapira, São Paulo, Brazil) every 8 hr for 5 days, dipyrone 25 mg/kg (Dipirona®, Medley, Suzano, São Paulo, Brazil) every 8 hr for 5 days and meloxicam 0.1 mg/kg (Maxicam®, OuroFino, Cravinhos, São Paulo, Brazil) every 24 hr for 3 days. Immediate postoperative abdominal ultrasound revealed no presence of other parasites, or any sign of kidney damage caused by the parasite. Likewise, no alterations were found in the patient's kidney function in postoperative laboratory tests. Ultrasound exam performed 221 days after surgery revealed asymmetry between the kidneys: the length of the left kidney was 5.08 cm, while that of the right kidney was 2.67 cm. The right kidney exhibited a regular contour and normal echogenicity. In addition, despite the reduction and loss of cortical-medullar definition, the Doppler signal was normal, with a resistivity index (RI) of 0.59 in the caudal pole and 0.72 in the cranial pole.

*Case 2*: Canine, female, mixed breed, three years old, body weight of 21 kg, free-ranging owned dog with access to water bodies living in an underprivileged region. The patient was referred for elective spaying. During the surgical procedure, one *D. renale* specimen was found in the abdominal cavity. After its removal and conclusion of ovariohysterectomy, the patient was subjected to abdominal ultrasound, urinalysis, and new hematological tests. These tests revealed normocytic and normochromic anemia, thrombocytopenia, eosinophilia, and babesiosis. Urinalysis indicated the presence of *D. renale* eggs in the urinary sediment, in addition to occult blood and leukocyturia. Ultrasound images of the right side kidney were compatible with *D. renale* in the renal parenchyma. A comparison of kidney sizes showed the right kidney was 3.28 cm in length and 1.84 cm in width, whereas the left one measured 6.82 cm in length and 4.13 cm in width. The right kidney maintained normal internal and external echogenicity and approximately 0.53 cm of renal parenchyma. However, no Doppler signal was found in the renal vessels. After conclusion of the babesiosis treatment, dioctophymosis treatment was initiated. The patient was referred to the surgical ward for nephrotomy or nephrectomy, depending on the macroscopic alterations found during the procedure.

Intramuscular acepromazine 0.03 mg/kg and morphine 0.4 mg/kg (Dimorfz®, Cristália, Itapira, São Paulo, Brazil) were administered as pre-anesthetic medications, and general anesthesia was induced with ketamine 1 mg/kg, lidocaine 2 mg/kg, propofol 2 mg/kg and dexmedetomidine 2.5 µg/kg (Dexdomitor®, Parsippany-Troy Hills, NJ, USA) intravenously. The patient

was intubated with a number 10 endotracheal tube and maintained in 1V% of isoflurane with 100% oxygen at a flow of 50 ml/kg/min and mechanical ventilation with a pressure of 12 $cmH_2O$ and a tidal volume of 12 ml/kg adjusting the respiratory rate to maintain normocapnia (35–45 mmHg). Also, proper continuous infusion of 2.5 µg/kg/hr dexmedetomidine, 20 µg/kg/min ketamine and 50 µg/kg/min lidocaine was applied during maintenance of anesthesia. After with the anesthetic plane was stabilized, surgery was initiated as described for Patient 1. A visual examination of structures and proper assessment of the right side kidney revealed normal pulsation of the renal artery and preserved organ anatomy. This finding was the basis for deciding to preserve the kidney and remove the parasite through laparoscopic nephrotomy. The same surgical technique was applied to this patient, except that nephrorraphy was achieved with an interrupted suture initially fixated to the renal capsule and reinforcing knots between the two ends of the suture. Warm ischemia time was 16.5 min.

Due to babesiosis, in addition to postoperative analgesia, the patient was prescribed doxycycline 5 mg/kg (Doxitrat®, Agener União, São Paulo, Brazil) every 12 hr for 14 days. On the day of discharge from surgery, additional hematological and biochemical tests were performed, in addition to urinalysis and abdominal ultrasound. Among the main results, thrombocytopenia and eosinophilia in the full blood count and slight hematuria and bacteriuria stood out. Abdominal ultrasound showed the left kidney remained in its normal physiological aspect; however, due to excessive gas in the abdominal cavity, an evaluation of the right side kidney yielded no clear Doppler signal and no other *D. renale* specimen. An overall clinical evaluation was performed 30 days after surgery to ascertain the patient's physiological parameters. Other laboratory tests and abdominal ultrasound requests were refused by the owner, in view of the patient's good clinical condition.

Dioctophymosis has been reported in several locations around the world, including Brazil [2, 25, 35]. A recent study by Rappeti *et al.* [27] reported the occurrence of 95 cases of the disease in dogs and cats in the city of Pelotas, Rio Grande do Sul, Brazil. In fact, 29 of these cases were diagnosed between 2012 and 2015 at the HCV-UFPel. This underscores the importance of reports and studies in southern Brazil and demonstrates that veterinary medicine techniques rarely described in the literature, such as laparoscopic nephrotomy in dogs, may have a major impact on the treatment of other patients. As far as the authors of this paper are aware, the two cases presented here are the first in which the use of laparoscopic nephrotomy is described for the removal of *D. renale* in dogs.

The non-specificity of clinical signs stood out in the first case, as did the incidental intraoperative finding in the second patient, corroborating reports in the literature about the difficulty of interpreting symptoms, particularly when the parasite infects only one kidney [15, 17, 23]. Hematological and biochemical tests are recommended, since patients often exhibit eosinophilia and/or basophilia caused by parasitism with tissue invasion [32]. Hematuria, which was observed in both patients, can also be explained by progressive destruction of the renal parenchyma by the nematode [23]. Moreover, eggs were found in the urine of Patient 2, which occurs when a sexually mature *D. renale* female is found in the kidney [23]. Although urinalysis is not the only recommended way of diagnosing dioctophymosis, Perera *et al.* [26] observed that 18.6% of urine samples in dogs and cats were infected by the helminth, which highlights the importance of this test for the diagnosis of parasitic infections.

As observed in the cases reported herein, abdominal ultrasound was essential to diagnose dioctophymosis. The exam showed images similar to those described in the literature, which suggest the presence of the parasite based on multiple cylindrical and round structures 5–8 mm in diameter [33]. Moreover, an evaluation of the kidneys through Doppler flowmetry underpinned the recommended therapeutic protocol and helped provide a prognosis for both cases. Doppler ultrasound evaluation allows the dynamics of renal vascular flow to be analyzed by determining vascular RI, i.e., the resistance to blood flow in arteries [22]. Therefore, this method provides a quantitative analysis of kidney hemodynamics directly related to tissue perfusion [19]. RI (resistive index) values of 0.56 and 0.67 are considered normal for dogs [3]. However, the first patient exhibited a higher level after surgery, possibly indicating a reduction in renal perfusion. This is expected after conventional nephrotomy, due to the temporary reduction of 25 to 50% in kidney function [8]. With this in mind, the decision was made to use a less invasive approach involving mini-nephrotomy of approximately 0.5 cm in both cases. Regarding the size of the incision, the authors observed that the size of 0.5 cm was one of the smallest found in the literature, when compared to nephrolithotomy procedures for stone removal. For these, 3–4 cm incisions were used in laparoscopic and open surgeries [9, 10].

Animals affected by dioctophymosis initially exhibit atrophy and then gradual destruction of the renal parenchyma, which eventually results in only a thin capsule that contains the parasites and hemorrhagic exudate [21]. Such complete destruction of the kidney has often been reported [1, 7]; hence, nephrectomy becomes the therapy of choice in animals. However, in humans, nephrectomy is considered an uncommon procedure for the treatment of dioctophymosis [35]. Surgical removal of the nematode and of the damaged portion of the kidneys is the therapy of choice. In order to preserve the structure of the parasitized kidney, when diagnosed early, nephrotomy may also become the therapy of choice in veterinary medicine.

The decline in kidney function resulting from nephron trauma, rupture of intersegmental vessels, edema and fibrosis due to inflammatory response, and ischemia caused by temporary occlusion of artery flow are often reported when nephrotomy is performed in patients with associated renal disorder [37]. However, Stone *et al.* [31], who compared kidney function and parenchymal injury after nephrotomy techniques were applied in dogs, concluded that the procedures did not result in loss of kidney function and that a similar extent of healing was achieved by the techniques in up to four weeks after surgery. Likewise, King *et al.* [14] fund that felines subjected to nephrotomy exhibited reduced glomerular filtration rates in the postoperative period, but did not detect this difference in patients evaluated 52 and 78 weeks after surgery. In the present study, the longest time of postoperative evaluation was 31 weeks for the first patient, whose increased RI in Doppler flowmetry was the only alteration. Nevertheless, given his clinical conditions in association with the results of complementary exams, it was concluded that the patient seemed to have no reduction in kidney function as a consequence of nephrotomy. In both cases, the choice was to maintain

the kidney in accordance with the principles of nephron-sparing surgery, which seeks to maintain renal viability even when a major part of the organ has been compromised [16]. It must also be kept in mind that, especially in areas where *D. renale* is endemic, as is the case of the two animals in this study, if a patient that has undergone nephrectomy is infected again in the remaining contralateral kidney, the options for treatment and cure will be limited.

Other indications for nephrotomy, such as the removal of uroliths, exploration of the renal pelvis in cases of neoplasia, or idiopathic hematuria [13, 20], can also be performed using laparoscopy. This approach provides a greater level of evidence of anatomical structures, minimal damage to the renal parenchyma, as well as improved stability of blood loss and less pain at the surgical site [36].

In the cases described in this manuscript, the surgical time was approximately 160 and 120 min, while the ischemia time was approximately 25 and 16.5 min, respectively. As described in the literature, to perform the laparoscopic nephrolithotomy, there was a surgical time of 127.5–192 min and the ischemia time had a margin of 20.8–32.8 min. While open procedures demonstrated a total surgical time of 121–180 min and ischemia time of 33 min [10]. We observed that the surgical times do not differ when comparing laparoscopic and open nephrotomy, however, the indication for nephrotomy is different from the cases presented, and, therefore, it is difficult to compare the times, since there are no reports of nephrotomy for removal of *D. renale*. Regarding ischemia time, we obtained a maximum time of 25 min, as according to Simmons *et al.* [29], shorter times or up to 30 min of ischemia are associated with minimal renal damage in patients with normal preoperative function. In addition, no intraoperative complications were reported and it is noteworthy that patients benefited from the potential advantages of laparoscopic procedures, such as rapid postoperative recovery, minimum tissue invasion, little postoperative pain, and lower rates of adherence and complications related to the surgical wound.

Laparoscopic nephrotomy proved effective in both cases described here, with the patients experiencing satisfactory recovery and having their right side kidneys preserved. Dogs living in regions with favorable conditions for dioctophymosis may benefit from treatment involving laparoscopic nephrotomy, since they can be reinfected, thus underscoring the importance of preserving the kidney whenever possible. The surgical technique described here allows nephrotomy to be performed on dogs and can be added to the list of procedures for the treatment of dioctophymosis in canines.

CONFLICT OF INTEREST STATEMENT. The authors declare they have no conflict of interest, and that they are responsible for the content and writing of this paper.

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