Canine Caval Syndrome Series

PART 3: MANAGEMENT OF CAVAL SYNDROME

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Caval syndrome (CS) is a life-threatening illness caused by a mass of heartworms located aberrantly in the right atrium, the ventricle, and often the vena cava. The worm mass interferes with closure of the tricuspid valve and impedes normal flow of blood through the right heart, leading to cardiovascular collapse.

To re-establish normal cardiac function, CS must be promptly treated by surgically extracting the mass of worms. Without surgical intervention, CS is associated with a grave prognosis. Even when surgery is not successful, attempting to help is better than knowing we did nothing to help.

This article focuses on the management and surgical removal of heartworms in dogs presenting with CS. Visit tvpjournal.com to read Parts 1 and 2 of this article series—Understanding Development of Caval Syndrome (November/December 2015) and A Practical Approach to Diagnosing Caval Syndrome (January/February 2016).

CLIENT EDUCATION
Most pet owners have a poor understanding of heartworm infection. The clinician must, therefore, begin with the basics of heartworm education and expand the discussion to cover the specifics of CS (see What the Client Needs to Understand, page 56).

It is important to:
• Explain that a mass of adult heartworms is hindering the normal blood flow through the heart and surgical extraction of the blockage is necessary if there is to be a reasonable chance for recovery
• Emphasize that CS progresses rapidly and treatment delay can be fatal, with most pets dying within a few days
• Urge the owner to promptly decide to allow treatment, and then move immediately toward surgical worm extraction.

Because pets diagnosed with CS often have not received preventive medication, and realizing this is a costly disease with an uncertain prognosis, pet owners often elect euthanasia. Even when treatment is chosen, financial constraints often lead to modification of the optimal diagnostic and therapeutic plan.

PROGNOSIS
One would expect that the prognosis for a pet presenting with CS could be based on the degree of clinical signs or diagnostic findings. Kitagawa and colleagues found that the degree of metabolic disturbance was measurably different in nonsurviving dogs compared with those that survived. Nonsurvivors had more significant elevations in
urea nitrogen, uric acid, and serum potassium levels, and decreases in sodium and chloride.5 Despite attempts to establish measurable prognostic aids, one of the most important indicators of survival in pets with CS was the total number of worms surgically removed from the individual. Removal of high numbers of worms may reflect elimination of the obstruction. As such, pets that are gravely ill at presentation can return to normal within days after successful worm extraction, whereas pets that present in a relatively stable condition may not survive if an ample number of worms is not extracted.

No specific diagnostic test consistently predicts which pets will, or will not, recover from CS. Because we are unable to predict the number of worms that will be removed surgically, the prognosis for pets presenting with CS must always be stated as guarded but hopeful, and potential outcomes vary widely (Table 1).

ANCILLARY DIAGNOSTICS
As described in the second article in this series—A Practical Approach to Diagnosing Caval Syndrome (January/February 2016)—CS can cause circulatory collapse, hemolytic anemia, organ failure, and coagulopathy. Thus, ancillary diagnostic tests are indicated, and include:2,4-13
- Complete blood count (CBC)
- Serum biochemical profile
- Coagulation panel
- Blood gas analysis
- Thoracic radiography
- Electrocardiography
- Echocardiography.

Although comprehensive diagnostic workups help provide optimal management, the practitioner must be mindful that the cost of diagnostics can make treatment unaffordable to many clients. Additionally, if treatment is delayed while results of outsourced tests are awaited, the patient’s condition can dramatically and rapidly decline. I recognize the value of each of the aforementioned tests, but suggest that a more pragmatic approach to diagnostics is sometimes necessary.

Much of CS is predictable. For example, thoracic radiographs are likely to depict changes consistent with heartworm disease, hypoxia and acidosis are expected, liver enzymes are dramatically elevated, and right-heart and pulmonary artery pressures are typically increased. Less certain findings can also exist and, when present, more directly influence treatment, prognosis, or both.

Thus, the 3 most important factors to evaluate during the preoperative period, and the 3 diagnostic tests that represent the basic minimum database, include:
- 1. The degree of anemia secondary to hemolysis,
- 2. Right-heart and pulmonary artery pressures, and
- 3. Thoracic radiographs.

What the Client Needs to Understand
- How and why heartworm infection occurs.
- In CS, adult worms have impaired blood flow through the right heart.
- Surgical extraction of the mass is the only reasonable chance of cure.
- Without surgery, most pets die within a few days, so a prompt decision to treat must be made.
- The prognosis is guarded despite aggressive management, and successful outcome cannot be guaranteed.
- While surgery can remove the mass of worms from the heart, it will not remove worms from the pulmonary arteries.
- An adulticide treatment must follow surgical recovery.
- Treatment will be expensive.

Visit heartwormsociety.org, then select Veterinary Resources from the top menu and Client Education to view a variety of tools for educating pet owners about heartworm disease.

TABLE 1. Caval Syndrome: Potential Outcomes

<table>
<thead>
<tr>
<th>TREATMENT APPROACH</th>
<th>RESULT</th>
<th>PROGNOSIS</th>
</tr>
</thead>
<tbody>
<tr>
<td>No Surgery</td>
<td>Worm mass remains in patient</td>
<td>Grave</td>
</tr>
<tr>
<td>Successful Surgery</td>
<td>Patient becomes clinically normal within 24 hours</td>
<td>Excellent</td>
</tr>
<tr>
<td></td>
<td>Patient recovers over period of days as renal and other metabolic issues resolve</td>
<td>Good</td>
</tr>
<tr>
<td></td>
<td>Patient remains ill due to irreversible organ failure and metabolic dysfunction</td>
<td>Poor</td>
</tr>
<tr>
<td></td>
<td>Patient remains ill due to obstructive pulmonary vascular disease or the presence of tricuspid valve disease</td>
<td>Poor</td>
</tr>
<tr>
<td></td>
<td>Patient dies of anesthesia-related perioperative complications</td>
<td>Death</td>
</tr>
<tr>
<td>Unsuccessful Surgery</td>
<td>Worms cannot be surgically removed from patient</td>
<td>Grave</td>
</tr>
</tbody>
</table>
which may be dramatic enough to require blood transfusion. A simple CBC, or even a packed cell volume (PCV), can resolve the question of anemia.  

2. The severity of renal impairment resulting from hypoperfusion, which may negatively influence prognosis and may predict a prolonged postoperative recovery. An abbreviated serum biochemical profile that includes blood urea nitrogen and creatinine can help assess renal function.  

3. The potential for significant cardiac arrhythmias, which may require specific treatment. Thorough cardiac auscultation can identify obvious arrhythmias, but electrocardiography allows identification of the specific arrhythmia, facilitating treatment.

Given the importance of a surgical cure, it may sometimes be appropriate to forego more extensive testing and quickly move to surgery.

MEDICAL MANAGEMENT

Attempts to treat CS medically are typically met with a poor outcome. Substantial improvement can be obtained only after surgical worm extraction. Therefore, the primary objective of medical care is to stabilize the pet’s condition so that surgery can be completed.

Presurgical Treatment

Presurgical treatment should be directed at correcting hypoxia, significant anemia, volume status, and acid–base abnormalities:  

- **Supplemental oxygen** is beneficial and can be administered via face mask, but use of a nasal cannula or oxygen cage may be more effective and less stressful for the anxious pet.  
- **Blood products** should be given only if necessary to correct severe anemia. If the patient’s PCV acutely drops below 25%, transfusion with blood from a dog that is negative for dog erythrocyte antigen 1.1 should be considered in order to optimally stabilize the patient for anesthesia.  
- **Intravenous fluids** are essential, although the proper rate of administration continues to be debated. Most patients with CS tolerate and benefit from relatively aggressive fluid administration during anesthesia and surgery as a volume loading deficit is present in the right heart.  
- **Glucocorticoids** are commonly administered because many pets with CS have concurrent pulmonary embolic disease, an indication for their use. Depending on clinical presentation, anti-inflammatory or shock treatment doses may be used.

Other Treatment Options

Heparin can be administered when disseminated intravascular coagulation is suspected. Antiarrhythmics are added as necessary. Other treatment options include various antithrombotic agents, antihistamines, and antibiotics, although no scientific basis for their use has been documented.

ANESTHETIC MANAGEMENT

Treating CS requires anesthetizing a patient that is in a compromised cardiovascular state. The degree of illness dictates the type and level of anesthesia required; the most important consideration to remember is less is more.  

Appropriate anesthetic management includes:  

- Preoxygenating and surgically prepping all patients with CS (as much as is possible) before any sedation or anesthesia is administered  
- Assigning one technician to solely monitor physical parameters during anesthesia  
- Incorporating continuous electrocardiography, blood pressure, and pulse oximetry for anesthetic monitoring, if possible  
- Using local anesthetic techniques frequently, which decreases the depth of general anesthesia required to complete surgical extraction.

No single anesthetic protocol has been shown to be optimal for use in patients with CS. The goal of anesthesia should be to keep the patient comfortable but quiet until the mass of worms is successfully extracted.

- Moribund pets can often be surgically treated using only a local anesthetic, supplemental oxygen, and gentle restraint.  
- Relatively stable pets may be able to tolerate full anesthetic induction and maintenance.  
- Most patients with CS fall somewhere in between moribund and stable, requiring thoughtful consideration with regard to drug choice and level of anesthesia desired. It is important that clinicians use drugs with which they are familiar.

Table 2 provides a partial list of anesthetic combinations that have been used successfully in patients with CS.

| TABLE 2. | Anesthetic Combinations* Used Successfully in Patients with CS

| Benzo diazepine + local anesthetic |
| Benzo diazepine + butorphanol + local anesthetic |
| Benzo diazepine + fentanyl + lidocaine constant rate infusion + local anesthetic |
| Benzo diazepine + ketamine + local anesthetic |
| Benzo diazepine + propofol + local anesthetic |
| Isoflurane/sevoflurane induction and maintenance + local anesthetic |

* Supplementation with isoflurane or sevoflurane can be considered with most protocols, keeping in mind that the goal is less is more.
Surgical Management

Any veterinarian capable of diagnosing CS probably has the basic surgical skills necessary to perform caval surgery. The surgery itself is relatively simple and can be easily accomplished without sophisticated or expensive equipment. Because most pets with CS will die without surgery, I urge all practitioners to attempt the procedure whenever presented with the need.

Retrieval Tools

The only special requirement for caval surgery is an instrument that can serve as a retrieval tool. Various instruments have been used successfully, but most practitioners choose alligator forceps (Figure 1) or a basket retrieval device (Figure 2) for this purpose.16-21

Various sizes of alligator forceps are available, although a single instrument, both long and slender, can be suitable for all but the smallest toy breeds. Basket retrieval devices are readily available through most endoscopy supply companies.

When these instruments are unavailable, standard red rubber feeding tubes can be modified and used in their place (Figure 3). They can be quickly modified for caval surgery by tying multiple monofilament sutures near the end; these sutures should be tied securely so they do not loosen and become lost during surgery.

Step by Step

STEP 1. To shorten the duration of anesthesia, surgically clip and prepare the area over the right jugular vein before anesthetic induction. All instruments are opened and ready, and the surgeon should be scrubbed.

STEP 2. Upon anesthetic induction, place the patient in left lateral recumbency and drape the surgical site.

STEP 3. Make an incision over the right jugular vein (Figure 4) and expose a reasonable section of the vein via blunt dissection.

STEP 4. Use stay sutures, umbilical tape, or Penrose drains to elevate the vein and help control hemorrhage (Figure 5).

STEP 5. Make a small incision in the jugular vein, just large enough to allow access of the retrieval instrument. Unless fluoroscopy is available, the instrument will be passed blindly to the level of the heart, so it is necessary to measure the distance from the venotomy site to the level of the loudest cardiac sound or right apical impulse. This is the target area where the worms are expected to be located.

STEP 6. Depending on the retrieval instrument used, there are a few variations in technique to consider; see Heartworm Retrieval Techniques.

STEP 7. If no worms have been retrieved, continue to make attempts. Without worm extraction, it is unlikely the pet will recover.

STEP 8. Make every effort to retrieve the mass of worms but realize that success is not always possible and that occasionally worms will migrate into the pulmonary artery after induction of general anesthesia, making retrieval challenging if not impossible.

STEP 9. Once a substantial number of worms have been recovered and several additional passes have failed to retrieve more, use ultrasonography to visualize the right heart. If no worms are observed, the procedure is completed. If ultrasonography is unavailable, auscultate the heart; if the tricuspid murmur has resolved or been reduced substantially in intensity, it is reasonable to believe that the obstruction has been removed.

STEP 10. Upon completion, most surgeons prefer to ligate the jugular vein above and below the venotomy site, although the vein can be preserved by using good vascular closure technique. Closure of the surgical site is otherwise routine.
Heartworm Retrieval Techniques

**Alligator Forceps**
- Insert the closed end of the forceps into the venotomy site and advance it past the thoracic inlet (Figure 6). Because this instrument is rigid, it is the most difficult to pass through the thoracic inlet. Patience and care are necessary to avoid traumatizing delicate vascular tissue.
- Gently manipulate the instrument into the cranial vena cava without penetrating the thin venous wall. The target location is the level of the loudest cardiac sound.
- Once in the cranial vena cava and near the heart, begin attempts to retrieve worms by opening the jaws of the forceps, advancing forward a few centimeters, and gently closing the forceps before withdrawing the instrument.
- Be gentle because these forceps can potentially grasp and tear the atrial wall or a tricuspid valve leaflet and can easily crush fragile adult worms (see Reaction to Damaged Worms, page 60).
- Repeat the procedure until no additional worms are retrieved (Figure 7).

**Basket Retrieval Device**
- Because of its small diameter and flexible nature, the basket device is the easiest to use. It passes readily through the thoracic inlet with minimal chance of damaging the vena cava. Because it does not grasp, there is little risk for damaging the atria or valve leaflets.
- Insert the closed basket into the venotomy site and pass it to the level of the heart. Open the basket, count to 3, and then partially close the basket and withdraw the instrument.
- Do not close the basket completely because doing so can damage or possibly sever any heartworms it contains (see Reaction to Damaged Worms). Experiment with your device to see how little it needs to be closed in order for it to grasp.
- Repeat the procedure until no additional worms are retrieved (Figure 8).

**Red Rubber Feeding Tube**
- Like the basket retrieval device, this tube is fairly easy to pass through the thoracic inlet and is flexible enough that it is unlikely to puncture the venous wall.
- Because suture knots on this device can irritate the venous surface and snag valve leaflets, be gentle upon insertion and removal.
- Manipulate the device into the venotomy site and pass it to the level of the heart, count to 3, and then rotate clockwise or counterclockwise several times before removal. Repeat until no additional worms are retrieved (Figure 9).
POSTOPERATIVE CARE

With successful caval surgery and re-establishment of normal cardiac output, it is impressive how quickly patients can improve (Figure 11). Hemolysis almost immediately stops, hepatic congestion resolves, oxygen levels increase, renal perfusion normalizes, acidosis corrects, and many pets are ready for discharge the following day.

Prolonged or significant renal impairment can require additional supportive care, but these pets usually recover within a few days. Some patients will continue to exhibit signs of right-sided heart failure. When this occurs, it may be reasoned that there is:

- Persistent disease of the tricuspid valve (ie, entanglement of heartworm(s) in the chordae tendineae [Figure 12])
- Significant obstructive disease within the distal pulmonary arteries (Figures 13 to 15).

These scenarios have less predictable outcomes and may require longer term cardiac management with potential resolution over weeks to months. Some patients never completely normalize.

POSTOPERATIVE ADULTICIDE TREATMENT

Caval surgery can remove the heartworms within the right heart but does not reach into the pulmonary arteries to eliminate all of the worms. For this reason, it is important to administer adulticide treatment after the patient’s surgical recovery.

According to the guidelines of the American Heartworm Society, a course of doxycycline should be completed, followed by an additional month of rest before the administration of the 3-injection adulticide treatment.22

After caval surgery, however, as long as pets normalize quickly, I typically suggest that adulticide treatment be administered beginning 2 weeks after surgical recovery rather than the usual 2 months.

IN SUMMARY

Heartworm disease is a complicated illness that presents a wide range of challenges, including the life-threatening illness CS (class IV heartworm disease). CS is particularly challenging because, unlike other presentations of heartworm disease, it is an urgent surgical rather than medical condition. It is, therefore, imperative that veterinarians not only recognize the clinical signs of CS but also understand that without taking the necessary next step, surgery, the outcome is almost always fatal.

Caval surgery requires little to no specialized equipment. It is a relatively simple procedure that most clinicians can successfully perform; even those attempting the surgery for the first time. Because caval surgery is a life-saving measure, clinicians are urged to recommend it as the appropriate treatment whenever the diagnosis of CS is confirmed.
of adult worm death. Ease is chronic, resulting from multiple episodes of thrombi, and necrotic debris. It is evident that much of this dis-embolization, well-organized granulation tissue, and significant fibrosis make it unlikely for disease such as this to completely resolve.

FIGURE 13. The main pulmonary artery is dilated and thickened with rugus endarteritis. Multiple branches of this distal artery are obstructed by dead worms, well-organized granulation tissue, and necrotic debris.

CBC = complete blood count; CS = caval syndrome; PCV = packed cell volume

References

FIGURE 14. This distal arterial branch contains both live and dead worms. The addition of active embolization, well-organized granulation tissue, and significant fibrosis make it unlikely for disease such as this to completely resolve.

FIGURE 15. This pulmonary artery contains dead adult worms that appear to have recently died. The distal aspect of this artery is completely occluded by well-organized granulation tissue, remnants of dead worm(s), and significant necrotic debris. It is evident that much of this disease is chronic, resulting from multiple episodes of adult worm death.

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