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Case report

Surgical closure of patent ductus arteriosus with persistent left cranial vena cava in an infant dog

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Abstract. A 40-day-old, non-spayed, female, Toy Poodle-based mix breed dog (body weight 515 g) was referred for delayed growth, decreased appetite, and worsened respiration. She was diagnosed a left to right shunt patent ductus arteriosus (PDA), with heart congestion, flattening of the interventricular septum and sinus bradycardia. It was difficult to control with conservative management. Surgical closure of the PDA with hemoclip application was performed. The residual shunt had resolved, and she grew up healthy without any medication. Surgical closure of the PDA with hemoclip can be conducted safely in a small puppy.

Key Words: patent ductus arteriosus, hemoclips, surgical management, infant dog.

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Case history

A 40-day-old, non-spayed, female, Toy Poodle-based mix breed dog with body weight (BW) of 515 g was referred to our hospital for delayed growth, decreased appetite, and worsened respiration (Tachypnea, Labored and Orifice Respiration). The body condition score was 3/5, and visible mucous membrane was slightly pale. A continuous murmur without thrill was detected on the left thoracic wall. Her breathing condition worsened easily under stress, and she was admitted directly to hospital as an emergency to the oxygen room (Day 1).

Transthoracic echocardiography (F75 ultrasound system: Hitachi Aloka Medical, Ltd, Tokyo, Japan) showed a left to right patent ductus arteriosus (PDA) shunt with a decreased flow rate. The maximum shunt flow velocity of the PDA was 3.5 m/s. The duct's diameter was about 5 mm. The early diastolic filling velocity (E wave) was 2.0 m/s, which showed severe congestive heart failure.

Other observations included flattening of the interventricular septum and mitral regurgitation (MR). In addition, a persistent left cranial vena cava (PLVC) was suspected based on it crossing the left atrium and connecting to the right atrium in the right four chamber view. These findings showed that this dog had severe congestive left heart failure and pulmonary hypertension, but there was no sign of an Eisenmenger's syndrome at that time.

The dog was medicated with furosemide (4.0 mg/kg/day) (for six days: from Day 1 to Day 6) and pimobendan (0.25 mg/kg, twice a day) (for three days: from Day 4 to Day 6). Though she was in the oxygen room, she occasionally showed sinus bradycardia with cyanosis. Therefore, surgical closure of the PDA with hemoclip application was performed on day 6.

In order to avoid the stress of vascular access, the dog was induced in an induction box connected to an isoflurane vaporizer, and she was intubated with a 2.5-Fr endotracheal tube. After induction of anesthesia and intubation, atropine (0.05 mg/kg, sc) was injected. Anesthesia was maintained with isoflurane (3.5-4.0%) (Isoflurane for Animal Use®; Intervet K.K., Tokyo, Japan). The 4th intercostal space was opened first, but cardiac displacement in the thoracic cavity was evident, and PLVC was observed over the duct. The PLVC was pulled to the cranio-dorsal side at the 4th intercostal space to provide surgical space. Then, the 5th intercostal space was opened, and a pericardial tent was made with 4-0 nylon thread. In order to reduce the surgical time (Mandhan et al 2006) and avoid hemorrhage behind the duct, duct closure was conducted with application of a titanium hemoclip (Aesculap® Titanium Ligating Clips and Appliers: B. Braun Aesculap Japan Co. Ltd., Tokyo, Japan). The clip was 8.1 mm in width and 7.9 mm in length. The clip was applied over the duct and was closed very softly to avoid rupture of the duct. After clip application, the pulmonary artery thrill disappeared. No echocardiographic study was conducted to check for a residual shunt during the operation. A chest tube (3-Fr) was inserted before chest closure. The amount of intraoperative bleeding was very limited.

Postoperative recovery was quick and uneventful. The dog showed good appetite and walked on her own two and a half hours after the operation. There was slight retention of the pleural effusion (postoperative 12 hours: 0.24 ml/kg/h), and the chest tube was removed 24 hours postoperatively after it was confirmed that no more pleural effusion was being absorbed. The oxygen density of the oxygen room was reduced progressively, and the dog was moved to a room air cage 20 hours postoperatively. The dog went home the day after surgery because her breathing was improved, and there were no signs of cyanosis. Postoperative improvement of heart congestion was also remarkable. The E wave was decreased to 0.6 m/s on day 6, although a residual shunt was still observed. On day 43, the

residual shunt was no longer observed, and she grew up healthy to 1.1 kg without any medication.

Discussion

PDA is one of most common congenital heart diseases in dogs (Meijer & Beijerink 2012; Broaddus & Tillson 2010). Poodles (Parker et al 2006), Chihuahuas (Bomassi et al 2011), Dutch Stabyhoun (den Toom et al 2016) and many other breeds (Broaddus & Tillson 2010; Oswald & Orton 1993) have an established predisposition for PDA.

PDA is more common in females than males in many breeds (Ackerman et al 1978). In the nonsurgical group, it was reported that more than 50% died within 1 year of examination (Eyster et al 1976). Surgical treatment is therefore recommended. When the patient is very small, invasive procedures requiring anesthesia as well as a surgeon of advanced skills, are often delayed until the patient has reached a safe and larger size. However, when the patient's condition is severe, waiting for growth might exacerbate the heart failure. The purpose of this case study was to investigate the treatment strategy for severe PDA in a small puppy. In the treatment, the effectiveness of an induction box for anesthesia and hemoclip application for surgical closure of a PDA in a severely ill infant dog was evaluated.

PDA requires surgical treatment as soon as the patient's condition stabilizes. However, determining when to perform surgery for PDA patients is a difficult issue, and it should be done based on balancing the merits and risks of surgery in an extremely low body weight infant dog, because of the risks of anesthesia and surgery.

The present patient had some difficulty in medical control. At initial presentation, transthoracic echocardiography showed a highly elevated E wave (2.0 m/s), which is closely related to congestive heart failure (June A.Boon, Veterinary Echocardiography, 2nd Edition, 2011) (Boon 2011), even though the E wave is affected by left atrial pressure and diastolic function, etc. This result suggested severe congestive left heart failure. Medical control with furosemide and pimobendan did not improve her condition, and it seemed problematic to wait for growth. Thus, surgical intervention was superior to medical control to achieve radical improvement in her condition. In addition, although the condition of the dog was very severe, the dog did not show any sign of an Eisenmenger's syndrome. This also supported the need for surgical intervention in this dog considering the state of her illness (Seibert et al 2010). On the other hand, the risk of the operation for this patient was its size. In a small patient, there also risks of intubation, an inability of the patient to tolerate general anesthesia, and difficulty to complete the surgical procedure in the small thoracic cavity. The present case showed that, if a patient has failed to thrive or has overt congestive heart failure, the ductus should be interrupted, regardless of age and size.

There are two options for surgical closure of a patent duct. One is surgical ligation, and the other is transvenous catheterization (interventional radiology (IVR)). IVR includes percutaneous placement of embolization coils (Tanaka et al 2001) or Amplatzer device (Smith & Martin 2007). When the patient is very small, it is necessary to wait for growth, especially in IVR. IVR is limited by blood vessel diameter size to insert a device from a peripheral vessel, even though IVR is minimally invasive compared with surgical ligation (Meijer & Beijerink 2012; Broaddus & Tillson 2010). According to a previous report, IVR was safe and effective for small dogs with a BW of more than 1.5 kg (Stauthammer et al 2015), and 1.0 kg to 2.9 kg (Henrich et al 2011). However, as in the present case, IVR is physically impossible for an infant puppy that is smaller than these reports. Thus, we selected surgical closure of the PDA, which is the most minimally invasive procedure with a vascular clip. Although there are various approaches to surgical ligation for PDA (Selmic et al 2013; Goodrich et al 2007; Broaddus & Tillson 2010; Birchard et al 1990), most of them have some difficulties in dissecting connective tissue around the friable duct. This increases the duration of the procedure and the risk of duct rupture. On the other hand, the clipping method is simple and minimally invasive compared to the traditional ligation technique, because it requires minimal blunt resection around the duct (Corti et al 2000; Valentik et al 2007). We considered that the advantages of this method outweighed the disadvantage (the risk of residual ductal flow and recanalization of the PDA after surgery). As shown in the present case, residual shunting is one of the reported complications of surgical treatment of PDA (Campbell et al 2006; Stanley et al 2003). However, a residual shunt usually disappears with the growth of the patient and does not become a major problem, because in our opinion, clip size does not change as patient size increase.

For surgery of infant dogs with heart failure, anesthesia management is another important problem. We used an induction box in order to avoid stressful conditions associated with anesthesia induction. In this patient, no vascular access was available, but intratracheal, intracardiac, or intramedullary injection was available if necessary. Surgical correction was very effective for the reduction of heart congestion, so the patient recovered quickly and uneventfully without any inotropes, vasodilators, and diuretics.

With proper selection of anesthesia and the surgical procedure, PDA closure can be conducted safely in a puppy. Many treatment methods are reported for dog with PDA, surgical (Meijer & Beijerink 2012; Goodrich et al 2007), clipping (Corti et al 2000; Borenstein et al 2004) and IVR (Wesselowski et al 2017; Henrich et al 2011; Hildebrandt et al 2010). Surgery is necessary for left to right shunt PDA (Bureau et al 2005; Saunders et al 2014), because if the dogs with PDA were not treated, 64% died within one year of the examination (Eyster et al 1976). However, the choice of the treatment method may be difficult for extremely low body weight infant dogs. In this case, an infant dog was treated by surgical closure of the PDA with hemoclip application. This method is reported to have a risk of significant residual ductal flow and recanalization of the PDA (Corti et al 2000). However, the clipping method required minimal blunt resection around the duct (Corti et al 2000; Valentik et al 2007), and this method has relative technical simplicity and shorter operative time (Mandhan et al 2006) and is less invasive (Iwase et al 2003). Thus we consider that the advantages of this method can overcome its disadvantages.

The limitations of this study include the small sample size, as there was only one case. It is necessary to verify the effectiveness and complications of this approach in many cases in the future. We would like to verify the perioperative and postoperative progress and complications, as well as whether a residual

shunt usually disappears with the growth of the patient and does not become a major problem with this clipping method in future studies.

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