Journal of Veterinary Internal Medicine
Open Access

Case Report
J Vet Intern Med 2017;31:1221–1224

Interventional Closure of a Patent Ductus Arteriosus Using an Amplatz Canine Duct Occluder in an Alpaca Cria

E.C. Chapel, J. Lozier, J. Lakritz, and K.E. Schober

A 6-month old female alpaca cria presented to The Ohio State University for evaluation of a cardiac murmur. Echocardiography revealed a left-to-right shunting patent ductus arteriosus, a restrictive left-to-right shunting perimembranous ventricular septal defect, and secondary moderate left atrial and ventricular dilation. Aortic root angiography demonstrated a type IIA patent ductus arteriosus (PDA). Interventional closure of the PDA was successfully performed, without complication, using an Amplatz canine duct occluder. This case report describes the materials and methods used for interventional closure of a PDA in an alpaca cria.

Key words: Camelid; Congenital; Minimally invasive.

A 6-month-old female alpaca cria was referred to The Ohio State University Food and Fiber Animal Medicine and Surgery Service for poor weight gain and evaluation of a previously diagnosed cardiac murmur. The dam rejected the cria at young age, causing her to nurse from other dams on the farm. The animal's growth was stunted with a body weight of 13.4 kg. The expected body weight for a 6-month-old alpaca cria is 25–30 kg.[1] On presentation, a grade V/VI continuous murmur was heard with a palpable thrill over the craniodorsal left heart base. The femoral pulses were hyperkinetic with a synchronous pulse rate of 80 pulses per minute. Respiratory rate (36 breaths per minute) and effort were normal and pulmonary auscultation was unremarkable. Given the murmur characteristics and femoral pulse quality, a patent ductus arteriosus (PDA) was suspected.

Transthoracic echocardiography[a] (TTE) was performed in the unsedated, restrained, and laterally recumbent patient using a 5 MHz phased-array transducer. The fiber over the region of the cardiac notch was shaved to improve image quality. Two-dimensional echocardiography revealed a moderately dilated left atrium (LA) (left atrial diameter, 46 mm) with dilated pulmonary venous ostia (Fig 1A).[2] The mitral valve leaflets appeared normal and competent. The left ventricle demonstrated moderate eccentric hypertrophy (left ventricular internal diastolic dimension, 49 mm) with preserved systolic function.[2] The right heart chambers were unremarkable. Spectral and color flow Doppler imaging (CFD) demonstrated a small (1.6 mm), restrictive muscular, inlet ventricular septal defect (VSD) with left-to-right shunting (Fig 1B, VSD peak velocity 4.5 m/s). As apical muscular VSDs are frequently diagnosed in alpacas at the authors' institution, the left ventricle (LV) apex was thoroughly assessed for defects in this region. There was a focal muscular thinning in the apical interventricular septum; however, turbulent blood flow in this region was not seen. A continuous left-to-right shunting PDA was confirmed (PDA peak velocity = 4 m/s, Fig 2A). The ductus was well visualized with TTE and appeared to taper abruptly at the left pulmonary artery branch. Given the restrictive nature of the VSD, it was estimated that the left heart enlargement was predominantly the result of the PDA. Therefore, the recommendation was made to have the PDA closed interventionally to prevent future development of left-sided congestive heart failure.

The cria returned 2 weeks later for interventional closure of the PDA. The body weight on representation was 14.2 kg. The murmur quality had not changed and the patient remained asymptomatic for cardiac disease. Preprocedural planning considered options for both coil embolization and Amplatz canine duct occluder[b] (ACDO) placement with the final material selection being based on the angiographic appearance of the PDA at time of interventional closure. The delivery sheath length was selected by estimating the distance

Abbreviations:

ACDO	Amplatz canine duct occluder
CFD	color flow Doppler
CHD	congenital heart disease
FS	fractional shortening
LA	left atrium
LVIDD	left ventricular internal dimension in diastole
LV	left ventricle
MDD	minimal ductal diameter
PDA	patent ductus arteriosus
TEE	transthoracic echocardiography
VSD	ventricular septal defect

From the College of Veterinary Medicine, The Ohio State University, Columbus, OH (Chapel, Lozier, Lakritz, Schober).

This case was presented to and treated at The Ohio State University, Veterinary Medical Center.

This case was presented at the 2016 International Camelid Health Conference, Columbus, OH.

Corresponding author: E.C. Chapel, College of Veterinary Medicine, The Ohio State University, 601 Vernon L Tharp , Columbus, OH 43210; e-mail: chapelvet@gmail.com

Submitted January 8, 2017; Revised March 24, 2017; Accepted April 12, 2017.

DOI: 10.1111/jvim.14736

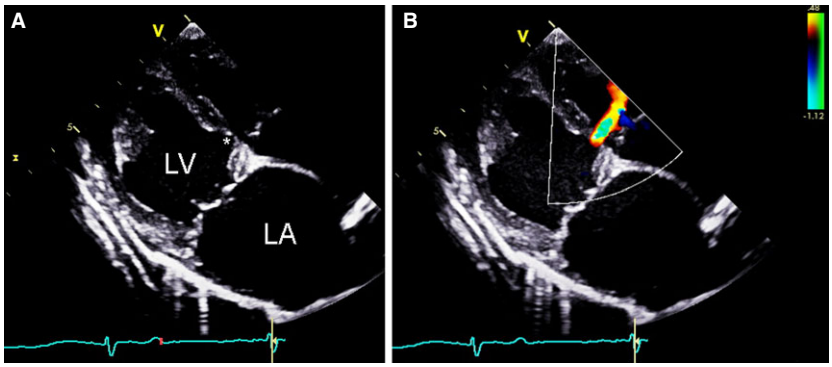

Fig 1. Two-dimensional echocardiographic images from a right parasternal long-axis view. (**A**) Note the moderate left atrial (LA) enlargement and left ventricular (LV) eccentric hypertrophy. There is focal echo dropout of the dorsal muscular portion of the interventricular septum (*). (**B**) Color flow Doppler demonstrates turbulent left-to-right shunting.

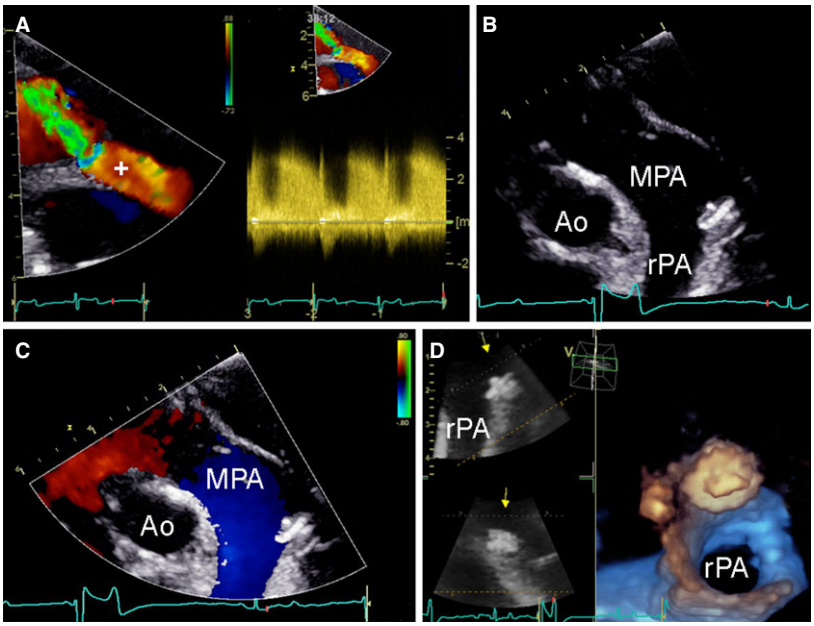

Fig 2. Transthoracic echocardiography (TTE) of the patent ductus arteriosus (PDA). (**A**) Two-dimensional imaging of the left cranial parasternal view optimized for the PDA and associated continuous wave spectral Doppler flow profile. Note the continuous, high velocity aorta to pulmonary artery flow across the PDA (+). (**B**) The same echocardiographic view as in panel A demonstrating proper placement of the Amplatz canine duct occluder (ACDO) device. (**C**) Color flow Doppler in the same region as panel B demonstrates complete attenuation of ductal flow. (**D**) 3D TTE of same region as panel B, showing the ACDO in position. Ao, aorta; MPA, main pulmonary artery; rPA, right pulmonary artery.

from the right inguinal region to the heart base. A variety of ACDO's and thrombogenic coils were available as needed, based on angiographic measurements of the minimal ductal diameter (MDD) and ampulla.

The cria was premedicated with midazolam (0.1 mg/kg IV) followed by injectable general anesthesia with propofol (4.3 mg/kg IV). Maintenance anesthesia was achieved with vaporized isofluoroane in oxygen via a circle rebreathing system. Ceftiofur (2.2 mg/kg IV) was administered immediately prior to the procedure.

The cria was placed in dorsal recumbency with the right pelvic limb abducted. The right femoral artery was isolated using sharp and blunt dissection. Once isolated, the artery was catheterized with a 6 Fr, 90 cm Cook Flexor sheath (Ansel-1)[c] via a modified Seldinger technique with an 18 g over-the-needle catheter and a 0.035″ 260 cm angle-tipped, hydrophylic guidewire[d]. Fluoroscopy was used to monitor the position of the catheter in relation to the estimated region of the ductus. The flexor sheath vessel dilator and wire were removed and the system was flushed with heparinized saline. A 5 Fr 100 cm Marker Pigtail[e] catheter loaded with the 0.035″ guidewire was advanced into the left ventricle. The wire was removed and left ventriculography was performed by hand injection using 15 mL (1.1 mL/kg) of commercial nonionic iodinated contrast media[f] (Video S1). Normal coronary arterial anatomy and cranial aortic arch vessels were noted. Interestingly, contrast media remained within a small region of the apical left ventricle for several cardiac cycles. The pigtail catheter was removed and a hand injection angiogram

was performed using 15 mL of contrast through the flexor sheath for minimal ductal diameter (MMD) and ampulla measurements (Fig 3A). A type IIA duct was identified with a 2.2 mm MMD and 6.4 mm ampulla.[3] While the PDA anatomy was amenable to either ACDO placement or coil embolization, the authors chose to place an ACDO based on previous experience and success with this device in dogs. Based on the recommended oversize factor, a 5 mm ACDO was selected.[4] After the flexor sheath was flushed with heparinized saline, the ACDO was placed via the flexor sheath.[4] Proper positioning and stability of the device was assessed by gentle back-and-forth maneuvering of the delivery cable and by a small hand injection of contrast media through the sheath. Complete attenuation of flow was achieved 10 minutes after deployment (Fig 3B,C). All devices were removed without complication. The right femoral artery was triple ligated with 2-0 polydioxanone (PDS) and routine closure using 3-0 PDS and 3-0 Monocryl completed the procedure. The cria recovered uneventfully.

The next day, a grade 3/6 systolic, right apical murmur remained and femoral pulses were normokinetic. On repeat TTE, the ACDO was visualized in place and CFD confirmed complete closure of the shunt (Fig 2B–D). The VSD flow velocity remained unchanged. Measurements of left atrial and left ventricular chamber sizes were slightly reduced (LA 41.1 mm, LV 37.1 mm). The left ventricle was scanned for apical aneurysm, which could not be visualized echocardiographically. The cria was discharged with instructions to have the skin suture removed in 14 days. The referring veterinarian reported that the sutures were removed 13 days postprocedure, the incision was healed, the cria was asymptomatic, and only a grade 3/6 systolic right apical murmur was auscultated.

Discussion

This case report describes interventional closure of a PDA using an ACDO in a species other than a dog and PDA closure in an alpaca cria. The incidence of congenital heart disease (CHD) in llamas has been reported previously;[5] however, no published data are available in alpacas. In a population of llama crias evaluated at Colorado State University, 24 of 663 (3.6%) crias had a congenital heart defect.[5] Based on information gathered from the Veterinary Medical Database at Purdue University, CHD was present in 36 of 2,167 (1.7%) llama crias.[5] Regardless of which database is cited, the most common CHD reported in llamas is VSD, followed by a PDA.[5] Whether there is a similar distribution in alpacas remains unknown. Several case reports have described a PDA as a component of a more complex CHD[6,7] or as an isolated defect.[2] In none of these reports was the PDA surgically or interventionally addressed.

Therapy for a PDA involves surgical ligation or interventional closure with either coil embolization or placement of an occluding device. Since its first reported use in 2007, the ACDO has gained popularity worldwide. Compared to other interventional methods, the ACDO carries the lowest reported complication risk,[8] though immediate and delayed embolization has been reported.[9,10] While the accepted classification for angiographic PDA morphology was created for dogs,[3] the morphology of the present cria's PDA most resembled a type IIA. Alternatively, the Krichenko type E could also be used to describe the anatomy of this cria.[11] This PDA morphology is well suited for ACDO placement, though an ACDO has been successfully placed in all types of PDA morphologies.

The reported prognosis for dogs with surgically ligated or interventionally closed PDAs before the onset of left-sided congestive heart failure is excellent.[12] Whether alpacas carry the same prognosis is unknown.

As previously mentioned, the most common congenital cardiac defect in alpacas is a VSD. The VSD in this cria was in the dorsal interventricular septum, beneath the aortic annulus and septal tricuspid valve leaflet. Based on a published classification scheme, if the defect is entirely surrounded by muscle, it is considered a muscular VSD.[13] These defects can be further broken down into inlet, trabecular (apical) and infundibular (outlet)

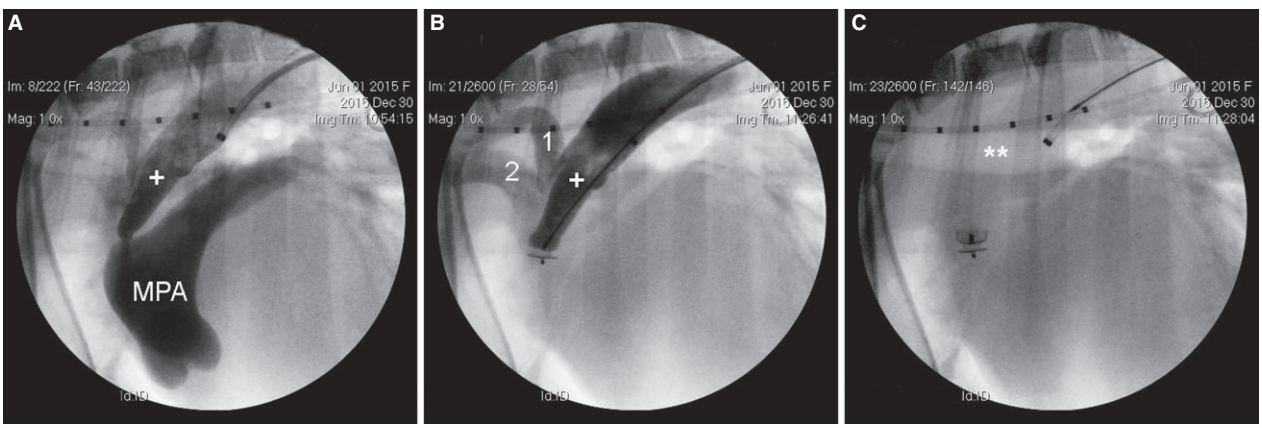

Fig 3. (**A**) Focused aortogram documenting the patent ductus arteriosus (PDA) (+) with Type IIA morphology. (**B**) A small volume of contrast administered through the sheath prior to device release confirms proper device location and complete attenuation of PDA shunt flow. Note the cranial aortic branches; the brachiocephalic trunk (2) and left subclavian artery (1). (**C**) Postrelease of the Amplatz canine duct occluder. Note that the device is placed in the similar region of the PDA in panel A, ventral to the trachea (**). MPA, main pulmonary artery.

defects. The defect in the presented patient is classified as a muscular inlet VSD that, given its small size and restrictive nature, does not represent a hemodynamically significant defect. Echocardiographic assessment of the LV apex demonstrated a region of muscular thinning which likely correlated with the region of stagnant contrast on angiography. Color Doppler assessment of this region did not reveal turbulent blood flow, suggesting that a perforating defect was not present. Possible causes for this abnormality include a forme fruste VSD, apical diverticulum, or apical aneurysm.

The presented cria had 2 cranial branches to her aortic arch, a brachiocephalic trunk and left subclavian artery. Alpacas are classified as new world camelids and, to the authors' knowledge, no publication exists describing new world camelid vascular anatomy. Normal vascular anatomy is available, however, for old world camelids and a single brachiocephalic trunk off which the other cranial arteries branch is normal.[14] A recent case series demonstrated the cardiac and proximal vascular anatomy of 3 juvenile alpacas with complex congenital heart defects using cardiac-gated computer tomographic angiography.[7] In an alpaca with truncus arteriosus, there were 2 cranially directed branches from the single great vessel leaving the heart. The other 2 reported alpacas had 2 cranial branches off the aortic arch. In addition, the Ohio State University Cardiology Service has several alpaca heart specimens stored in formalin, all of which have the same branching pattern as the presented case. Therefore, while the normal cranial branching pattern in alpaca has not been specified in the literature, these consistent findings of a brachiocephalic trunk and a left subclavian artery arising from the aortic arch support its normality.

South American camelids are becoming increasingly popular in the United States as companion animals;[2] thus, treatment options for congenital heart defects previously unexplored for production animals might become requested. Our familiarity with ACDO placement in dogs enabled us to perform this procedure without clinically important challenges. Therefore, we anticipate that minimal additional training would be required to adapt ones technique to other mammalian species of similar size. Interventional closure of a PDA using an ACDO was safely and successfully performed in this cria and could serve as a valid option in other alpaca crias.

Footnotes

[a] Vivid 9, GE Medical Systems, Waukesha, WI
[b] Amplatz Canine Duct Occluder, Infiniti Medical, LLC, West Hollywood, CA
[c] Flexor Check-Flo introducer, Cook Inc., Bloomington, IN
[d] HiWire hydrophilic wire guide, Cook Inc
[e] Marker pigtail catheter, Cook Inc
[f] Omnipaque 240 mg iodine/mL, GE Healthcare Inc, Marlborough, MA

Acknowledgments

Grant support: This work was not supported by any grant or otherwise.

Conflict of Interest Declaration: Authors declare no conflict of interest.

Off-label Antimicrobial Declaration: Authors declare no off-label use of antimicrobials.

References

1. Van Saun RJ, Herdt T. Nutritional assessment. In: Cebra C, Anderson DE, Tibary A, Van Saun RJ, Johnson LW, eds. Llama and Alpaca Care, 1st ed. St. Louis, MO: Elsevier; 2013:121–122.

2. Margiocco ML, Scansen BA, Bonagura JD. Camelid cardiology. Vet Clin North Am Food Anim Pract 2009;25:423–454.

3. Miller MW, Gordon SG, Saunders AB, et al. Angiographic classification of patent ductus arteriosus morphology in the dog. J Vet Cardiol 2006;8:109–114.

4. Nguyenba TP, Tobias AH. The Amplatz® canine duct occluder: A novel device for patent ductus arteriosus occlusion. J Vet Cardiol 2007;9:109–117.

5. Boon JA, Knight AP, Moore DH. Llama cardiology. Vet Clin North Am Food Anim Pract 1994;10:353–370.

6. McKenzie EC, Seguin B, Cebra CK, et al. Esophageal dysfunction in four alpaca crias and a llama cria with vascular ring anomalies. J Am Med Assoc 2010;237:311–316.

7. Stieger-Vanegas SM, Scollan KF, Meadows L, et al. Cardiac-gated computed tomography angiography in three alpacas with complex congenital heart disease. J Vet Cardiol 2016;18:88–98.

8. Singh MK, Kittleson MD, Kass PH, Griffiths LG. Occlusion devices and approaches in canine ductus arteriosus: Comparison of outcomes. J Vet Intern Med 2012;26:85–92.

9. Gordon SG, Saunders AB, Achen S, et al. Transarterial ductal occlusion using the Amplatz® canine duct occluder in 40 dogs. J Vet Cardiol 2010;12:85–92.

10. Carlson JA, Achen S, Saunders AB, et al. Delayed embolization of an Amplatz® canine duct occluder in a dog. J Vet Cardiol 2013;15:271–276.

11. Krichenko A, Benson LN, Burrows P, et al. Angiographic classification of the isolated, persistently patent ductus arteriosus and implications for percutaneous catheter occlusion. Am J Cardiol 1989;63:877–897.

12. Saunders AB, Gordon SG, Boggess MM, Miller MW. Long-term outcome in dogs with patent ductus arteriosus: 520 cases (1993–2009). J Vet Intern Med 2014;28:401–410.

13. Soto B, Becter AE, Moulaert AJ, et al. Classification of ventricular septal defects. Br Heart J 1980;43:332–343.

14. Smuts MMS, Bezuidenhout AJ. The heart and arteries. In: Smuts MMS, Bezuidenhout AJ, eds. Anatomy of the Dromedary. New York, NY: Oxford University Press, 1987;142–167.

Supporting Information

Additional Supporting Information may be found online in the supporting information tab for this article:

Video S1. Left ventriculogram in a 6-month-old alpaca cria. Note the normal branching pattern of the aortic arch, left-to-right shunting PDA, and retention of contrast media in the left ventricular apex.