Innovative Approach to Laparoscopic Adrenalectomy for Treatment of Unilateral Adrenal Gland Tumors in Dogs

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Objective: To report a technique for, and short-term outcome of unilateral laparoscopic adrenalectomy in dogs positioned in sternal recumbency without abdominal support.
Study Design: Experimental and prospective clinical study.
Animals: Healthy dogs (n = 5) and dogs with unilateral adrenal gland tumor (n = 9).
Methods: Anesthetized dogs were positioned in sternal recumbency with 2 cushions placed under the dog to elevate the chest and pelvic area so that the abdomen was not in contact with the surgical table allowing gravitational displacement of the abdominal viscera. Three 5-mm portals were located in the paralumbar fossa. Adrenal glands were carefully dissected and surrounding tissues sealed and cut using a vessel-sealing device. A retrieval bag or part of a surgical glove finger was used to remove the adrenal gland from the abdomen. Surgical time and complications were recorded, and short-term outcome assessed.
Results: Adrenal glands in normal dogs and unilateral adrenal tumors (8 left, 1 right) not involving the caudal vena cava in affected dogs were successfully removed laparoscopically. There were no major intraoperative complications. Of the dogs with adrenal tumors, 1 dog died within 24 hours of surgery from unrelated causes. Eight dogs recovered within 1 day and were discharged within 72 hours. Surgical times ranged from 42 to 117 minutes and were significantly shorter than those reported previously.
Conclusions: Positioning anesthetized dogs in sternal recumbency with the abdomen suspended to facilitate gravitational displacement of the abdominal viscera improves access to, and visibility of, the adrenal gland for laparoscopic removal.

Laparoscopic adrenalectomy in dogs with either right- or left-sided adrenal tumors (AT) not invading the caudal vena cava can be accomplished by oblique lateral positioning of the anesthetized dog.[1] Potential advantages of laparoscopic adrenalectomy over an open technique, include limited manipulation of other abdominal organs, an excellent view of abdominal structures, decreased surgical wound complications, and improved postoperative comfort.

We reasoned that laparoscopic access to the adrenal gland could be further improved if the movement of the abdominal viscera away from the adrenal gland could be facilitated by positioning. By supporting the trunk in sternal recumbency so that abdominal wall is free to move under gravitational influence, the viscera should displace ventrally to create an improved working space for laparoscopic access to the adrenal gland, thus minimizing visceral manipulation. Our purpose was to develop the technique in a pilot study in dogs and then evaluate the technique in dogs with a unilateral AT that had not invaded in the caudal vena cava. Operative times were compared to those reported by Pelàez et al[1] and a group of dogs with a paracostal open approach.

MATERIALS AND METHODS

Pilot Study

Five healthy mixed breed dogs weighing 15–50 kg used in a nonsurvival teaching laboratory were studied at the end of the teaching exercise. This study was approved by the University of Georgia Institutional Animal Care and Use Committee.

Anesthetized dogs were positioned in sternal recumbency with firm gelatin supports placed under the pubis and each thoracic limb or sternum depending on the body shape of the dog. Support was adjusted so the abdomen had a profile similar to the standing position, taking care to avoid pressure on the abdomen from the supports or contact with, and compression of the abdomen from the table surface.

The left and right adrenal glands were identified using a flank laparoscopic approach. The 1st portal for laparoscope insertion was placed, using a modified Hasson technique, in the paralumbar fossa 2–3 cm caudal to the costal arch ipsilateral to the affected side. Incisions in the skin and each layer of the body wall were incrementally reduced in length, and the transversus abdominis muscle was elevated from the viscera with stay sutures before entry into the abdomen with a scalpel blade. The initial incision into the abdomen was slightly smaller than the diameter of the 5 mm cannula (Karl Storz Veterinary Endoscopy, Goleta, CA). The cannula was placed using a blunt obturator. A 30° endoscope (Karl Storz Veterinary Endoscopy) was used to evaluate access to the adrenal gland using 6 mmHg positive intra-abdominal pressure from CO_2 insufflation, which was adjusted according to dog size and physiologic variables to 12–15 mmHg for percutaneous placement of 2 more ports. One port was located craniodorsal and 1 caudodorsal to the endoscope port for insertion of a dissecting forceps and a retractor, respectively. The 3 portals were placed in a virtual half-circle with the radius determined subjectively, according to dog size.[1]

Adrenalectomy was performed by dissection with a curved dissecting forceps (Karl Storz Veterinary Endoscopy), grasping forceps (Karl Storz Veterinary Endoscopy), and a vessel-sealing device (LigaSure™ 5 mm sealer and divider connected to a LigaSure™ or Force Triad™ generator; Covidien, Mansfield, MA). Grasping forceps were used to elevate the peritoneum, and the vessel-sealing device was used to start the dissection. Curved dissecting forceps and grasping forceps were used to elevate the tissue surrounding the adrenal gland, and the vessel-sealing device was used to seal and transect the tissue. Exposure to the adrenal gland, ability to remove the gland, instrument interference, and hemorrhage were subjectively evaluated. After bilateral adrenalectomy, dogs were euthanatized.

Clinical Study

Inclusion Criteria. Between February 2011 and March 2012, with informed client consent, dogs with unilateral AT without involvement of the caudal vena cava were prospectively enrolled for laparoscopic adrenalectomy at Utrecht University and the University of Georgia. Recorded variables included age, body weight, breed, clinical signs, location and size of the AT, surgical time, complications, and clinical outcome. Dogs with neoplastic invasion of the caudal vena cava and distant metastasis were excluded.

Diagnostic Evaluation. Suspicion of hypercortisolism was based on history, physical examination, and laboratory findings. A diagnosis of hypercortisolism was considered confirmed when the mean urinary corticoid to creatinine ratio (UCCR) in 2 consecutive morning urine samples collected at home exceeded 10×10^{-6}.[2] After collection of the 2nd urine sample, dogs were administered 3 doses of dexamethasone (0.1 mg/kg) orally at 8-hour intervals and the 3rd urine sample collected the next morning. Adrenal hypercortisolism was diagnosed when the 3rd UCCR sample was suppressed by <50% of the mean of the first 2 samples and basal plasma ACTH concentration was suppressed. Using a low-dose dexamethasone suppression test, blood was collected for a baseline cortisol before dexamethasone was administered (0.01 mg/kg IV). Additional blood samples were obtained 4 hours and 8 hours after dexamethasone administration.

Confirmation of unilateral AT was by abdominal ultrasonography and computed tomography (CT). For tumor staging, a routine thoracic CT scan was performed in 7 dogs. Complete blood count (CBC) and serum biochemical profile were performed in all dogs before surgery.

Anesthesia. Dogs were premedicated with methadone (0.5 m/kg intravenously [IV]), atropine (0.02 mg/kg intramuscular [IM]) and if necessary midazolam (0.3 mg/kg IV). Anesthesia was induced with propofol (2–4 mg/kg IV) and maintained with isoflurane in oxygen and fentanyl (10–20 μg/kg/h IV). At the University of Georgia, fentanyl (4 mg/kg IV) or hydromorphone (0.1 mg/kg IV) were used as premedication followed by propofol induction with diazepam or midazolam (0.2 mg/kg IV) with etomidate (1 mg/kg IV) and maintained using either isoflurane or sevoflurane in oxygen and appropriately monitored. Cefazolin (20 mg/kg IV) was administered after induction before surgery. In dogs with cortisol-secreting AT, hydrocortisone acetate (Solu-Cortef®, 2 mg/kg/IV in 6 hours) or dexamethasone (0.07 mg/kg IV) was administered immediately after anesthetic induction.

Surgical Procedure. Laparoscopic adrenalectomy was performed by 3 surgeons (J.K., E.N., M.G.R.). Operative time was defined as the time from initial incision to final suture placement.

The caudal aspect of the hemithorax and the lateral abdomen on the affected side were clipped and prepared for aseptic surgery. Dogs were positioned in sternal recumbency supported by 2 inflatable or gelatin cushions. One cushion was placed between the pelvic limbs extending no further cranial than the pubis to support the pelvis and the other cushion was placed under the sternum to elevate the chest. The dog was secured to allow rotation of the table during adrenalectomy (Figs 1 and 2) and care was taken to avoid compression of the ventral aspect of the abdomen from the surgical table.

The video monitor was positioned on the contralateral side to the affected adrenal gland. A 5-mm, 0° or 30° laparoscope (Storz, Tuttlingen, Germany) was connected to a video camera and a light source and images were recorded. The endoscopic equipment included an irrigation/suction unit, a self-retaining retractor, grasping forceps and a vessel sealing and dividing device. After draping, a towel clamp was used to retract the 13th rib to reduce risk of puncturing underlying abdominal organs during Veress needle placement. The Veress needle was inserted just caudal to this rib in the paralumbar fossa ipsilateral to the affected side or a modified Hasson technique was used for insertion of the 1st port. After abdominal insufflation with

Figure 1 Dog positioned in sternal recumbency with 2 cushions placed to elevate the chest and the pelvic area so that the abdomen was unsupported.

Figure 3 Position of the surgical portals along the paralumbar fossa.

CO_2 (intra-abdominal pressure, 8–10 mmHg), 2 or three 5-mm ports were located just caudal to the kidney in the paralumbar fossa. The portals were placed in a semicircular line extending from the 13th rib to the iliac crest (Fig 3). The laparoscope was inserted through portal 1 and the instruments through portal 2 and if 2 instruments were necessary, also through portal 3.

Exposure and dissection of the adrenal glands was performed differently on the right and left sides because of anatomic differences. To achieve full exposure of the right adrenal gland, the right lateral hepatic lobe was retracted cranially and the kidney was retracted caudally, whereas on the left side it was only necessary to retract the kidney caudally for sufficient exposure (Fig 4). After exposing the affected adrenal gland, examination of surrounding tissues and partial examination of the liver was performed. To achieve better exposure of the adrenal gland and to minimize manipulation of the AT, the peritoneum was incised on the dorsolateral border of the adrenal gland. Circumferential dissection of the adrenal gland was performed using dissecting forceps and the vessel sealing and dividing device. The approach was extended first dorsally by sealing or clipping the dorsal phrenicoabdominal vessel. The adrenal gland was carefully dissected from its attachments to the fibrous tissue between it and the aorta, laterally and caudally to the adrenal gland. After the final dissection plane was established, the adrenal gland was attached on the ventral side to the remaining structures, including the vena cava. By careful manipulation and dissection, the ventral phrenicoabdominal vessels were isolated and either sealed or a hemoclip was applied. The periadrenal tissue was grasped as little as possible to minimize the risk of capsular rupture. After dissection of the adrenal gland, either a retrieval bag or a finger from a surgical glove was used for gland removal to prevent abdominal wall contamination (Fig 5). The abdomen was decompressed after inspection for hemorrhage, and the laparoscopic port sites were sutured. The AT tissue was submitted for histopathologic examination.

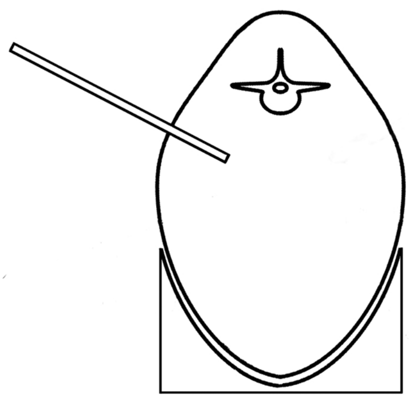

Figure 2 Schematic representation of the dog in sternal recumbency and orientation of portals.

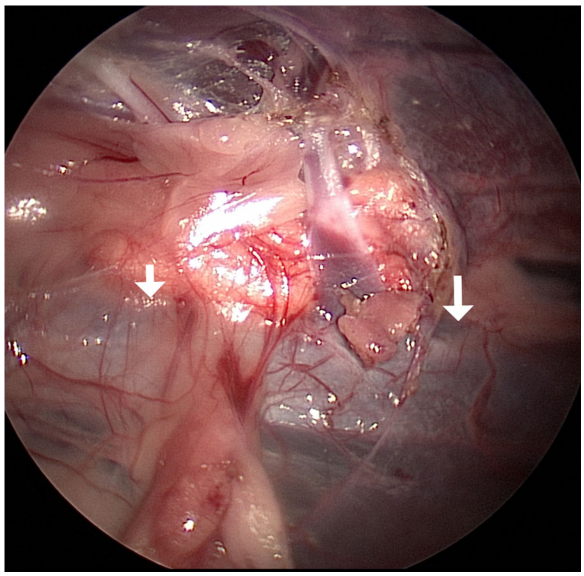

Figure 4 Laparoscopic view of right adrenal gland tumor. White arrow indicates vena cava.

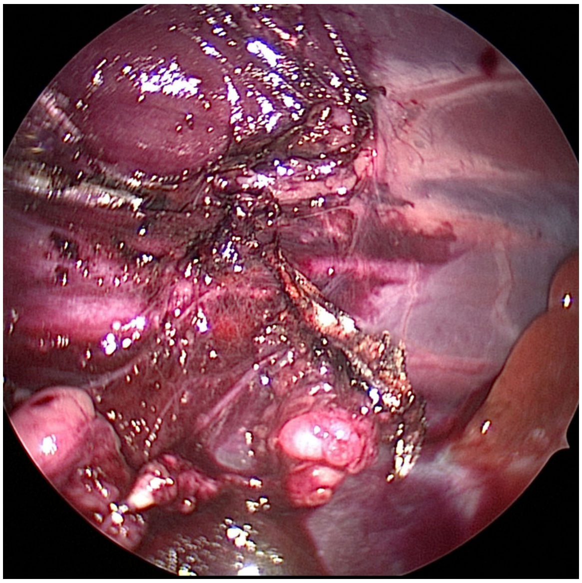

Figure 5 Laparoscopic view after removal of right adrenal gland tumor.

Postoperative Care

Methadone (0.3 mg/kg IM or slowly IV) or hydromorphone (0.05 mg/kg IV) immediately after surgery and continued at 4-hour intervals for 24–36 hours was administered for analgesia.

In dogs with cortisol-secreting AT, prednisone (0.2 mg/kg orally) or hydrocortisone acetate (1 mg/kg subcutaneously every 6 hours) was administered after recovery from surgery. When dogs started eating, hydrocortisone acetate was replaced by cortisone acetate (1 mg/kg orally every 12 hours). Dosages of cortisone acetate and prednisone were tapered over 6–10 weeks, and then discontinued when the mean urinary corticoid to creatinine ratio (UCCR) showed no signs of recurrence.

Amoxicillin with clavulanic acid (Synulox®Pfizer Animal Health B.V., Capelle a/d IJssel, the Netherlands) were continued for 5–10 days. Dogs treated at the University of Georgia were not administered antibiotics after hospital discharge.

Histopathology

Formalin-fixed, paraffin-embedded tissues were cut and stained with hematoxylin and eosin for microscopic examination. An AT was considered a carcinoma when there was histologic evidence of invasion of neoplastic cells into blood vessels, peripheral fibrosis, capsular invasion, a trabecular growth pattern, hemorrhage, necrosis, and single cell necrosis.[3] Typical histologic characteristics for adenomas were hematopoiesis, fibrin thrombi, and cytoplasmic vacuolization.[3]

Outcome

Dogs were reevaluated by the referring endocrinologist 4–8 weeks after surgery.

Statistical Analysis

Student's t-test was used to determine if differences existed between operative time of cases in this report and historical controls of Pelàez et al[1] and cases operated with a flank laparotomy (unpublished data Utrecht University; technique described in van Sluijs et al[4]). Continuous data were screened for normality using a Shapiro–Wilk test. Log transformation was performed on data that were not normally distributed. Results are expressed in mean, median or range. $P < .05$ was considered significant.

RESULTS

Pilot Study

Each adrenal gland was adequately identified using the ports described. The right adrenal gland was more difficult to remove using these portal locations, and in 2 dogs a 4th port was placed cranial to the endoscopic portal and ventral to the initial craniodorsal instrument portal. The cranial mesenteric artery was visible during dissection of the left adrenal gland. The phrenicoabdominal vein was easily sealed with the vessel-sealing device at its dorsal attachment on both sides of the abdomen. The vein was used to manipulate the adrenal gland and to provide traction during dissection and application of the sealing and dividing device. The vena cava was visible during dissection of the right adrenal gland, and a plane could be made between the adrenal gland and vena cava in these dogs. Retraction of the right kidney was required in 3 dogs to facilitate removal of the right adrenal gland.

Clinical Study

Nine dogs (mean age, 9 years [range, 8–11 years]; mean weight, 23 kg [range, 8–50 kg]) were enrolled. There were 5 females (1 intact, 4 spayed) and 4 males (2 intact, 2 castrated). Breeds were Dachshund, Poodle, Labrador, English bulldog, White shepherd dog, Beagle, Weimaraner, and a mixed breed (Table 1).

Mean diameter of AT was 25 mm (length; range, 13–50 mm). No pulmonary metastases were identified in 7 dogs that had thoracic CT. In dogs with cortisol-secreting AT, the contralateral adrenal gland was atrophic, except in dog 4, where CT scan revealed a pituitary microadenoma and bilateral enlargement of the adrenal glands with a suspicion of an AT on the left side.

Eight dogs had left laparoscopic adrenalectomy and 1 dog right adrenalectomy. Contralateral adrenal glands were atrophic in all dogs except in dog 4.

All AT were successfully removed and surgical time ranged from 42–117 minutes (mean, 78 minutes; median 73 minutes; right adrenal, 103 minutes; left adrenal, 75 minutes). In dog 2, two intraoperative complications occurred: pneumothorax during Veress needle insertion, which was controlled during surgery by percutaneous drainage and the capsule of the AT developed a small rupture despite careful manipulation. The

Table 1 Summary Data for 9 Dogs Treated by Laparoscopic Unilateral Adrenalectomy in a Sternal Position

Dog	Signalment	Adrenal Length (mm)	Surgery Time (min)	Recovery Time (ICU Stay—Hours)	Complications	Histology
1	Dachshund 11 years SF, 8 kg	24	74	<24		Adenocarcinoma
2	Poodle 9 years SF, 9 kg	18	103	<24	Pneumothorax, capsule rupture	Adenoma
3	Labrador 8 years SF, 8 kg	24	63	<24		Adenoma
4	English Bulldog 8 years SF, 31 kg	35	117	n/a	Died < 24 hours postoperative	Adenoma/hyperplasia
5	White Shepherd 9 years M, 50 kg	52	94	<48		Adenocarcinoma
6	Beagle 11 years F, 12 kg	36	42	<24		Adenocarcinoma
7	Weimaraner 8 years, M, 44 kg	30	57	<24	Capsule rupture	Adenocarcinoma
8	Dachshund 9 years NM, 10 kg	17	58	<72		Adenocarcinoma
9	Mixed breed 8 years NM, 11 kg	30	100	<48	Cortisol insufficiency	Adenocarcinoma

SF = spayed female; M = male; F = female; NM = neutered male.

latter complication also occurred in dog 7. No other intraoperative complications occurred.

Portal size in dogs with the 5 cm tumor had to be extended to facilitate adrenal tumor removal, but the surgical excision itself was performed without major difficulty.

Operative Time

Operative time data from dogs that had a paracostal approach was not normally distributed. Operative time for the sternal approach was significantly faster than the historic control data of Pelàez et al ($P = .01$) and the group of dogs that had a paracostal open flank approach (Table 2).

Postoperative Complications

Dog 4 (English Bulldog) died within 24 hours of surgery because of respiratory complications. On necropsy, there was moderate diffuse alveolar lung edema. Surgical complications from stress or hypoxia may have contributed to death. Although monitored in our intensive care unit and in an oxygen cage as a precautionary measure, the dog arrested abruptly after 24 hours. Although the history of the dog revealed increased exercise intolerance and respiration rate, upper airway surgery had not been performed because these clinical signs were thought to be associated with the dog's Cushing's syndrome.

Table 2 Mean ± SD and Median Surgery Time (Minutes) for Dogs Treated by Laparoscopic Unilateral Adrenalectomy in a Sternal Position Compared to Historical Control Data of Pelàez et al[1] and Dogs Treated With an Open Paracostal Approach at Utrecht University (Unpublished Data)

Study	Mean (±SD)	N	Median
Current	78.7 ± 25.6	9	74*,**
Pelàez et al[1]	113.6 ± 21.4	7	110
Utrecht data	129 ± 39.1	26	100

*Mean surgery time is significantly less compared to Pelàez data[1] ($P = .01$).

**Mean surgery time is significantly less compared to Utrecht data ($P < .001$).

Outcome

Surviving dogs were discharged within 3 days (median, <24 hours; range, <24–48 hours). Except for dog 2, clinical signs of hypercortisolism rapidly improved in dogs that had cortisol-secreting AT. Dog 2 was diagnosed 3 months postoperatively with one of the newly recognized forms of hypercortisolism meal-induced hypercortisolism.[5] No re-growth of the AT was noted; however, the contralateral adrenal gland became slightly enlarged. Diagnosis of meal-induced hypercortisolism has been done based on the combination of: (1) low plasma ACTH concentration in the absence of an AT; (2) an increase of >100% in UCCR after ingestion of a meal; (3) prevention of the meal-induced increase in plasma cortisol concentration by octreotide; and (4) reversal of signs of hypercortisolism by administration of trilostane a few hours before the meal.

Histopathology

Adrenocortical carcinoma was diagnosed in 6 dogs (nr 1, 5–9) Histologic evidence of neoplastic emboli was observed in the AT tissue of dogs 5 and 7. Adrenocortical adenoma was identified in dogs 2 and 3. There was moderate multifocal chronic bilateral cortical nodular hyperplasia with mild multifocal necrosis and hemorrhage in dog 4.

DISCUSSION

We were able to successfully perform unilateral laparoscopic adrenalectomy with dogs positioned in sternal recumbency so that the abdomen was unsupported and not in contact with surgical table. Changing the surgical position of the dog or conversion to an open laparotomy was not necessary.

Positioning the dog in sternal recumbency without abdominal support provides excellent exposure of the adrenal gland and once the retroperitoneum has been dissected, the adrenal gland moves ventrally, improving access. Good visibility and access to the adrenal gland likely contributed to our significantly shorter mean surgical time for laparoscopic adrenalectomy compared to historic control data[1] and unpublished data from an open flank approach

(Utrecht University). Comparing these data with only historic controls is a major study limitation and these results should be interpreted with caution. Additionally, use of the Ligasure in our study and the possible learning curve in the Pelàez study should be taken into account.

Pelàez et al[1] created a small window in the adrenal capsule to aspirate necrotic content and minimize the risk of intrasurgical rupture of the AT and spillage of neoplastic cells. Although the clinical consequence of capsule rupture and leakage of adrenal tumor cells remains unclear in dogs, it is generally accepted that it is better to avoid this complication by delicate dissection, initial sealing, and dividing of the dorsal aspect of the phrenicoabdominal vein, and perhaps by use of a retrieval bag. Preventive measures, like creating a small window in the adrenal tumor capsule and content aspiration were unnecessary with our approach because it was possible to dissect more tissue dorsal and lateral to the adrenal gland without grasping the capsule.

Adrenal tumor size varied from 2 to 5 cm and did not pose a problem for laparoscopic removal. We were comfortable removing tumors up to 7 cm through a laparoscopic approach. With our technique, improved visibility was achieved with 3 ports compared to 4 reported by Pelàez et al[1] resulting in less abdominal wall trauma.

One dog died in the perioperative period, which is comparable to other reports.[4,6,7] This dog (dog 4), an English Bulldog, died from signs of acute severe respiratory distress, which has also been described with thromboembolism or pneumonia as likely causes.[1,8,9] On necropsy, there was moderate diffuse alveolar lung edema, but no evidence of thromboembolism or pneumonia. Considering breed, the most likely cause could be acute respiratory stress syndrome caused by obstructive brachycephalic syndrome. On preoperative CT scan, a pituitary microadenoma, a slightly enlarged right adrenal gland, and suspicion of a left adrenal tumor were identified. Based on the CT scan and endocrine test results, which supported adrenal hypercorticism, left laparoscopic adrenalectomy was performed. On necropsy, examination of both adrenal glands was possible and revealed moderate multifocal chronic bilateral cortical nodular hyperplasia with mild multifocal necrosis and hemorrhage, without suspicion of a tumor in the left adrenal gland. Because of owner request for a cosmetic necropsy, examination of the pituitary gland was not possible. No signs of complications directly associated with the surgery were visible. The abdomen did not contain any blood and the surgical site had neither signs of major inflammation nor hemorrhage.

Based on our experience in these 9 dogs, we conclude that sternal recumbent positioning with the abdomen unsupported is feasible for unilateral laparoscopic adrenalectomy. This positioning permits gravitational displacement of the abdominal viscera improving access to, and visibility of, the adrenal gland and may require less portals and result in significantly shorter surgical time compared to laparoscopic or open adrenalectomy with the dog positioned in a latero-oblique position.

DISCLOSURE

The authors declare no conflict of interest related to this report.

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