

Evaluation of phenylephrine and exercise with or without trocarization for treatment of suspected nephrosplenic entrapment in horses

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OBJECTIVE

To report the outcomes of horses with suspected nephrosplenic entrapment (NSE) of the large colon treated by IV phenylephrine administration and exercise with and without trocarization (ie, medical management).

DESIGN

Retrospective, observational study.

ANIMALS

134 horses.

PROCEDURES

Electronic medical records were searched to identify horses that underwent medical management for suspected NSE at a veterinary teaching hospital between 1995 and 2014. Demographic information, physical and ultrasonographic examination findings, treatment information (including the number of times the treatment was performed and patient response), surgical findings if applicable, complications, and patient outcome were recorded. Descriptive statistics were reported.

RESULTS

72 horses had suspected NSE that resolved with medical treatment; 59 of 62 horses underwent laparotomy when medical management failed, and 3 were euthanized without surgery. Twenty-five of the 59 horses had confirmed NSE that was surgically corrected, and 34 had lesions other than or in addition to NSE. All horses that had surgically corrected NSE and 18 of 34 horses that had other lesions survived to hospital discharge. The odds of resolution of NSE with medical management were greater for horses that underwent ≤ 2 (vs > 2) treatments. The treatment success rate for horses that underwent trocarization was not greater than that for horses that did not have the procedure.

CONCLUSIONS AND CLINICAL RELEVANCE

Suspected NSE resolved with the described medical management for most horses. However, results indicated the potential for misdiagnosis was high. Timely surgical intervention is recommended for horses that fail to respond to medical treatment. (*J Am Vet Med Assoc* 2019;254:1448–1453)

Nephrosplenic entrapment of the large colon in horses occurs when the left dorsal colon and ventral colon migrate dorsally between the spleen and the body wall and become entrapped over the nephrosplenic ligament.¹ Treatment options include medical and surgical management. Previously, surgical correction via ventral midline celiotomy was considered to be the standard of care.² In the last few decades, medical treatment has become a preferred option for many cases, provided that a horse's clinical status and observations by the veterinarian do not disqualify this treatment option. Medical treatment options include analgesic administration, IV and oral fluid therapy with feed restriction, exercise with or without IV administration of phenylephrine, rolling the horse under general anesthesia with or with-

out IV phenylephrine administration, or a combination of these options.^{3–5} Trocarization can also be performed in addition to phenylephrine treatment.¹

Phenylephrine hydrochloride is an α_1 -adrenergic receptor agonist. This sympathomimetic agent is commonly used in conjunction with exercise or rolling of the horse to facilitate medical resolution of NSE.⁵ Although several authors have reported successful medical resolution of NSE with these methods,^{4,6} others found no significant increase in the success rate of nonsurgical management when phenylephrine was included in the treatment protocol.⁵ Although a large retrospective study⁴ was performed to evaluate the effect of phenylephrine in horses treated by the rolling procedure, studies^{4,6} evaluating the effect of phenylephrine in horses treated by exercise have been described with relatively small populations. Studies evaluating the benefit of trocarization compared with a control group are also lacking.

ABBREVIATIONS

NSE Nephrosplenic entrapment

The purpose of the study reported here was to assess the outcomes of horses with suspected NSE of the large colon treated by phenylephrine administration and exercise with and without trocarization. We hypothesized that phenylephrine administration and exercise would result in successful resolution of suspected NSE in horses in which the condition was diagnosed on the basis of transrectal palpation findings and inability to visualize the left kidney ultrasonographically. We also hypothesized that large colon trocarization would improve the rate of successful resolution with this medical treatment and that the mean age of horses with confirmed NSE would be approximately 5 years, similar to the ages found in a previous investigation.⁴

Materials and Methods

Electronic and hard copy medical records of horses evaluated for signs of acute abdominal pain (ie, colic) at the John Thomas Vaughn Large Animal Teaching Hospital of Auburn University between January 1, 1995, and December 31, 2014, were reviewed to identify horses with suspected or confirmed NSE treated with IV phenylephrine hydrochloride administration and exercise with or without trocarization of the large colon. To be included in the study, horses had to have a presumptive diagnosis of NSE made on the basis of transrectal palpation and inability to visualize the left kidney on transabdominal ultrasound images or a definitive diagnosis made at surgery after the less invasive approaches failed to resolve the condition. Transrectal palpation findings suggestive of NSE included palpation of the large colon within the nephrosplenic space or palpation of colonic bands coursing dorsally toward the nephrosplenic space.⁶ Horses that were treated by means of a rolling technique were excluded. To be included in the study, the medical record of a patient had to yield the following minimum information: age, sex, breed, examination findings (including rectal and ultrasonographic findings), number and type of phenylephrine treatments, other treatments administered, and outcome. Each horse was only included once in the study.

Search terms used in the electronic records retrieval included the following: equine, nephrosplenic or renosplenic, and phenylephrine. Patient demographic information, the duration of signs of colic prior to evaluation at the hospital, degree of discomfort (as interpreted by the attending clinician on the basis of clinical and behavioral signs), physical examination findings (including results of transrectal palpation), ultrasonographic findings, treatment information (including the number of times the treatment was administered), response to treatment, surgical findings if applicable when less invasive treatment failed, complications (including hemorrhage, ventricular arrhythmias, and collapse), and outcomes were recorded.

The presence or absence of ventricular arrhythmias was determined by auscultation. Horses were selected for trocarization on the basis of clinician preference; criteria included the degree of gas distension of

the large colon and the ability to confidently visualize a large gas-distended viscus ultrasonographically. All horses received IV fluid therapy (60 to 120 mL/kg/h [27 to 55 mL/lb/h]) after phenylephrine administration and exercise, unless signs of discomfort dictated surgical intervention. Horses received flunixin meglumine^a (1.1 mg/kg [0.5 mg/lb], IV, q 12 h) for analgesia and xylazine hydrochloride^b or detomidine hydrochloride^c for sedation while medical treatment was initiated when deemed appropriate by the attending clinician.

Phenylephrine^d (20 mg, diluted in 1 L of saline [0.9% NaCl] solution^e) was administered IV over 10 minutes immediately prior to exercise. Exercise (once the degree of sedation [when applicable] did not affect ability of the horse to be exercised) consisted of trotting the horse on a lunge line in a 20-m circle for 20 minutes (10 minutes in each direction [clockwise and counterclockwise]).¹ After exercise, horses were examined by transrectal palpation and transabdominal ultrasound to assess the location of the large colon. At a minimum, these examinations were repeated every 12 hours, in addition to further assessment if signs of discomfort were observed. Horses received repeated phenylephrine and exercise treatments, with or without trocarization, on the basis of clinician preference with owner consent and consideration of the horse's apparent level of comfort, the degree of distension of the large colon, and financial constraints.

Trocarization was performed percutaneously through the left flank following administration of xylazine hydrochloride^b or detomidine hydrochloride^c for sedation. The gas-distended viscus was visualized by transabdominal ultrasonography, and a 5 × 5-cm area was clipped of hair and aseptically prepared. Local anesthesia was provided with 2% mepivacaine hydrochloride solution,^f and a 14-gauge, 14-cm catheter^g was inserted through the skin until the gas-distended viscus was penetrated. An extension set was joined to the catheter, and a cup of water was used to ensure placement within the colon (by creation of bubbles in the water from escaping gas). The procedure was continued until gas was no longer being evacuated (typically 20 to 40 minutes). Horses were monitored visually and ultrasonographically for evidence of complications associated with trocarization (swelling, abscessation, and peritonitis) throughout their hospitalization period.

Abdominal ultrasonography was performed after treatment to monitor for hemorrhage. Horses for which signs indicative of NSE did not resolve with the less invasive treatments underwent surgical exploration and treatment with a ventral midline approach or were euthanized if cost or other concerns precluded surgery. Short-term survival was defined as survival to discharge from the hospital. For study purposes, treatment with phenylephrine and exercise, with and without trocarization, was termed medical management.

Statistical analysis

Descriptive statistics are reported. Normal distribution of horse age data was confirmed with the

Anderson-Darling test ($P = 0.215$). Data are expressed as median (range) or mean \pm SD. A χ^2 test was used to compare outcomes with respect to the ages of horses. Odds ratios were used to compare outcomes of medical management. The median number of treatments was determined for all horses, and the OR and 95% confidence interval for treatment success were compared between horses that did and did not have more than the median number of treatments. A 1-tailed t test was used to compare outcomes for medically managed horses that did and did not undergo trocarization. Treatment success was defined as resolution of the confirmed or suspected NSE without the need for laparotomy, and survival to discharge from the hospital. Statistical analyses were performed with commercial software.^h Values of $P < 0.05$ were considered significant.

Results

The medical records search identified 135 horses with suspected NSE of the large colon treated with phenylephrine and exercise. Of these, 1 horse was excluded because the horse was rolled under general anesthesia rather than being exercised after phenylephrine treatment, and 134 were included in the study. The median age was 11 years (range, 1 to 30 years); the population comprised 10 stallions, 64 geldings, and 60 mares. Breeds included American Quarter Horse ($n = 64$), Thoroughbred (18), Tennessee Walking Horse (9), Arabian (7), American Paint Horse (6), Trakehner (2), Morgan (2), Standardbred (2), Friesian (2), Paso Fino (2), Irish Draft (1), and Percheron (1). Eighteen were warmblood-type horses.

Seventy-five of 134 (56%) horses were treated with phenylephrine and exercise, with or without trocarization (ie, medical management), and 72 (53.7%) had resolution of colic with these treatment methods. The remaining 3 of these 75 horses were euthanized without further treatment owing to client financial constraints, and NSE was confirmed at necropsy.

Fifty-nine of 134 (44%) horses that did not have resolution of colic with medical management subsequently underwent laparotomy. Twenty-five of 59 (42%) horses underwent surgical correction of NSE and survived to discharge from the hospital. The remaining 34 (58%) were found to have lesions other than or in addition to NSE at surgery.

Conditions other than NSE in surgically treated horses included right dorsal displacement of the large colon (14), volvulus of the large colon (12), small intestinal mesenteric volvulus (1), epiploic foramen entrapment (3), cecal volvulus (1), and small colon hematoma (1). Two horses had volvulus of the large colon in addition to NSE. Of the 34 horses, 24 (71%) survived to discharge from the hospital. One (3%) horse underwent correction of right dorsal displacement of the large colon but was subsequently euthanized when the clinical signs recurred. The remaining 9 (26%) horses were euthanized during surgery; reasons included ischemia of the small intestine or large colon that would have resulted in a grave prognosis.

For the 72 horses that had resolution of suspected NSE following medical management, the median number of times these horses received treatment was 1 (range, 1 to 4). Treatment frequency for horses that required > 1 of these treatments ranged from repeated treatment in ≤ 1 hour to treatments every 24 hours. All horses had ultrasonographic examination and transrectal palpation performed before and after each treatment. The 28 horses with confirmed NSE that did not resolve with medical management (25 that underwent laparotomy and 3 euthanized without the surgery) received a median of 2 treatments (range, 1 to 10; **Figure 1**). One horse received 10 treatments over 5 days (treatments q 12 h); this horse did not have signs of colic during the treatment process, but the large colon was still found to be entrapped on rectal examination, and laparotomy was performed for correction of NSE. When all suspected or confirmed cases of NSE were evaluated, excluding those horses confirmed to have an alternative or additional lesion ($n = 100$), the odds of resolution with medical management alone were significantly ($P = 0.033$) higher for horses that received only 1 or 2 treatments than for horses that received > 2 treatments (OR, 1.9; 95% confidence interval, 1.02 to 3.66). Horses that were confirmed to have a lesion other than or in addition to NSE at surgery had received a median of 2 treatments (range, 1 to 8). No hemorrhage, arrhythmias, collapse, or other adverse events attributed to phenylephrine administration developed, despite the fact that horses up to 30 years of age were treated.

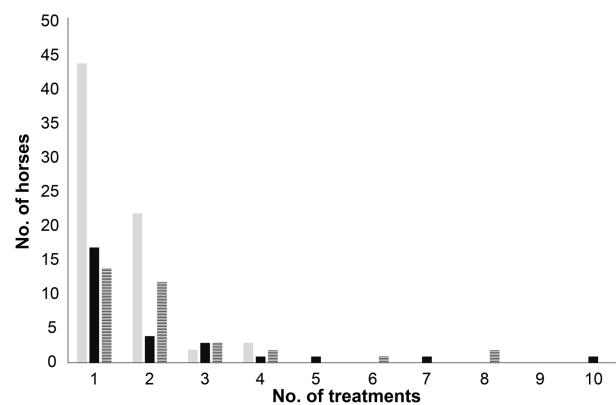


Figure 1—Comparison of the number treatments administered to horses in a study to assess the outcomes of 134 patients with suspected NSE of the large colon treated with phenylephrine administration and exercise with or without trocarization of the large colon (ie, medical management). Phenylephrine (20 mg/horse) was diluted in 1 L of 0.9% NaCl (saline) solution and administered IV over 10 minutes immediately prior to exercise, which was followed by abdominal ultrasonography and transrectal palpation. Examinations were repeated at ≤ 12 -hour intervals and performed before and after the treatment was repeated. Results are shown for horses that had resolution of suspected NSE following medical management ($n = 72$; gray bars) and horses that failed to respond to medical management and underwent laparotomy or necropsy in which NSE was confirmed (28; black bars) or lesions other than or in addition to NSE were found (34; striped bars).

Twenty-six of 134 (19.4%) horses were > 15 years of age. The mean \pm SD age of horses that were confirmed to have NSE at necropsy or during surgery was 9 ± 5.4 years (range, 3 to 28 years). The mean \pm SD age of horses found to have lesions other than or in addition to NSE at surgery was 11.2 ± 5.1 years (range, 3 to 25 years). The mean \pm SD age of horses with suspected NSE that resolved with medical management was 11.3 ± 5.3 years (range, 2 to 30 years). Age did not differ significantly ($P = 0.967$) among horses with NSE confirmed during surgery or necropsy, horses that had confirmed lesions other than or in addition to NSE, and horses with suspected NSE that resolved with medical treatment.

Nineteen of 134 horses were treated with trocarization of the gas-distended viscus in addition to phenylephrine administration, and 115 were not. Eleven of 19 (58%) horses that had trocarization and 61 of 115 (53%) horses treated with phenylephrine and exercise alone had resolution of suspected NSE with medical management. Trocarization was performed only once in horses that underwent the procedure. Thirty-four of the 54 horses that did not have trocarization and subsequently underwent laparotomy or necropsy had lesions other than or in addition to NSE. The treatment success rate was not significantly ($P = 0.805$) greater for horses that underwent trocarization in addition to phenylephrine and exercise treatment than for those that did not. When horses with surgically confirmed lesions other than NSE were excluded from the analysis, the success rate was still not significantly ($P = 0.275$) improved with trocarization. There was no evidence of complications associated with the trocarization procedure during the hospitalization period.

Discussion

Phenylephrine administration in combination with exercise, with or without trocarization (both considered medical management for study purposes), was successfully used to treat 72 of 134 (53.7%) horses with suspected NSE in the present study. This proportion was slightly lower than has been reported for horses in some other retrospective investigations. Hardy et al⁴ stated that 5 of 5 horses with NSE treated with IV phenylephrine administration and exercise (including 2 that had trocarization) had resolution of the condition, and Lindegaard et al⁷ reported that 9 of 9 cases of NSE resolved with phenylephrine and exercise treatment. Conversely, Abutarbush and Naylor⁸ reported that only 1 of 3 cases successfully resolved with phenylephrine administration and exercise. The small sample sizes in investigations by Hardy et al⁴ and Lindegaard et al⁷ may have resulted in an overestimation of success rates for this treatment. However, results of a larger retrospective study by Fultz et al⁶ revealed that 24 of 38 (63%) cases of NSE resolved with phenylephrine and exercise. McGovern et al⁹ also reported resolution for 38 of 50 (76%) cases of NSE after horses were

treated with IV administration of phenylephrine and exercise. Excluding horses with confirmed conditions other than or in addition to NSE in the present study, the success rate of medical management in our study increased to 72 of 100 (72%). Therefore, with improved case selection, it is possible that a higher proportion of cases could be expected to resolve with medical management.

All horses that underwent surgery for NSE in the present study survived to hospital discharge. Surgical treatment of NSE is considered to have a high rate of survival to discharge, with success rates ranging from 20 of 25 (80%) to 7 of 7.^{4,7,9} A possible reason for the relatively high rate of survival to discharge in our study and in previous reports is that the viability of the colon is rarely compromised, even in horses that have prolonged attempts to treat conditions medically.¹ However, it must be conceded that multiple attempts at treatment with phenylephrine can only be performed for horses that have signs of minimal discomfort and are considered unlikely to have compromise of the large colon. In our study, all horses with confirmed NSE ($n = 28$) had this lesion only, except for 2 (7%) horses that also had large colon volvulus. This is similar to findings reported by Hardy et al,⁴ in which 13 of 174 (7.5%) horses with NSE had an additional lesion, most commonly large colon volvulus. In the present study, both horses with NSE and concurrent large colon volvulus survived to hospital discharge; however, it should be noted that more timely surgical intervention is required for horses with additional or alternative lesions than for those with NSE alone.⁴

Thirty-four horses that underwent medical management for suspected NSE in our study had lesions other than ($n = 32$) or in addition to (2) NSE. These lesions included small and large intestinal abnormalities. This highlights the importance of making an accurate diagnosis so that valuable time is not wasted on medical management for a lesion that requires surgical intervention. McGovern et al⁹ reported alternate lesions in 19 of 36 (53%) horses that underwent surgery for suspected large colon displacement. In our investigation, 10 of the 34 (29%) horses with lesions other than or in addition to NSE were euthanized (9 while under general anesthesia and 1 because clinical signs recurred). The reason cited for euthanasia in several cases was that ischemia of the bowel had developed, making the prognosis grave. This indicates that, in addition to the importance of an accurate diagnosis, it is imperative that horses be reevaluated frequently and the diagnosis reconsidered for those that fail to respond to medical management.

Horses received medical treatment between 1 and 10 times in this study, and those that did not have resolution of suspected NSE after ≤ 2 treatments had significantly lower odds of resolution without surgery than those that had > 2 treatments. A long duration of NSE may lead to abnormal motility or lack of motility, reducing the incidence of resolution.¹ Therefore, on

the basis of our study results, the authors suggest that horses requiring > 2 treatments of phenylephrine have a reduced likelihood of resolution with medical management. However, it must be acknowledged that 3 horses had successful resolution of suspected NSE with medical management after receiving 4 treatments of phenylephrine and exercise. This highlights the fact that repeated administration of phenylephrine and exercise is a valid method of treatment in patients that are clinically stable and exhibiting minimal discomfort.

Interestingly, although NSE is generally considered a condition of young horses, the current study found no difference in age between horses with surgically confirmed NSE, horses with surgically confirmed lesions other than or in addition to NSE, and horses with suspected NSE that resolved with medical treatment. In addition, the median age for all horses with a suspected diagnosis of NSE was 11 years. However, only horses with confirmed or suspected NSE were evaluated, and investigation of the relationship between age and the diagnosis of NSE was beyond the scope of the study. Our findings were in contrast to those of others who found horses with NSE to have a median age of 5 years (range, 9 months to 24 years).⁴ The reason for this difference was unknown, but case selection may have played a role in these findings. The breeds included in the present study were also skewed toward those typically described as prone to this disease but were similar to the overall population of horses examined at this hospital.⁴

The rate of medical resolution of NSE for horses in the present study was not significantly greater for horses that underwent trocarization than for those that did not. Other studies^{4,10} have demonstrated some benefit for this procedure, but the number of horses that underwent trocarization in each of these studies (2) was too small to make comparisons. The logic of decompressing the large colon via a catheter placed percutaneously through the left flank is that less distension will leave more space in the abdomen to allow it to slip off of the nephrosplenic ligament.^{1,4} However, we speculate that decompression could possibly work against resolution of NSE by allowing the colon to slide more ventrally in the nephrosplenic space, thereby reducing its ability to slip out of this space when phenylephrine is administered. Corroborating evidence for this is lacking in the literature, and several manuscripts state the benefits of trocarization.^{1,3,4,11} First, exercise may not be possible for horses with marked gas distension of the colon unless trocarization is performed. Furthermore, it is likely that trocarization may be necessary to provide or maintain comfort in patients for which surgery is not an option. Finally, decompression of the large colon can improve intrathoracic pressure in horses prior to general anesthesia.¹ It should be acknowledged that trocarization can increase the risk of peritonitis, hemorrhage, and abscess formation.^{1,4,12,13} However, for the 19 horses that underwent trocarization in

the present study, no complications were observed during the hospitalization period. The decision for trocarization in this retrospective study was made on the basis of physical examination results and clinician preference, and thus horses were selected for this treatment. In addition, the number of horses that had this procedure was low.

As a retrospective, records-based study, our investigation had several limitations. Mainly, case selection for the treatments assessed was not randomized. The number of horses in some categories (eg, those that had trocarization and those that received > 2 medical treatments) was fairly low, impacting the statistical value of the data. The frequency of treatment administration for horses during medical management was dictated by clinical signs, transrectal palpation results, and clinician preference. A case-control study of horses with NSE receiving phenylephrine with and without trocarization on a set treatment schedule would be ideal from this standpoint but would be difficult to implement in a clinical population. In addition, our study did not include a control group of horses that did not receive phenylephrine, and it is possible that some cases may have resolved with other conservative treatments (not including phenylephrine) as detailed by Lindegaard et al.⁷ Although an attempt was made to evaluate physical examination findings, the duration of colic, and the degree of horses' discomfort on admission, such observations were frequently lacking in the medical records and no meaningful evaluation of the data was possible. Furthermore, owing to variability in the clinical conditions of patients, there were differences in the quantities of IV fluids and dosages of flunixin meglumine and sedatives administered, which could have confounded results. Another limitation was the fact that all horses received the same quantity of phenylephrine for each treatment; although this has been reported^{4,9} as an acceptable quantity to administer, it is possible that the actual dose administered to each horse on a milligram-per-kilogram basis could affect the likelihood of medical resolution of NSE. No horses in the present study had any adverse effects of treatment with phenylephrine, despite the fact that horses of up to 30 years of age were treated. However, it is acknowledged that phenylephrine should be used with caution, especially in horses \geq 15 years of age, because of the risk of hemorrhage.¹⁴

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Footnotes

- a. Banamine, Merck Animal Health, Madison, NJ.
- b. Anased, Akorn Animal Health, Lake Forest, Ill.
- c. Dormosedan, Zoetis, Parsippany, NJ.
- d. Phenylephrine hydrochloride, Baxter Healthcare Corp, Deerfield, Ill.

- e. Baxter Healthcare Corp, Deerfield, Ill.
- f. Carbocaine, Carestream Health Inc by Novocol Pharmaceuticals of Canada Inc, Cambridge, ON, Canada.
- g. Mila International Inc, Florence, Ky.
- h. XLSTAT, version 2017.1, Addinsoft, New York, NY.

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From this month's AJVR

Cardiac structure and function characterized across age groups and between sexes in healthy wild-born captive chimpanzees (*Pan troglodytes*) living in sanctuaries

Aimee L. Drane et al

OBJECTIVE

To comprehensively characterize cardiac structure and function, from infancy to adulthood, in male and female wild-born captive chimpanzees (*Pan troglodytes*) living in sanctuaries.

ANIMALS

290 wild-born captive chimpanzees.

PROCEDURES

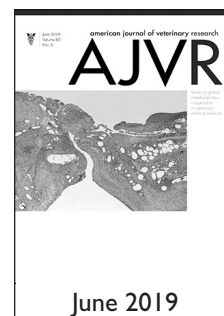
Physical and echocardiographic examinations were performed on anesthetized chimpanzees in 3 sanctuaries in Africa between October 2013 and May 2017. Results were evaluated across age groups and between sexes, and potential differences were assessed with multiple 1-way independent Kruskal-Wallis tests.

RESULTS

Results indicated that left ventricular diastolic and systolic function declined at a younger age in males than in females. Although differences in right ventricular diastolic function were not identified among age groups, right ventricular systolic function was lower in adult chimpanzees (> 12 years old), compared with subadult (8 to 12 years old) and juvenile (5 to 7 years old) chimpanzees. In addition, male subadult and adult chimpanzees had larger cardiac wall dimensions and chamber volumes than did their female counterparts.

CONCLUSIONS AND CLINICAL RELEVANCE

Results of the present study provided useful reference intervals for cardiac structure and function in captive chimpanzees categorized on the basis of age and sex; however, further research is warranted to examine isolated and combined impacts of blood pressure, age, body weight, and anesthetic agents on cardiac structure and function in chimpanzees. (*Am J Vet Res* 2019;80:547-557)



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