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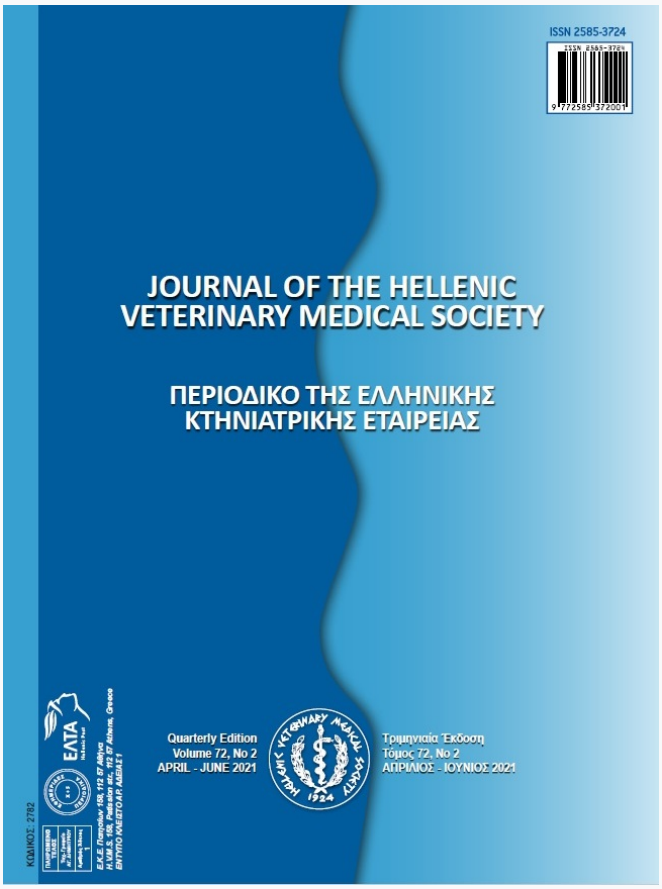

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Research article
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Sand colic: A retrospective study of 6 cases

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ABSTRACT: Colic- loosely defined as abdominal pain- is very common in horses, with clinical signs ranging from mild to severe. More than ninety causes of colic have been described. When horses consume significant amounts of sand while eating, they may develop symptoms of sand colic. Sand accumulation in the gastrointestinal tract of horses can irritate the colonic mucosa (less likely gastric mucosa), leading, usually, to sand impaction. Six horses with sand colic were referred to the School of Veterinary Medicine of Aristotle University of Thessaloniki from 2014 to 2018. Age ranged from 7 years to 19 years. The horses were presented with a history of: mild to severe colic (6/6), anorexia (4/6), weight loss (3/6) and diarrhea (6/6). Gastrointestinal auscultation revealed a characteristic sound of "pouring sand" (4/6) while sand was found in the faeces in large quantities (6/6). In order to identify sand in the faeces, sand sedimentation test can be performed easily in the field. Rectal examination findings were: gassy dilation of the colon (2/6) and impacted segment of colon (4/6) with (2/6) or without (2/6) cecum tympany. These cases, depending on the severity of the symptoms, were treated either pharmaceutically (4/6) or surgically (2/6). Pharmaceutical treatment consisted of administration of fluids, NSAIDs, antibiotics and laxatives, with the later given via nasogastric tube. Psyllium and paraffin oil were selected as laxatives of choice in this study. Surgical treatment was elected in 2 horses due to failure of conservative treatment. One of the two horses, that underwent surgery, survived while the other developed postoperative peritonitis and died. Horses that were treated pharmaceutically, either showed improvement and survived to discharge (2/4) or did not survive due to poor response to treatment (2/4). Minimizing exposure to sand and dietary management were important in preventing recurrence of sand colic in all 3 cases. According to the authors' knowledge, this is the first report of sand colic cases in Greece.

Keywords: equine, colic, sand

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INTRODUCTION

Accumulation of sand in the colon of the horses is reported as a common cause of colic in places with loose sandy soil like California, Arizona, Michigan and coastal regions of USA (Kilcoyne et al. 2017, Rakestraw and Hardy 2012). It may also occur where horses selectively ingest dirt or gravel with food (Hart et al. 2013, Niinisto et al. 2014). The prevalence of sand colic in USA varies from 5% to 30% of all colic cases (Landes et al. 2008). Accumulation of sand in the colon of horses and subsequent colic related to it has been reported worldwide, treated either with conservative therapy or surgery (Kilcoyne et al. 2017). Even though surgical and pharmaceutical treatment of sand colonic accumulation has been described both in clinical cases and experimentally, retrospective studies of clinical cases are lacking (Rouhoniemi et al. 2001, Korolainen et al. 2002, Landes et al. 2008, Niinisto et al. 2014, Niinisto et al. 2018).

Sand accumulation in the colonic lumen causes significant irritation of the mucosa and disrupts normal motility patterns leading to diarrhea (Mair 2002a). The most common clinical signs at presentation included colic (chronic or acute), weight loss, diarrhea, abdominal distension, decreased appetite and poor exercise performance (Mair 2002a, Granot et al. 2008). Sand colic can be confirmed with gastrointestinal auscultation, rectal palpation, faecal evaluation for presence of sand and ultrasonography (Rouhoniemi et al. 2001, Korolainen et al. 2002, Rakestraw and Hardy 2012). However, radiography can be very helpful in determing both the amount of accumulated sand in the colon and the clearance of it following treatment (Rouhoniemi et al. 2001). Sand enteropathy or impaction can be treated with either conservative or surgical therapy. Pharmaceutical therapy includes intravenous or/and per os fluid administration, pain relief, antibiotic therapy and laxatives to promote the clearance of sand. Prognosis of sand colic cases is fair to good (Sanchez 2018).

According to the authors' knowledge, there have not been any reports of equine sand colic cases in Greece so far. The purpose of this study was to present cases of sand colic, presented to the School of Veterinary Medicine of the Aristotle University of Thessaloniki from 2014 to 2018. Aetiology, clinical signs, diagnosis and therapeutic protocol of the cases are described and discussed.

MATERIALS AND METHODS

Six horses, diagnosed with sand colic, were included in this study. These horses were presented to the School of Veterinary Medicine of Aristotle University of Thessaloniki between the years 2014 - 2018. Their age spans from 7 to 19 years (Table 1). All of them were living in the area of Northern Greece. According to their history, the majority of the horses were referred because of mild to severe colic with duration from 48 hours to 8 days and diarrhea (Table 1). Most importantly, these horses lived in fields with sandy soil or were fed in sandy paddocks. All the information about breed, gender, clinical findings and outcome are described in Table 1.

On clinical examination dehydration 5- 10%, and abnormal motility of the gut were mainly noted (Table 1). The findings upon abdominal auscultation are also thoroughly described in Table 1. Rectal palpation revealed gassy dilation or impacted segment in a part of the colon. Abdominocentesis was performed in only one case because of the severity of symptoms. The peritoneal fluid was modified transudate. Although haematology results were normal in two cases, in the majority of them (4/6) lymphopenia was noted (0.4-1.0 K/μl). Biochemical profiles were normal with no signs of hepatic or kidney failure. The diagnosis in all 6 horses was based on the sand identified in the faeces and the characteristic sound of ''pouring sand'' during the auscultation. In order to identify sand in the faeces, 2-3 faecal balls were diluted in water within a container or a rectal glove. The "solution" was left to rest for a few minutes up to 2 hours, leading sand to sediment at the bottom of the container.

Conservative therapy was elected in 3 horses, while surgery was recommended in the other 3. Despite our recommendation, the owner of one horse declined surgical treatment, therefore, conservative treatment was pursuit.

The medical therapeutic protocol (4/6) included the administration of a) fluids, lactated Ringer's (10 litres) and dextrose 5% (5litres) iv BID for 5 days, b) flunixin meglumine (1.1 mg/kg b.w. iv BID for 7 days and then SID for another 5 days) (Niglumine®, CALIER), c) antibiotics such as penicillin-streptomycin (20.000 IU im SID for 10 days) (Pen & Strep, Norbrook) with either metronidazole (15mg/kg b.w. p.o. BID for 5 days) (Flagyl®, Pfizer) (3/6) or trimethorpim-sulfonamide (30mg/kg b.w. im BID for 7 days) (Borgal®, Virbac) (1/6). In the treatment protocol vitamin B complex (10ml iv SID for 5 days) (Catosal®, Bayer), probiotics (Equigest Plus, Equiplanet) and also clanobutin sodium (10ml iv SID for 5 days) (Bykahepar®, MSD)

were included. Psyllium (250gr p.o. BID) (Flohsamen Psyllium, Waldhausen) along with 1litre of paraffin oil was considered the cornerstone of the medical management. These 2 laxatives were given to horses via nasogastric tube with 10 litres of water on a daily basis. Once appetite was restored, psyllium was offered to horses per os, with or without food.

Two horses were treated surgically. Abdominal laparotomy was performed under general anaesthesia in dorsal recumbency. A pelvic flexure enterotomy was performed, according to what has been previously described (Rakestraw and Hardy 2012) (Figure 1 and 2). Postoperative treatment was mostly similar to those patients treated pharmaceutically. Horses undergone surgery were given marbofloxacin (2mg/kg b.w. iv SID for 10 days) (Marbocyl 10%, Vetoquinol) instead of trimethoprim sulphonamide or metronidazole.

Table 1: Summary data for horses included in our study.

Case	Horse breed, age (years), gender	Symptoms	Clinical Findings	Findings upon Rectal Palpation	Treatment	Recovery
1	Fresian, 7, gelding	anorexia colic diarrhea weight loss	pyrexia dehydration 5-10% endotoxemia hypomotility of left, right colon and cecum	impaction in right dorsal colon with cecum tympany	conservative (even though surgical treatment was strongly recommended)	no
2	Greek, 11, gelding	colic diarrhea	tachycardia dehydration 5-10% sound of ‘’pouring sand’’ decreased frequency of borborygmi at cecum and hypermotility of the left colon	gassy dilation of colon	conservative	yes
3	Fresian, 16, stallion	anorexia colic diarrhea	tachycardia dehydration 5-10% sound of ‘’pouring sand’’ decreased frequency of borborygmi at cecum and hypermotility of the left colon	gassy dilation of colon	conservative	no
4	Warmblood, 9, mare	colic diarrhea weight loss	dehydration 5-10% hypomotility of left colon while in right colon and cecum the motility was normal	doughy impaction in left dorsal colon without cecum tympany	conservative	yes
5	Cob, 19, mare	anorexia colic diarrhea	tachycardia dehydration 5-10% endotoxemia sound of ‘’pouring sand’’ decreased frequency of borborygmi at cecum and hypermotility of the left colon	doughy impaction in cecum	surgical	yes
6	Warmblood, 13, mare	anorexia colic diarrhea weight loss	tachycardia dehydration 5-10% endotoxemia sound of ‘’pouring sand’’ decreased frequency of borborygmi at cecum and hypermotility of the left colon	impaction in right dorsal colon with cecum tympany	surgical	no

*** All six cases lived in sandy soils or were fed in sandy paddocks, according to their history.**

Figure 1: Sand colic surgery. Pelvic flexure enterotomy was performed.

Figure 2: Sand removal from the lumen of the colon.

RESULTS

Horses treated pharmaceutically were hospitalized in the School of Veterinary Medicine of the Aristotle University of Thessaloniki for 5 up to 20 days, depending on their clinical improvement. Two of 4 horses recovered fully, while the other 2 did not survive. Still, it is worth noting that one of these 2 horses followed the conservative protocol despite our recommendation for surgery, due to financial constraints (Table 1). One horse that underwent surgery survived while the other developed postoperative peritonitis and died.

DISCUSSION

Horses living in areas with sandy soil or selectively ingest gravel or dirt, are more prone to episodes of sand colic (Rakestraw and Hardy 2012, Hart et al. 2013, Niinisto et al. 2014). Acute ingestion of big amount of sand is an uncommon cause of sand colic (Mair 2002a). Poor pasture management, inadequate nutrition, dry weather, overstocking and feeding horses in paddocks can all result in horses consuming significant quantities of sand (Mair 2002a). It has been proven that ~80% of the consumed sand can be excreted within 5-11 days, while the other ~20% can remain in the lumen of the colon (Husted et al. 2005). This remaining amount of sand can eventually lead to an obstruction in a part of the gastrointestinal tract (Husted et al. 2005). This retrospective study is the first report of sand colic in Northern Greece. The small number of cases are maybe due to the fact that Northern Greece's soil is not sandy and drought or even because many veterinary practitioners are not familiar with this type of colic. However, poor management of the equine stables can lead to the appearance of sand colic, even in Greece. Interviewing horse owners of all 6 cases presented in our clinic revealed many management flaws, especially as far as feeding is concerned. In most cases, horses ate directly from a soil ground. In other words, although cases referred to our Hospital did not live in coastal regions where horses would graze on sand, problems arose because owners kept their horses in paddocks artificially covered with sand. Moreover, they would feed their horses on such grounds. According to literature, the majority of horses suffering from sand colic are more than 1 year old, like in this study (Rakestraw and Hardy 2012). However, many cases of sand colic in foals have been reported, due to pica (Rouhoniemi et al. 2001, Rakestraw and Hardy 2012). In our study no foal was presented with symptoms of sand colic, maybe due to the fact that the few equine reproductive farms of Northern Greece do not breed horses on sandy pastures. As mentioned before, all our cases were related to owners' mistakes.

Horses with sand colic are typically presented with

mild to severe abdominal pain, continuous or intermittent diarrhea, reduced faecal production (sand impaction), weight loss, decreased appetite, intermittent or continuous pyrexia, mild to severe dehydration, normal to gradually elevated heart rate and respiratory rate (Mair 2002a, Granot et al. 2008, Rakestraw and Hardy 2012). In cases with severe inflammation and irritation of the intestinal mucosa tachycardia, tachypnea, congested mucous membranes, prolonged capillary refill time and toxic rim at the gum margin may be seen (Mair 2002a). The horses of the study were admitted in our clinic with signs of mild to severe abdominal pain, diarrhea and dehydration. Three of them had signs of endotoxemia, such as congested mucous membranes and toxic rim at the incisor margin.

Intestinal mucosal inflammation and irritation exists in almost, every equine colic case (Mair 2002a, Sanchez 2018). In sand colic cases, the sand or the gravel accumulates in the gastrointestinal lumen. This accumulation has been described as "coffee sediment". This irritation influences the rate of the secretion and absorption, leading usually to intestinal hypersecretion and malabsorption (Mair 2002a, Sanchez 2018). Colonic absorptive processes are limited to surface epithelial cells, whereas secretory processes are a function of the crypt epithelium (Sanchez 2018). According to this, the sand can cause intestinal motility dysfunction leading to profuse, exudative diarrhea (Mair 2002a, Sanchez 2018). Severe mucosal inflammation and irritation may result in endotoxemia and secondary peritonitis that can be septic if bowel perforation occurs (Mair 2002a, Sanchez 2018). Chronic consumption of sand may lead to colonic impaction, although there are cases that successfully passed large amounts of the intestinal sand. The intestinal distention with gas before the impacted area is the main reason of pain during an episode of equine colic (Sanchez 2018). In our study 2 horses had gassy distention in a part of the colon, while another 2 had cecum tympany with an impacted segment of colon. In the rest of the cases (2/6) no gassy dilation was palpated. The sand may accumulate in any part of the gastrointestinal tract (Rouhoniemi et al. 2001). Usually, the majority of the sand is gathering in the right dorsal colon, transverse colon and cecum (Rouhoniemi et al. 2001, Mair 2002a). On the contrary, stomach, left dorsal colon, small intestine, descending colon and pelvic flexure have been rarely referred as sites of sand accumulation (Rouhoniemi et al. 2001). Coarse sand usually accumulates in the dorsal colon, whereas fine sand tends to accumulate in the ventral colon (Mair 2002a). In our study, impacted mass was found in cecum (1/6), in right dorsal colon (2/6) or in left dorsal colon (1/6). In 2 horses, doughy mass was palpated, while in the other 2 horses the impaction was hard.

Auscultation of the abdomen, sand sedimentation test, abdominal ultrasound, rectal palpation and abdominal radiography can help with the diagnosis of sand colic. The characteristic sound of "pourring sand" can be usually heard caudally to the xiphoid region (Mair 2002a, Husted et al. 2005, Rakestraw and Hardy 2012). This sound was present in 4 of our cases. Moreover, our auscultation findings revealed either hypomotility or hypermotility in different parts of the colon. In a study of 59 horses with sand colic, 33, 8% had normal intestinal gut sounds, 55,9% had hypermotility and 10,1% had hypomotility (Hart et al 2013). It is obvious that abdominal auscultation is not a reliable diagnostic test for this disease.

Peritoneal fluid can be a useful diagnostic tool, because it can show an elevation in total proteins (Mair 2002a, Rakestraw and Hardy 2012). According to many authors, abdominocentesis should be performed with extreme caution as there is a high risk of enterocentesis (Mair 2002a, Sullins 2017). Abdominocentesis was deemed necessary and performed in only one, critical case. Peritonitis was ruled out and the horse was treated medically. Abdominal radiology is the best way of sand colic diagnosis, since the amount of sand within the intestinal lumen can be approximately measured. Also, the effectiveness of the treatment can be monitored by measuring the quantity of the sand coming out from the gastrointestinal tract (Rouhoniemi et al. 2001, Rakestraw and Hardy 2012, Niinisto et al. 2014, Niinisto et al. 2018). Abdominal x rays can replace rectal palpation both in foals and ponies (Rouhoniemi et al. 2001, Mair 2002a). Abdominal ultrasonography, is useful in assessing the motility and peristalsis of the intestines but cannot assist in establishing a final diagnosis. Unfortunately, in this study, abdominal radiology was not performed as the size of the horses and the lack of large radiographic units was discouraging.

As in most colic cases, conservative treatment in sand colic consists of: non steroidal anti-inflammatories, intravenous or per os fluids and broad spectrum antibiotics. Having said that, the most important part of the treatment is the administration of laxatives such as paraffin oil, psyllium, magnesium sulphate and Dioctyl Sodium Sulfosuccinate (DSS) (Landes et

al. 2008, Kilcoyne et al. 2017). Psyllium hydrophilic mucilloid is a natural product, produced by *Plantago spp* seeds (Sullins 2017). Psyllium (as powder or flake) is a polysaccharide forming a sand-psyllium mucilloid mixture in the intestinal lumen (Mair 2002a). This bulk laxative hydrates intestinal contents and stimulates intestinal peristalsis, promoting intestinal evacuation (Mair 2002a, Baljit 2007). Psyllium can increase intestinal motility, by temporarily stimulating muscarinic and serotonergic receptors (Mair 2002a, Niinisto 2018). At the same time, intestinal calcium receptors get blocked causing suppression of the intestines' motility (Niinisto 2018). Arguments against the efficacy of psyllium usage are based on these 2 antagonistic ways of action (Niinisto 2018). The long-term use of psyllium can cause alterations in the normal gastrointestinal flora. For this reason, the concurrent use of probiotics has been advised in horses treated with psyllium (Rouhoniemi et al. 2001, Baljit 2007, Landes et al. 2008). Probiotic powder was given in all 6 cases of our study. Psyllium can be administered to horses suffering from enteropathy or impaction due to sand (Mair 2002a, Landes et al. 2008, Rakestraw and Hardy 2012). Many researchers argue about the optimal dose of psyllium that can be given per os or via nasogastric tube. The latest records indicate that the effective dose is 0,5- 1g/kg bw/24h (Rouhoniemi et al. 2001, Mair 2002a, Niinisto et al. 2014, Niinisto 2018). Taking into account all the above, we decided to add psyllium in the medical treatment protocol of the horses. Paraffin oil can promote sand excretion from the gastrointestinal tract (1-4 litres SID or BID, with 4-8 litres of water). Its effectiveness has been doubted, due to the fact that it may not go through the impacted mass (Rouhoniemi et al. 2001, Mair 2002a, Husted et al. 2005, Kilcoyne et al. 2017). According to previous reports, the combination of psyllium and paraffin oil can increase the excretion of the sand from the gastrointestinal tract, even if there is a large amount of sand (Rouhoniemi et al. 2001, Mair 2002b). Taking into consideration all the above, we decided to treat these horses with a combination of psyllium (250gr BID) and paraffin oil (2 litres BID with 8-10 litres of water).

Other types of laxatives that can be used in the treatment of sand colic are magnesium sulphate (Epsom salts) and DSS. Magnesium sulphate acts as an osmotic laxative, by moving water from the intestinal mucosa to the intestinal lumen (Rouhoniemi et al. 2001, Niinisto et al. 2018). Also, it can increase the motility of the intestines (Rouhoniemi et al. 2001, Niinisto et al. 2018). Magnesium sulphate is more effective in the small intestine rather than the colon, where sand usually accumulates (Murray 2004). It should be used continuously in order to be effective; in particular, it should be used daily for 3 days. If need be, this treatment can be repeated after 7 days (Rouhoniemi et al. 2001). Big and continuous amounts of magnesium sulfate may cause severe dehydration, colitis or even magnesium toxicosis (Murray 2004). The recommended dose is 0,5g/kg-1g/kg bw (Rouhoniemi et al. 2001, Niinisto et al. 2014, Niinisto et al. 2018). So, we decided not to add magnesium sulphate (Epsom salts) in the treatment protocol, considering the part of the gastrointestinal tract being affected by sand and the possible adverse effects of long-term use. DSS is a synthetic derivative that reduces surface tension and allows water to penetrate impacted material, increases intestinal secretion and alters mucosal permeability (Rouhoniemi et al. 2001, Murray 2004). The recommended dose is 10-25mg/kg bw diluted in 4-8 litres of water (Rouhoniemi et al. 2001, Murray 2004). High doses may cause mild to severe diarrhea and abdominal pain or even laminitis, endotoxemia and tachycardia (Rouhoniemi et al. 2001, Hotwagner and Iben 2008). Also, vitamin B complex and phosphorus were administered to horses as supportive treatment due to poor nutrition, weakness and exhaustion. Stimulation of hepatic function by promoting the bile secretion was attempted by the administration of clanobutin sodium in all 6 cases.

The decision for surgical treatment in a colic case has to be taken considering many clinical and laboratory factors. The patients' response to pain, heart rate, respiratory rate, temperature, intestinal motility and the gastric reflex should be taken into account as well as blood lactic acid (>3mmol/litre) and glucose (>180mg/dl) (Cook and Hassel 2014). The success rate in horses with sand impaction that underwent early exploratory abdominal laparotomy, was 75%-95% (Granot et al. 2008). On the contrary, the prognosis and the survival rate of horses receiving conservative treatment for some days and then treated surgically was poor (Hart et al. 2013). Meaning that, the decision for surgery has to be made when the equine patient is still stable before severe mucosal necrosis occurs (Granot et al. 2008, Hart et al. 2013). The decision to perform abdominal surgery is challenging, as in every colic case. It has to be made taking into consideration a number of clinical and laboratory parameters. Rectal palpation can be very simple and important diagnostic tool, but not so accurate, as impaction cannot always

be palpated (Husted et al. 2005, Cook and Hassel 2014, Kilcoyne et al. 2017). Distension in the ascending colon or cecum can be palpated in 51% of horses with sand impaction (Granot et al. 2008). Horses with obvious impaction in the colon diagnosed using abdominal radiology are far more likely to undergo exploratory laparotomy, when the appropriate equipment is available. In this study, surgical treatment was recommended in 3 of the cases. In 1 of these cases, surgery was strongly recommended due to the severe endotoxemia. In the other 2 horses, exploratory laparotomy was carried out due to failure of conservative treatment. In total, one horse survived and 2 died. We feel that the small survival rate in this study was a result of horses not being operated at all (1/3) or being operated in a critical stage (2/3). This is may be due to the fact that horses in Greece are not insured and horse owners are extremely reluctant to take up the financial burden of colic surgery.

Minimizing exposure to sand is important in preventing recurrence. Nutritional management of sand colic cases varies from highly digestible forage or concentrated feed for 2-3 weeks after sand has been excreted, to hay ab libitum, to no dietary change at all (House and Warren 2016). Administration of a moist bran mash containing 450gr psyllium, once a week, is recommended as good prophylactic measure to prevent the occurrence of sand impaction colic in horses exposed to sand (Mair 2002b). In order to prevent a recurrence, horses should not feed from the ground, but rather on a rubber mat, from a manger or raised buckets (Mair 2002b). Grazing in fields with not adequate grass seems to be a risk factor of sand ingestion (Mair 2002a). Also, a monthly faecal sample from horses with predisposition in sand colic should be examined in order to monitor this condition. In this study, horses discharged from our clinic (3/6) follow all the above preventing measures. At the same time, administration of psyllium (100gr p.o. BID) was advised, combined with moist bran mash (2-3kg/day) for 7 days and then psyllium (450gr p.o.) once a week as prophylactic measurement. Two years following discharge all horses are alive.

CONCLUSIONS

According to this study, sand colic should not be considered as an ‘exotic disease’ in Greece. For this reason, sand colic (impaction or enteropathy) should be included in the differential diagnosis of cases with chronic diarrhoea and/or abdominal pain.

CONFLICT OF INTEREST

None declared by the authors.

REFERENCES

Baljit S. (2007) Psyllium as therapeutic and drug delivery agent. International Journal of Pharmaceutics, 334: 1-14

Cook V L, Hassel D M. (2014) Evaluation of the Colic in Horses: Desicion for Referral. In: Veterinary Clinics of North America Equine Practice Volume 30, Issue 2. Elsevier, New York, pp 383- 398

Granot N, Milgram J, Bdolah-Abram T, Shemesh I, Steinman A. (2008) Surgical management of sand colic impactions in horses: a retrospective study of 41 cases. Aust Vet J., 86:404-407

Hammock P D, Freeman D E, Baker G J. (1998) Failure of Psyllium Mucilloid to Hasten Evacuation of Sand From the Equine Large Intestine. Vet Surg, 27: 547-554

Hart KA, Linnenkohl W, Mayer JR, House AM, Gold JR, Giguere S. (2013) Medical management of sand enteropathy in 62 horses. Equine Vet J, 45:465-469

Hotwagner K, Iben C. (2008) Evacuation of sand from the equine intestine with mineral oil, with and without psyllium. J Anim Physiol Anim Nutr, 92: 86-91.

House A M, Warren L K. (2016) Nutritional management of recurrent colic and colonic impactions. Equine Vet Educ, 28 (3): 167-172

Husted L, Andersen M S, Borggaard O K , Houe H, Olsen S N. (2005) Risk factors for faecal sand excretion in Icelandic horses. Equine Vet J., 37(4): 351-355

Kilcoyne I, Dechant J E, Spier S J, Spriet M, Nieto J E. (2017) Clinical findings and management of 153 horses with large colon sand accumulations. Vet Surg, 46(6): 860-867

Korolainen R, Kaikkonen R, Ruohoniemi M. (2002) Reliability of ultrasonography compared to radiography in revealing intestinal sand accumulation in horses. Equine Vet J, 34: 499-504

Landes AD, Hassel DM, Funk JD, Hill A. (2008) Fecal sand clearance is enhanced with a product combining probiotics, prebiotics and psyllium in clinically normal horses. Journal of Equine Veterinary Science, 28(2): 79-84

Mair T. (2002) Chronic diarrhea. In: Manual of Equine Gastroenterology. 1st Edition, WB Saunders, London, pp 426-446

Mair T. (2002) Colic. In: Manual of Equine Gastroenterology. 1st Edition, WB Saunders, London, pp 279-297

Murray M J. (2004) Drugs acting on the gastrointestinal system. In: Equine Clinical Pharmacology. 1st Edition, Elsevier Saunders, China, pp 85-120

Niinisto K, Hewetson M, Kaikkonen R, Sykes BW, Raekallio M. (2014) Comparison of the effects of enteral psyllium, magnesium sulphate and their combination for removal of sand from the large colon of horses. Vet J, 202:608-611

Niinisto K E, Rouhoniemi M O, Freccero F, Raekallio M R. (2018) Investigation of the treatment of sand accumulations in the equine large colon with psyllium and magnesium sulphate. Vet J, 238: 22-26

Rakestraw Peter C. and Hardy Joanne (2012) Large intestine. In: Equine Surgery. 4th Edition, Elsevier Saunders, Missouri, pp 454-493

Rouhoniemi M, Kaikkonen R, Raekallio M, Luukkanen L. (2001) Abdominal radiography in monitoring the resolution of sand accumulations from the large colon of horses treated medically. Equine Vet J, 33: 59-64.

Sanchez L. Chris. (2018) Disordes of the gastrointestinal system. In: Equine Internal Medicine. 4th Edition, Elsevier, Missouri, pp 709-842

Sullins K E. (2017) Sand impaction. In: The Equine Acute Abdomen. 3rd Edition, Wiley- Blackwell, NJ, pp 748-774