Retrospective study on medical vs. surgical management of right dorsal displacements in the horse

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Tiemä - Referat – Abstract

Tämän lisensiaatinnikeatelmen kirjallisuuskatsaus käsittelee hevosen paksusuolen asennonmuutoksia. Tutkimusosa on retrospektiivinen tutkimus hevosen paksusuolen oikeanpuoleisesta asennonmuutoksesta. Hypoteesinä oli, että Suomessa paksusuolen oikeanpuoleinen asennonmuutos joudutaan hoitamaan useammin kirurgisesti kuin muualla maailmassa. Tutkimuksen tavoitteena oli myös selvittää leikkaushoidon tarpeenä joutuneiden hevosten kasvot, selviämisprosentteja ja mahdollisia vuodenaiheisia vaihteluita esiintyvyydessä.


Tutkimusotanta koostui yhteensä viidestä yksilöstä kahdeksasta hevosesta, joista 30,8% hoidettiin konservatiivisesti ja 69,2% kirurgisesti. Potilaista 63% sairastui syys- ja tammikuun välisenä aikana. Vetosuhde hiekan havaitsemiseen syksyllä verrattuna keväällä oli 18 (khi:n neliö 10,3, p=0,0014) Kirurgisesti hoidetuista potilaista 83,3% kotiutettiin. Konservatiivisesti hoidetuilla vastaava luku oli 81,2%.

Tässä tutkimustalamassa suurempi osuus hevosista päädyttiin hoitamaan kirurgisesti verrattuna aiempiin julkaisuihin aiheesta. Paksusuolen oikeanpuoleista asennonmuutosta esiintyi eniten syksyllä. Vetosuhde (odds-ratio) hiekan esiintymiselle paksusuolen oikeanpuoleista asennonmuutosta sairastavilla hevosilla oli huomattavasti korkeampi syksyllä kuin keväällä. Tämä ei vielä todista hiekan olevan altistava tekijä paksusuolen oikeanpuoleiselle asennonmuutokselle, mutta se antaa viitattua mahdollisesta korrelaatiosta. Tämä ongelmanakentä vaati jatkotutkimuksia.

Keywords
paksusuolen oikeanpuoleinen asennonmuutos, RDD, ähky, hevonen

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1. INTRODUCTION

Displacement of the large colon into an abnormal topographical position is a common cause of colic in the horse. Displacement causes an extra-mural obstruction, leading to accumulation of ingesta and gas in the colon lumen, and in some cases vascular occlusion. Medical treatment is often successful, but depending upon the type of displacement, surgical intervention may be required. This is especially important if there is evidence of vascular occlusion. There are currently four types of displacements reported in the literature and each will be reviewed briefly:

1.1 Left dorsal displacement

In left dorsal displacement (LDD), the left dorsal and ventral colons move dorsolaterally over the spleen to lie on the nephrosplenic ligament (between the spleen and the left kidney). In LDD, the colon is trapped dorsally by the abdominal wall, medially by the left kidney, ventrally by the nephrosplenic ligament and laterally by the spleen. The colon’s sternal and diaphragmatic flexures can stay at their normal positions ventrally to the stomach or they can dislocate dorsally to the stomach (Brown et al 2007). Of all colic patients requiring surgery, only 2.7% (8/300) are LDD patients (Mair & Smith 2005)

LDD is typically diagnosed via rectal examination and ultrasonography findings. On rectal examination, the left ventral colon is situated dorsal to the left dorsal colon and one is able to follow the colon up to the nephrosplenic space using the colon taenial bands as a reference (Rakestraw & Hardy 2012). LDD can also be diagnosed by ultrasonography. On ultrasonography of a normal horse, the left kidney should be visible adjacent to the spleen in intercostal spaces 15-17. In the case of a LDD, there is gas-filled large colon behind the spleen and the left kidney is therefore not ultrasonographically visible (Rakestraw & Hardy 2012).

Typical medical treatments for LDD are withholding of food, fluid therapy, exercise, analgesics, rolling under general anesthesia and the judicial use of phenylephrine (Hardy et al 2000). Phenylephrine causes vasoconstriction of the
spleen, hence reducing it’s size (van Harreveld et al 1999). As the spleen shrinks, it gives the large colon room to escape the nephrosplenic space and thus helps the LDD resolve. Phenylephrine and rolling the horse under general anaesthesia are considered more effective compared to horses treated with phenylephrine and exercise (Fultz et al 2013). The success rate of horses rolled under general anaesthesia was 84% in comparison to exercise, where the success rate was 63.2% (Fultz et al 2013).

Medical treatment might not work if there is excessive gas accumulation in the trapped large colon. In these cases the gas may be evacuated by using a trocar in the left paralumbar fossa (Hardy et al 2000).

If medical treatment is not effective or if the horse is severely painful or bloated, abdominal surgery should be performed and the colon displacement should be manually corrected. Surgical treatment can be performed via standing flank laparotomy or ventral midline celiotomy (Hardy et al 2000). The advantages of a standing flank laparotomy are that no general anaesthesia is needed, the recovery time is shorter and the surgeon has direct access to the nephrosplenic space (Rakestraw & Hardy 2012). The advantages of the ventral midline celiotomy are that if the original diagnosis is incorrect and there is some other type of displacement, it is still possible to correct the problem, which would not be possible when performing a standing flank laparotomy (Rakestraw & Hardy 2012). Also, if the sternal and diaphragmatic loops of the colon are situated dorsally to the stomach, it is possible to correct that too using a ventral midline celiotomy approach (Rakestraw & Hardy 2012). Due to these reasons, the ventral midline celiotomy is a more common approach compared to standing flank laparotomy (Hardy et al 2000).

Suturing the dorsal splenic margin to the nephrosplenic ligament can prevent re-occurrence of LDD (Röcken et al 2005). This method prevents the colon from rising to the nephrosplenic space, but the colon can still dislocate between the spleen and the abdominal wall (Röcken et al 2005).
1.2 Large colon volvulus
In large colon volvulus, a loop of large colon rotates along its long axis. The cecum can also be involved in this type of displacement. Large colon volvulus causes occlusion of the mesenteric blood supply to the colon, leading to infarction of the affected segment of intestine, and is a life-threatening condition (Brown et al 2007). Compared to other types of large colon displacements, large colon volvulus usually causes the most intense pain reaction. Predisposing factors for large colon volvulus are recent parturition, recent dietary changes, access to lush pasture, medication during the previous 7 days, increase in stabling hours in the previous 14 days and previous recurrent colic episodes (Suthers et al 2013, Rakestraw & Hardy 2012). The only effective treatment for large colon volvulus is surgical reposistioning of the colon (Rakestraw & Hardy 2012, Fiege et al 2014). Preoperative measurements, like fluid therapy and relief of pressure in the abdominal cavity should be performed in order to increase the amount of circulating blood (Rakestraw & Hardy). Large colon volvulus is one of the most typical reasons for colic horses ending up in surgery (17,0% of all types of colics) (Mair & Smith 2005). The short-term survival rate of large colon volvulus is 65-70% (Mair & Smith 2005, Fiege et al 2014).

1.3 Retroflexion of the pelvic flexure
There is very little published data on retroflexion of the pelvic flexure. Mair&Smith (2005) describe an overall prevalence of 2,3% of all colic surgeries presented at a large referral centre and a short-term survival rate of 85,7%. In comparison, a study performed on the Norwegian horse population reported a prevalence of 3,4% (Wormstrand et al 2014). Interestingly, horses that have had retroflexion of the pelvic flexure are more predisposed to recurrent colic episodes when compared to horses that have had other types of colic surgeries (Smith & Mair 2010). The reason for this is unclear.

1.4 Right dorsal displacement
Right dorsal displacement (RDD) is a type of large colon displacement in which the left dorsal and ventral colons migrate to the right side of the abdominal cavity and lie between the cecum and the abdominal wall (Brown et al 2007). RDD is a non-strangulating obstruction and causes mild to moderate colic signs in horses.
Patients with RDD can either be treated medically or surgically. Medical treatment consists of intravenous fluids and analgesics. In surgery, a ventral midline celiotomy is performed in order to correct the displacement and, if needed, evacuate impacted feed or gas from the large intestine.

While much has been written about the treatment of LDD and large colon volvulus, very little information on RDD is available in the literature, despite the fact that it is a common cause of colic in the horse. In particular, predisposing factors, clinical information used to determine the need for medical vs. surgical treatment of RDD and short term prognosis for medical vs. surgical treatment of RDD have not been well described before. Furthermore, in our study population, it has been hypothesized that sand accumulation may predispose horses to RDD.

Therefore, the aims of this study were to analyse retrospective data from a large group of horses with RDD, and determine if 1) there are any predisposing actors that can be indentified and in particular, determine if there is an association between sand accumulation in the colon and RDD; 2) determine if there are any specific clinical or clinicopathological factors at presentation that may help differentiate between horses that require medical vs. surgical treatment, and 3), compare the short term survival for horses with RDD treated medically vs. surgically.

2. PATHOGENESIS OF RIGHT DORSAL DISPLACEMENT

The large colon of a horse is only attached to the abdominal wall at 3 sites: the ceocolic fold, the dorsal attachment of the right dorsal colon and the duodenocolic fold. Otherwise the entire large colon is unattached and therefore prone to displacements. Normally the left colon shortens and relaxes lengthwise in the tempo given by the pacemaker cells located in the pelvic flexure (Rakestraw & Hardy 2012). If the pacemaker cells become disturbed for some reason, the pelvic flexure can start moving towards the diaphragm. In the case of RDD, the pelvic flexure (which normally lies in the left caudal part of the abdominal cavity) migrates cranially towards the diaphragm. Then it turns to the right caudal quadrant of the abdominal cavity. Finally it moves between the
cecum and the right abdominal wall. This is called a counterclockwise rotation (when viewed caudoventrally). Another migratory route for the pelvic flexure is a clockwise rotation. In this scenario, the pelvic flexure will end up lying next to the diaphragm and the left colon will be situated between the cecum and the right abdominal wall. This is a far less common presentation for a RDD. Right dorsal displacement is a non-strangulating displacement where gas and ingesta are not able to pass through the alimentary tract. The displacement can also be partial i.e. the pelvic flexure only moves next to the diaphragm but does not migrate between the caecum and right abdominal wall. In this scenario, the horse will often continue to pass small amounts of faeces (Rakestraw & Hardy 2012).

There is very little published data on the predisposing factors for RDD, but it has been suggested that excessive amounts of carbohydrates could expose horses to right dorsal displacements (Blikslager 2010). Carbohydrates are fermented in the large colon and if a horse ingests excessive amounts of carbohydrates it can result in the production of excessive gas that predisposes to displacements (Rakestraw & Hardy 2012). There is also some evidence that large colon displacements might be seasonal, with peak occurrence in spring and fall (Archer et al 2006, Hillyer et al 2001). In contrast, a study in Sweden reported that colic was more likely to occur during the winter months from October to March (Egenvall et al 2008). The authors hypothesized that the incidence of colic increased during wintertime due to different exercise and feeding routines when compared to summertime. As a whole, colic (including colon displacement) is more likely to occur at times when the horses were managed intensively (Archer et al 2006).

In one study looking at simple colon obstruction and distension, it was reported that travelling in the previous 24 hours increased the risk of colic (Hillyer et al 2002). In the same study, it was found that horses that wind sucked or cribbed were 70 times more likely to get colic compared to horses that didn’t have these habits (Hillyer et al 2002). Other significant predisposing factors in this study were a change in exercise routines, hours spent in the stable, long duration between routine dental care, anthelmintic admission during the past 7 days and previous colic episodes (Hillyer et al 2002).
Sand accumulation in the large colon is also thought to predispose horses to RDD but as of yet, there is no data to support this.

3. PREVALENCE OF RIGHT DORSAL DISPLACEMENT

There are only two studies available where large colon displacements are separated to their own groups and not counted as a single group. In this study, RDD was the second most common reason for surgical treatment of colic (14%). The most common reason was large colon volvulus with 17% (Mair & Smith 2005). Another study reported that 11.1% of horses that went to surgery had a RDD and it was the second most common reason for surgery (large colon volvulus being the most common reason) (Wormstrand et al 2014).

4. DIAGNOSIS OF RIGHT DORSAL DISPLACEMENT

There is no single diagnostic test with which one would be able to diagnose a RDD. The most important diagnostic methods are evaluation of clinical signs, rectal examination, ultrasonography and laboratory data. A right dorsal displacement can only be confirmed definitively during an exploratory laparotomy or at autopsy.

4.2 Clinical signs

Horses with RDD have been reported to have mild to moderate abdominal pain. Horses may kick at their ventral abdomen, try to lie down, roll, or they can just be lethargic and anorexic. The abdominal discomfort usually decreases with analgesics, but often recurs soon thereafter. The amount of discomfort is often progressive (Gardner et al 2005). Horses can continue to pass small amounts of faeces despite a right dorsal displacement (Rakestraw & Hardy 2013). In some cases, bloating and a “ping” sound on percussion may occur (McGovern et al 2011). Horses with right dorsal displacement usually have some gastrointestinal sounds audible (McGovern et al 2011). The heart rate in horses with RDD is usually elevated and typically horses with RDD will have no signs of endotoxemia or circulatory shock (McGovern et al 2011).
4.2 Rectal examination

Rectal examination is one of the most important diagnostic methods when diagnosing right dorsal displacement. In a counter-clockwise RDD the pelvic flexure is palpable on the right hand side and in a clockwise rotation the pelvic flexure is not palpable (Rakestraw & Hardy). In addition to the lack of pelvic flexure, the examiner is able to feel a large distended, gas-filled colon that is orientated horizontally across the abdominal wall (McGovern et al 2011). In the early stages of a RDD, one might still be able to feel the pelvic flexure, but the right dorsal colon is distended with gas.

4.3 Laboratory findings

In one study it has been reported that 18 of 37 horses (49%) with RDD had elevated gamma glutamyl transferase (GGT) values (Gardner et al 2005). In comparison, only 1 of 48 (2%) of horses with LDD had increased GGT values. GGT is a hepatic enzyme which is associated with hepatic injury. Probably the elevation in GGT values during RDD is because the right dorsal colon is attached to the visceral surface of the liver by a fibrous sheet. This proportion of the mesoduodenum blends with the hepatoduodenal ligament for the last 5 cm before attaching to the liver. The bile duct is situated within this 5 cm part. When a RDD occurs, the right dorsal colon moves caudally and laterally causing tension on the fibrous sheet. The portion of the hepatoduodenal ligament closest to the liver also becomes tense, causing obstruction of the bile duct. This increases GGT activity. As the disease progresses, the liver is not able to pass the conjugated bilirubin into the bile ducts, thus conjugated bilirubin values in blood will increase. This increase was reported in 33% of RDD patients (Gardner et al 2005). The GGT values normalized after surgical treatment of RDD in 9 of 11 horses (Gardner et al 2005).

Other bloodwork and peritoneal fluid is usually within the normal range, but can become abnormal as time passes (Grenager & Durham 2011).
4.4 Ultrasonography

Blood is supplied to the right dorsal colon via the right colic artery and to the right ventral colon via the ileocolic artery. Both of these vessels are situated on the medial aspect of the mesocolon, thus they should not be visible on ultrasound of a normal horse. When a RDD occurs, the left dorsal and ventral colons rotate to the right side of abdominal cavity between the cecum and the abdominal wall. At the same time, the medial surface of the left dorsal and ventral colons will be situated laterally. So, as the medial surface of the mesocolon now lies adjacent to the abdominal wall, it is possible to detect the branches of the ileocolic and right colic artery on ultrasonography in a horse with RDD. Similar vessels can also been seen in horses with a 180° colon volvulus. (Ness et al 2012)

At first the caecal vessels are identified and they are followed axially and cranially (Grenager & Durham 2011). The abnormal vascularisation can be seen in the intercostal spaces approximately at the costochondral junction on the right side of the horse (usually from 12th to 17th intercostal space) (Ness et al 2012). In order to make a diagnosis, one should see the vessels in at least 2 intercostal spaces (Grenager & Durham 2011). In order to rule out other causes of colic, the rest of the abdomen is also scanned routinely. One should evaluate the thickness of the large colon wall, determine the location of colonic sacculations, evaluate the small intestine motility, distension and wall thickness, evaluate the amount of peritoneal fluid, evaluate the gastric location and size and check the nephrosplenic space (Grenager & Durham 2011).

In two studies, 57-70% of horses with RDD showed abnormal vascularization on ultrasonography (Grenager & Durham 2011 and Ness et al 2012). All the horses with abnormal vascularization detectable on the ultrasonography were diagnosed with RDD during an exploratory laparotomy (Grenager & Durham 2011).

Sand accumulation that may be associated with RDD can also be investigated with ultrasonography. Ultrasound has been reported to have a specificity and sensitivity of 87.5%. Ultrasonography is not very good in defining the quantity of sand accumulation however (Korolainen & Ruohoniemi 2002).
5. DEFINING WHETHER A RDD SHOULD BE TREATED SURGICALLY OR MEDICALLY

5.1 Pain assessment

Pain is the most important factor when defining whether a horse should be treated surgically or medically (Toefner et al. 2003). Pain should be evaluated when the horse is not restrained, preferably in a box. A horse is showing pain when it is pawing the bedding, looking at the flanks, kicking the abdomen, lying down and rolling (Rakestraw & Hardy 2012).

The most severe colic patients, whom require surgical intervention immediately, are generally the most painful ones. RDD patients are not typically severely painful, instead they show mild to moderate signs of pain. Still, in some cases, horses with RDD can show intensive signs of pain. In this situation the horse won’t respond to analgesics or at least the pain will re-occur shortly after medication (Rakestraw & Hardy 2012). On the other hand, non-strangulating colics will respond to analgesics and don’t need immediate abdominal surgery.

The degree of pain can be determined by the horse’s response to non-steroidal anti-inflammatory drugs. Mild pain typically responds to NSAID’s for 8 to 12 hours. Moderate pain decreases for a limited time and requires several administrations. Horses with severe pain show violent behaviour and the pain will not be controlled with analgesics. Horses with severe pain require immediate abdominal surgery. (Rakestraw & Hardy 2012)

A study by Toefner et al. (2003) shows that the most important variables suggesting surgical intervention were severe abdominal pain (OR=57,17), distended small intestine (OR= 31,42), cyanotic mucous membranes (OR=17,88), peritoneal fluid hemolysis (OR 15,14) and absent abdominal sounds (OR= 11,97). Lethargic horses were also reported to have a high odds ratio (OR= 36,75) compared to horses not showing any signs of pain. Here we of course have to take to account, that this study was done on all types of colics and colic surgeries, not only RDDs, so the importance of pain might vary in the case of RDD, being a non-strangulating displacement and typically not causing severe signs of pain.
The problem with horses with severe pain is that they would need immediate surgery but the owner can’t transport the horse to an equine hospital if it is acting violently. Therefore it is necessary for a vet to come to the stables and give the horse a sufficient amount of analgesics prior to the transport.

5.2 Status
Capillary refill time (CRT) indicates the circulatory function of the horse. If CRT is prolonged in a horse with RDD, it indicates that the RDD has caused a circulatory dysfunction. A horse with prolonged CRT is 1.70 times more likely to end up in surgery (Toefner et al 2003).

5.3 Rectal examination
A horse with intestinal impaction detectable on rectal palpation is 2.51 times prone to surgical intervention compared to a horse with no abnormal rectal findings (Toefner et al 2003). Horizontal distension, which is the most common type of rectal finding in RDD patients, was not reported as it’s own group in this study. It was probably grouped into the category of “other findings”. Horses that had “other findings” in rectal examination had an odds ratio of 2.85 compared to horses with no rectal abnormalities.

5.4 Abdominal distension and gas accumulation
An article by Ducharme et al (1989) reports that abdominal distension is the most important factor discriminating whether a horse should be treated medically or surgically. Ninety percent of horses with moderate or severe abdominal distension were surgical candidates (Ducharme et al 1989).

5.5 Laboratory findings
Blood lactate concentration reflects the amount of ischemic injury and may therefore be used to determine the prognosis in colic horses (Rakestraw & Hardy 2012). Lactate can also be determined from peritoneal fluid. A high lactate concentration in peritoneal fluid is a more sensitive indicator for intestinal ischaemia than plasma lactate values (Latson et al 2005). This is controversial, as another study demonstrated that peritoneal fluids with high lactate value had a lower odds ratio for going to surgery compared to plasma lactate concentration (15.50 versus 18.55) (Toefner et al 2003). As RDD is typically a non-
strangulating displacement, it might be that neither plasma nor peritoneal lactate concentration increases in horses with RDD. If the RDD is severe and starts obstructing blood vessels, lactate values may begin to elevate.

5.6 Other factors
One study has reported increased rectal temperature decreased the need for surgery in horses with severe pain (Toefner et al 2003). The rise of rectal temperature was thought to result from increased activity due to pain, inflammation of the rectal area or cardiovascular dysfunction. Increased body temperature is often associated with peritonitis, enteritis or colitis, which do not require surgical intervention (Toefner et al 2003).

The colour of the peritoneal fluid is also a factor that can be used to discriminate surgical and non-surgical patients from one another (Ducharme et al 1989). If the colour of the peritoneal fluid is normal or cloudy, the horse typically doesn’t require surgical intervention (Ducharme et al 1989). If the abdominal fluid is serosanguineus, the horse is more likely to require surgical intervention (Ducharme et al 1989)

In summary, it should be remembered that delayed surgical intervention predisposes the horse to visceral rupture. Therefore it is recommended to take the colic horse to surgery promptly after admission. This way we are able to maximize the probability of a successful outcome (Rakestraw & Hardy 2012).

6. MEDICAL TREATMENT OF RDD

6.1 Medical treatment
Horses with RDD are treated with intravenous fluids, analgesics and forced exercise (McGovern et al 2011). Exercise can be, for example 10-15 minutes lunge reining every 1-2 hours (McGovern et al 2011)

Horses treated medically should be reassessed regularly. PCV should be taken and a rectal examination performed once every 2 hours. If there are any signs of endotoxemia or cardiovascular compromise (e.g. increased body temperature or
heart rate, abnormally coloured mucus membranes etc), the need for surgical intervention should be reassessed. (McGovern et al 2011)

The main goals of medical treatment of colic are to relieve pain, restore normal gut motility, restore and maintain hydration and electrolyte/acid-base balance and, if needed, treat endotoxaemia (Edwards 2013). When relieving pain it must be taken into account that the pain medication should not depress the gut activity, predispose to hypovolemic shock or mask the signs of endotoxemia (Edwards 2013).

6.2 Treating pain
Nonsteroidal anti-inflammatory drugs are used to relieve visceral pain. They function through inhibition of cyclo-oxygenase enzyme-mediated biosynthesis of prostaglandins (Moilanen & Kankaanranta 2013). Sedatives can also be used for achieving analgesia and sedation. Examples of sedatives used for colic are xylazine, detomidine, romifidine and acepromazine (Edwards 2013).

The ability of achieving analgesia and sedation varies among different sedatives. Fourty mg/kg of detomidine has been reported to have a satisfactory sedative effect on 84.2 % of colic horses. In comparison, 20mg/kg of detomidine had a satisfactory effect in only 71.5% of colic horses (Jochle et al 1989). The analgesic effect was rated satisfactory or highly satisfactory in 100% of the horses receiving 40 mg/kg detomidine. None of the horses receiving 0,1mg/kg butorphanol were reported to have satisfactory or highly satisfactory effect on pain. Also no differences in side effects were reported between the detomidine doses or the butorphanol dose (Jochle et al 1989). So one could say that detomidine is the most effective analgesic and sedative agent compared to flunixin, butorphanol and xylazine. Problem in detomidine is that it has more cardiovascular effects compared to, for example, xylazine (Yamashita et al 2000). Xylazine has also been reported to have less effect on duodenal motility compared to detomidine and a combination of xylazine and butorphanol (Merritt et al 1998). Xylazine has also been reported to have a longer analgesic effect than butorphanol (90 minutes versus 60 minutes) (Muir & Robertson 1985).
Narcotic agents, such as morphine can also be used, but it can cause excitement in horses and is thus combined with some other drug, like xylazine (Edwards 2013).

6.3 Alterations in intestinal motility
If the horse has increased intestinal motility, spasmolytics can be used. Horses with large colon displacements usually have decreased intestinal motility and so spasmolytics are not indicated in most cases.

6.4 Laxatives
Laxatives are used to resolve impaction masses by increasing the amount of fluid in the large colon and hence increasing gastrointestinal motility. Magnesium sulphate, sodium sulphate and mineral oils have been reported to have a laxative effect (Hotwagner & Iben 2008, Lopes et al 2004). Laxatives should always be administered with either enteral or iv-fluids to avoid dehydration. Enteral fluids combined with laxatives have been reported more effective compared to iv-fluids (Lopes et al 2002). Balanced electrolyte solution containing sodium chloride, potassium chloride and sodium bicarbonate is the safest enteral fluid, while compared to water it does not predispose to hyponatremia (Lopes et al 2004). Sodium sulphate hydrates the right dorsal colon better than magnesium sulphate (Lopes et al 2004). The problem in using sodium sulphate as a laxative is that it can cause severe hypocalcemia and hypernatremia (Lopes et al 2004). Magnesium sulphate did not have similar injurious effects.

Mineral oil given orally via a nasogastric tube is considered a safe but not very effective laxative. In the case of sand enteropathy, psyllium increases the outflow of sand from the intestine when combined with mineral oils (Hotwagner & Iben 2008). Psyllium is especially useful for horses with sand enteropathy. Although this crossover study proves that psyllium increases the outflow of sand artificially fed to horses, another study shows that feeding psyllium does not always resolve the sand enteropathy (Ruohoniemi et al 2001). In this study, 14 horses with large colon sand accumulation were fed psyllium and the results were monitored with abdominal x-rays. In this study, the sand accumulation resolved with only psyllium administration in 2 foals and 4 adult horses. Other 3 horses required laxatives, like mineral oil or magnesium sulphate in order to
resolve the sand accumulation. In one horse, no laxatives were effective, but the sand accumulation resolved on pasture.

6.5 Fluid therapy
Fluid therapy consists of 3 different kinds of goals: replacing the deficits, maintaining the achieved hydration status and overhydration. Overhydration is commonly used in horses with colonic impaction (Edwards 2013).

7. SURGICAL TREATMENT OF COLIC
Surgical treatment of RDD is typically done using a ventral midline celiotomy approach. There are some reports that a standing flank laparotomy would be another way to manage RDD (Rakestraw & Hardy 2012). This is contradictory to other articles that claim that a standing flank laparotomy is only useful for uterine torsions, ovariectomies and small intestine problems (Kummer 2012). For ventral midline celiotomy, the horse is in general anaesthesia and placed in dorsal recumbency. The incision is made through the linea alba because it is a fibrous structure which is easy to close and the amount of haemorrhage is minimal. In ventral midline celiotomy, one has a good visibility to the abdomen and more parts of the intestine are possible to exteriorize (Kummer 2012). At surgery, the pelvic flexure is identified, the large colon is exteriorized and the displacement is corrected (Rakestraw & Hardy 2012). If there is a large impaction mass present in the large colon, an enterotomy can be performed. If there is just accumulation of gas in the large colon, it can be evacuated with a needle.

The most typical reason for deaths during colic surgeries have been reported to be cardiac arrest (13 of 635 colic surgery patients) (Mee et al 1998). Anaesthetic complications occur more frequently in emergency colic surgeries compared to elected anaesthesia (Dukti & White 2008). Abdominal bloating is associated with ventilation difficulties causing hypoxia (Dukti & White 2008). This is why it is important to evacuate gas from to intestine as quickly as possible during surgery. Possible complications requiring euthanasia during RDD surgery are intestinal rupture, inaccessible large colon and haemorrhage (Mee et al 1998). If bleeding and haemorrhage occur during surgery, the source of the blood should be located and sutured. The mesenteric vessels of the large colon are especially prone to
bleeding (Dukti & White 2008). Mesenteric vessels should be ligated with both staples and sutures (Dukti & White 2008). The large colon is especially predisposed to ruptures if it is gas-filled or otherwise distended. If a rupture occurs, it is important to prevent the intestinal contents contaminating the abdominal cavity. Gastrointestinal ruptures can occur spontaneously or they can be iatrogenic. Gastrointestinal ruptures predispose to patient to incisional infections and peritonitis (Dukti & White 2008), and are in most cases fatal.

8. PROGNOSIS

Horses with RDD going to surgery have a short-term survival rate (= to discharge) of 93% (Mair & Smith 2005). This is relatively high compared to the total short-term survival rate of horses going to colic surgery, which was only 70.3% (Mair & Smith 2005). The survival rate is also better compared to all types of large colon colics, which was 89.9% (Mair & Smith 2005). Only one of the 42 RDD patients included in this study was euthanized during anaesthesia. The reason for the euthanasia was an intestinal rupture (Mair & Smith 2005). Another study presented less optimistic short-term survival rates for large colon colic horses. A study done in Norway by Wormstrand et al (2014) reported a short-term survival rate for RDD patients of 81.8% and for all types of large colon colics a short-term survival rate of 66.7%. So, in both studies, we are able to see that right dorsal displacement has a better short-term survival rate compared to other types of large colon colic surgeries.

Horses with RDD are likely to have recurrent colic episodes after RDD surgery (Smith & Mair 2010). Forty one percent of horses with a RDD episode had recurrent colic. Typically this recurrent colic was also RDD. Horses with RDD are more likely to develop postoperative colic compared to horses with LDD or nonstrangulating volvulus (Smith & Mait 2010). Horses with retroflexion of the pelvic flexure were as likely to develop post-operative colic as were horses with RDD (Smith & Mair 2010). The reason for RDD patients to have postoperative recurrent colics is unclear.

9. MATERIALS AND METHODS
The data was collected from Helsinki University Equine hospitals patient information system from the January 2008 to December 2013. The Provet® patient information system was searched with terms “Right dorsal displacement”, “RDD”, or in finnish “large colon displacement”. All patient reports containing these search terms were reviewed. Patients that had sufficient admission status, laboratory results and were diagnosed with RDD either by rectal, ultrasonography, surgical or pathological findings were included in this study. Horses that were euthanized during the first 24 hours without an attempt of surgery were categorized as non-treated horses because the reason for euthanasia was either financial or poor prognosis. Horses that went to surgery were categorized as surgically treated patients and horses that did not go to surgery but were at the hospital for longer than 24 hours were categorized as medically treated patients. A pre-surgical diagnosis of RDD was made on rectal examination by identifying horizontal distension of the large colon. Ultrasonography was also used to rule out other possible colics and, in some cases, to identify a turtle sign suggesting a RDD. In some of the horses, the diagnosis was confirmed at surgery or autopsy.

Information was collected with OpenOffice database datasheet. Information retrieved included the age, gender and insurance status of the horses. Duration of colic symptoms and whether the horse was referred or not was also recorded. Of the basic status, heart rate, respiratory rate, degree of abdominal distension, borborygmi, nasogastric reflux, mucus membranes and capillary refill time was recorded. borborygmi were typically recorded from 4 locations (right flank side up and down, left hand side up and down). The borborygmi were recorded with zeroes and plus-signs. 0 means no borborygmi audible, one plus-sign means decreased, but audible borborygmi, two plusses mean normal borborygmi and three means increased borborygmi. In order to get an overall understanding of the amount of borborygmi present in RDD patients, we changed the plus signs into numbers (1 referring to decreased borborygmi and number 3 referring to increased borborygmi and counted the average of all 4 sites. From the rectal examination, findings on impaction, gas distension and horizontal distension was recorded. From the ultrasound, signs of large colon edema, distended small intestine, excessive amounts of abdominal fluid and signs of turtle formation.
were recorded. Also, if available, white blood cell count and total protein of abdominocentesis was recorded. From the laboratory findings packed cell volume, total protein, lactate, creatinine, white blood cell count, fibrinogen, pH, sodium, calcium, bicarbonate, chloride and GGT was recorded.

The presence of sand in the large colon was diagnosed by either sand x-ray or at surgery. Many of the horses had sand x-rays taken but only a few of the patient records had the results of the x-ray available. The sand x-rays were re-reviewed for this thesis in order to get the information of sand impaction in horses presented at the hospital with RDD. In horses that went to surgery, sand accumulation was marked positive only if there was a specific remark of sand in the surgery report.

The outcome (discharged or euthanized), bill and time spent at the hospital were also recorded. No follow-up after discharge was performed.

**Statistical analysis**

The information retrospectively collected from Provet® patient database were first screened for typing errors and consistency by assessing the extreme values in Excel® spreadsheet. In cases, where the suspicious entries could not be corrected with acceptable certainty (lab value order of magnitude, wrong sequence of time stamps etc.) the original record in Provet® was re-reviewed.

The clean database was locked before statistical analysis with SPSS® (version 21). In addition to SPSS some basic illustrations of the data were performed with Wizard for Mac. Wizard is a statistics program that provides basically the same information as SPSS but the user interface is more straightforward and the view is more illustrative.

No formal power calculations were performed. The number of included patients was dependent on the cases in the Provet system of Equine Hospital of Helsinki University.

The statistical analyses are of a descriptive nature. Means or medians are presented depending on which is appropriate. Either quantiles, standard
deviations, or 95% confidence intervals are given to describe the observed distributions.

Since no formal H0 hypothesis has been established, the p-values presented should be interpreted only as an alternative way of presenting confidence intervals, not as an indicator of statistical significance.

10. RESULTS

Fifty-eight horses were included in this study. Six of these horses were euthanized due to poor prognosis or financial reasons during the first 24 hours at the hospital. These patients were evaluated as their own, non-treated group. Those horses that went to surgery were counted on their own, as the surgically treated group. The horses that were not treated surgically were counted as the medically treated group. There were 36 surgical and 16 medical patients. So, of the treated patients, 30.8% of the patients were treated medically and 69.2% surgically. The study population consisted of 31 geldings, 21 mares and 6 stallions.

The median age of horses presented was 10.4 (SD 5.88). The median age of non-treated was 16.5 (SD 8.16) years, medically managed 9.5 years (SD 4.6) and surgical 10.4 years (SD 5.6).

Seasonal distribution of RDD patients is shown in figure 1. Notably 37/58 (64%) of the horses were diagnosed during the fall (September to January).
The seasonal distribution of sand observed is visible in Figure 2. The information of the sand status of the horse was available in 43/58 (74%) of the horses included in the study. Of these horses, 14/43 (33%) had sand and 29/43 (67%) did not. Of horses that went to surgery, 11/36 (31%) were reported to have a sand impaction in their large colon. Of the medically treated horses 3/7 (43%) of the horses had a sand impaction based on X-ray. All except one of the RDD patients
with a sand impaction in their large colon where presented between September and January.

Thirty nine out of fifty eight (67.2%) of the horses included in this study were insured. Only 2/6 (33.3%) of the non-treated horses had insurance. Of the surgical treated horses, 27/36 (75%) had insurance. Of the medically treated patients, 10/16 (62.5%) had insurance.

The median time at the hospital for medically treated patients was 3.8 days (SD 5.0) and for the surgically treated patients 7.5 days (SD 4.7).

The bill of horses going to surgery ranged from 1951-8401€ (mean 5023€). The medical patients’ bills ranged from 480-1984€ (mean € 1295). The bill of the non-treated patients ranged from 603-1275€ (mean € 914).

Horses that were not treated had a shorter duration of symptoms before admission compared to the two other groups (non-treated median 0.33 days (range from 0.08-1.48 days), medical median 0.75 days (range from 0.21-2.42 days) and surgical patients median 0.42 days (range from 0.08-10.29 days))

The non-treated horses had the highest heartrate (median 60.67 bpm). There was not much difference between medical and surgical patients (median 44 bpm and 48 bpm, respectively).

The mean borborygmi were slightly decreased in all three groups (mean 0.81 CI ±0.17). The surgically treated horses had the poorest borborygmi (mean 0.69 CI ±0.24). The mean mean borborygmi of medically treated patients was 1.13 (CI ±0.25) (p=0.032).

In the medically treated horses there was the fewest amount of gas accumulation in the intestines on rectal examination (9/16, 56%). Of the surgically treated patients, 25/36 (69%) had gas in rectal examination. Five out of six (83%) of the non-treated patients had gas on rectal examination.

The total protein was lower in surgically treated patients compared to patients that were treated medically (surgical: 60.68 g/l (CI ±2.79) and medical: 65.82 g/l
The non-treated horses had the highest total protein concentrations (70.5 g/l ±9.43).

The blood ionized calcium concentration varied between medically and surgically treated patients. The medically treated patients had a mean calcium concentration of 1.43 mmol/l (CI ±0.05) and the surgically treated had a mean calcium concentration of 1.36 mmol/l (CI ±0.04) (p=0.019).

Medically treated patients had higher plasma potassium levels compared to surgical patients (3.52 mmol/l CI ±0.25 and 3.26 mmol/l CI ±0.14 (p=0.074)).

GGT was measured from 45 of the RDD patients. Only 9 (18.2%) of these had increased GGT-values (over 50 U/l). There was no significant difference in GGT between the three different groups.

The pH value also varied among different groups. The medically treated patients had the mean pH of 7.421 (CI ±0.025), the surgically treated 7.463 (CI ±0.016) and the euthanised horses 7.443 ±0.034 (p=0.196).

Of the horses admitted during fall (from September to January) 13 horses had sand and 13 did not have sand. During the rest of the year, only 1 horse was diagnosed with sand impaction in its’ large colon and 18 were diagnosed negative for sand. Odds ratio for sand observed during fall was 18, Chi-square 10.3, p=0.0014.

Of the medical patients 13/16 (81.2%) survived to discharge and 30/36 (83.3%) of the surgically treated patients survived to discharge.

11. DISCUSSION

There is one retrospective article on medical and surgical management of RDD (McGovern et al 2011). So knowledge of factors indicating whether a horse should be treated medically or surgically are not thoroughly illustrated. The aim of this study was to illustrate some of these factors.

Twelve of fifty-eight (20%) of the horses were admitted in November and 37/58 (64%) of the horses were admitted at the hospital between September and
January. In Finland the horses are taken off pasture typically in the end of August or beginning of September. Through the winter horses are usually kept in sand paddocks. We believe that one reason for the increase of RDD cases during autumn is the feeding change (from pasture to dry hay) and that when moved to a sand paddock, horses start eating sand. Most of the sand accumulations were diagnosed between October and November, which coincides well with the time when pasture season ends in Finland. In Southern Finland there is a permanent snow cover from beginning of January to the beginning of March (FMI 2012). This could be one reason for the decrease of diagnosed RDD patients between February and May.

Horses diagnosed with RDD during fall had a significantly higher odds ratio for observed sand compared to horses that were diagnosed at other time of the year.

Of all the patients presented at the equine hospital (excluding the ones that were categorized as non-treated) only 25% were treated successfully medically and 69.2% went to surgery. It seems that we have a higher rate of surgically treated RDD patients compared to previous reports (64% treated successfully conservatively) (McGovern et al 2011). One suspected reason is that in Finland horses spend more time in sand paddocks and less time on pasture compared to horses in the United Kingdom, where the previous study was done. Also there is not so much sandy soil in the southeast United Kingdom. In the previous study, sand was not confirmed as a factor predisposing to RDD. It is likely that sand accumulation causes large intestine hypermotility, which predisposes the horse to RDD. Sand can also accumulate to the left dorsal colon. Sand is heavier than normal intestinal content and therefore pulls the dorsal intestine ventrally. In the case of a clockwise right dorsal displacement, sand accumulated in the right dorsal colon is more prone to flip and situate itself ventrally to the right ventral colon. In our case, 14/45 (31%) of the horses had sand in their large intestine. This could be one reason why we have more RDDs that require surgical intervention.

The non-treated horses had higher heart rates compared to the other two groups. Probably this is because these horses were the most painful ones and they were
evaluated to have a poor prognosis and were therefore elected for euthanasia without treatment.

The surgically treated horses had poorest GI-sounds. This is probably because patients going to surgery are usually the severest and most painful ones and therefore their borborygmi is also most depressed.

On rectal examination, surgical and the non-treated patients were more often reported to have gas accumulation in their intestines compared to the medically treated patients. Gas accumulation causes abdominal distension and abdominal distension causes visceral pain. Horses showing acute pain are the most common ones to be elected for surgery.

There were only 9 horses that had a GGT value over the reference value. This is only 18,4% of the horses from which GGT was measured. In a previous study it was reported that 49% of horses that went for surgery because of right dorsal displacement had high GGT values. In our study, this percentage is much lower. Differences to this previous study are that not all of our horses went to surgery and the GGT sample was taken either post or preoperatively. It is possible that some of our surgically treated patients had elevated GGT values preoperatively but when the displacement was corrected and the tension in the hepatoduodenal ligament eased and the biliary duct opened again, allowing bile to flow the intestine and so reduce the plasma GGT level before the GGT sample was taken. Also, in the previous study all the horses were opted for surgery. Of the medically treated patients, only 10% had plasma GGT above the reference range. In contrast, 28,1% of the operated patients had elevated plasma GGT value. So it could be interpreted that the more severe displacements, that required surgical intervention, were also the ones obstructing the bile duct and therefore these patients had higher plasma GGT values.

There was a significant difference in blood calcium levels in surgically and medically treated patients. The surgically treated patients had lower calcium levels compared to the medically treated. It has been reported that colic horses have a slightly lower calcium concentration compared to healthy controls, but this was not a significant difference (Latson et al 2005). The reason for this can
be anorexia or that calcium is lost into the intestinal lumen (Hesselkilde et al 2014).

The survival rate of surgical patients (83.3%) is well in line with the previous study made in Norway (81.8%) by Wormstrand et al (2014). The present study’s survival rate was lower compared to the study performed by Mair & Smith in 2005. No clear explanation for this difference could be presented. Possibly there are some differences in the surgical techniques between Helsinki equine hospital and Bell Equine Veterinary Clinic. Many of the surgical RDD patients at Helsinki Equine hospital had also colonic impaction masses that required enterotomy. Enterotomy predisposes to post-operative complications and might be an explanation to the lower survival rate.

The medically treated patients spent less time at the hospital compared to the surgically treated horses. Medically treated horses were re-fed and discharged as soon as the displacement had resolved. Surgically treated patients were more prone to get complications (wound infections, peritonitis etc.) and required longer hospitalizing compared to medically treated patients. The time spent at the hospital influences also the size of the bill. Also the cost of surgery is higher than the cost of intravenous fluids and pain medication. Therefore surgically treated patients had larger bills compared to medically treated.

81% (47/58) of the RDD patients admitted at the hospital were referred by a colleague in the field. In most cases, the referring vet had given the horse some pain medication, so probably the heart rate and respiratory rate were lower at the hospital than what they would had actually been without the pain medication.

Because Helsinki equine hospital is a referral hospital, we most likely get the most severe cases that have already been assessed by the referring vet to be surgical patients. Probably some of the mildest RDD patients that do not require surgical intervention are treated at home medically and therefore do not end up in our records. So probably our data is not fully representative when assessing how many of the right dorsal displacements need surgical intervention and how many can be treated medically.
There were very few horses that showed the turtle sign in ultrasonography. This is probably because the first research articles on turtle sign have been published in 2011 and it hasn’t been looked for before. All three cases in which turtle sign has been reported have been during year 2013. So it is probable that there has been more horses presenting with the turtle sign in ultrasonography but it has not been looked for.

Of the insured horses, 27/37 (69%) went to surgery compared with horses that did not have insurance where only 6/15 (47%) went to surgery. It is probable that the insured horses were more valuable and the owners opted for surgery straight away when it was recommended, because they did not have to consider the costs. On the other hand, those owners that did not have their horses insured were concerned about the bill and wanted to try medical treatment first. So it might be that some of the horses that went to surgery could have recovered with medical treatment but went ahead with surgical correction to be on the safe side.

It is also possible that the surgeons at Helsinki university equine hospital tend to send horses with milder symptoms to surgery than the surgeons at Donnington Grove. In the previous study by McGovern et al (2011) the horses were treated medically if there was no sign of endotoxemia, severe pain, seroanguious fluid on abdominocentesis or severe distension of the large colon. In the case of our study, in some cases it might have been that the horse was opted for surgery without any of these symptoms but only with a diagnosis of right dorsal displacement.

This study shows that there is a seasonal distribution in RDD cases diagnosed at Helsinki University Equine Hospital. It also shows that odds ratio for sand in horses diagnosed with RDD is higher during fall months compared to other times of the year. This does not prove that sand in the large intestine is a predisposing factor for RDD, but it shows that there is a possible correlation. Further research should be done on this field.
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