A case of quadruple limb lameness in a horse

by

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Case Report

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Preface

I would like to thank my promotor and co-promotor for helping me find an interesting case and providing me with the needed information. Furthermore I want to say a very big thank you to my family and boyfriend for helping me work on this thesis and for their endless support throughout the entire study!
Abstract

Navicular syndrome is a common cause of lameness in middle-aged horses. It primarily affects the front legs, but in some cases the hind legs can be affected too. Discomfort in the region of the navicular apparatus can be caused by pain in this region, by derogation of the navicular bone itself, or by the surrounding soft tissues.

This thesis describes a case of a horse that was presented to the department of Surgery at the Faculty in Merelbeke (UGent). The clinical examination pointed out that the horse was very stiff and lame. Radiographic imaging was done foremost due to the severity of the symptoms, to see if there were any subtle or obvious changes in the hoof. Since this was not the case for this horse, local analgesia was safe enough to use to locate the region from where the pain originated. Because palmar digital nerve block on all four legs was positive, and the intrabursal anaesthesia of the most lame limb was positive as well, the horse was diagnosed with navicular syndrome.

The owners decided to try a conservative therapy, before going over to advanced medical imaging such as magnetic resonance imaging. The therapy consisted of an intrabursal injection with a corticosteroïd (methylprednisolone) combined with corrective shoeing and trimming.

After 5 months the owners were contacted to check up on the horse. It had responded very well to the treatment and was still sound.
Hoefkatrol of podotrochleïtis is een veel voorkomend probleem, vooral beschreven bij warmbloedende middelbare leeftijd. In de vakliteratuur wordt podotrochleïtis vaak vermeld als een probleem dat voornamelijk voorkomt in de voorvoeten. Desondanks worden er op de Faculteit in Merelbeke (UGent) jaarlijks een 30-35 gevallen van paarden die aan de vier voeten mank zijn gediagnosticeerd, waarvan er een deel zelfs wordt aangeboden met de zwaarste kreupelheid komend uit de achtervoeten. Podotrochleïtis is een aandoening waarbij het probleem zich lokaliseert in de regio podotrochlearis van de hoef. Het kan gaan om simpelweg pijn in die regio, vroege of al meer uitgesproken botveranderingen van het straalbeen, of aantasting van de omgevende weke delen.

In deze thesis wordt een casus besproken van een paard met viervoetsmanker conditie. Het dier werd kreupel en stijf bij de vakgroep Heelkunde en Anesthesie van de huisdieren aan de Faculteit in Merelbeke (UGent) gebracht. Het werd enkele dagen gehospitaliseerd om de uitgebreide klinische onderzoeken en herhaaldelijke lokale anesthesiën correct te kunnen uitvoeren.

Het gebruik van lokale anesthesie wordt erg gewaardeerd als diagnostische methode om aan te kunnen tonen waar de pijn in het lidmaat vandaan komt. Lokale anesthesie in de bursa is erg specifiek; wordt de bursa positief bevonden, kan men vervolgens nog aanvullende diagnostische methodes, zoals medische beeldvorming, gebruiken om het onderzoek verder toe te spitsen op de oorzaak van de pijn in die regio. Bij het paard in deze casus werden er nauwelijks radiografische veranderingen aangetroffen. Het is vaak zo dat op radiografische opnames niet veel veranderingen te zien zijn, of dat deze niet significant genoeg zijn om de pijn in de regio podotrochlearis te verklaren. Andere medische beeldvormingstechnieken, zoals magnetic resonance imaging (MRI), geven vaak betere beeldkwaliteit, van zowel het straalbeen als van de omgevende weke delen. De eigenaars van het paard besloten om eerst een therapeutische behandeling te proberen, vooraleer over te gaan naar MRI. Op basis van de positieve lage anesthesie op alle vier de benen, en een positieve bursa anesthesie van het meest manke lidmaat, werd het paard conservatief behandeld voor hoefkatrol.

Het paard werd lokaal behandeld in de bursa podotrochlearis met een middellang-werkend glucocorticoid (methylprednisolone). Om laminitis te voorkomen werd deze behandeling in 2 stappen uitgevoerd, eerst de voorvoeten en enkele dagen nadien de achtervoeten. Ook werd er een correctief beslag aangebracht op alle 4 de hoeven. Een rustperiode werd aangeraden waarna de werklast gradueel kon worden opgebouwd.

Er zijn meerdere behandelingen beschreven voor podotrochleïtis, maar het gaat hier voornamelijk om tijdelijke oplossingen die het paard een hoger comfort kunnen geven. De uitkomst van de gekozen behandeling of combinatie van verschillende behandelingen dient afgewacht te worden. Het effect van de behandeling is individu afhankelijk en kan moeilijk voorspeld worden.

Vijf maanden na de lokale behandeling werden de eigenaren gecontacteerd, waaruit bleek dat het paard sinds de behandeling niet meer gemankt heeft.
Introduction

1. Anatomy of the distal limb

The equine hoof consists of different important structures. The bone inside the hoof is called the distal phalangeal bone (P3). The distal interphalangeal (DIP) joint or coffin joint is outlined by the navicular bone, P2 and P3. On the proximal-caudal aspect of P3 there is a distal sesamoid bone, called the navicular bone, which is the heart of the navicular region. The navicular bone is boat shaped and lies palmar/plantar to the DIP. The dorsal surface of the navicular bone is where it articulates with the distal-palmar/plantar aspect of the middle phalanx (P2). This surface is covered with hyaline cartilage. The deep digital flexor tendon (DDFT) glides over its palmar/plantar surface, which is covered with fibrocartilage to keep it smooth (R. Getty 1975). The distal border of the navicular bone is covered with a thin layer of hyaline cartilage for the articulation with the distal phalanx. On this distal border, there are also a few foramina that are filled with synovium (Poulos and Smith, 1988).

On either side of the DIP joint there is a dorsal and a palmar/plantar pouch (Sack and Habel, 1977). The palmar/plantar pouch can be subdivided into 2 pieces, i.e. a proximal pouch that lies on the palmar surface of P2, and a distal pouch that reaches in between the navicular bone and the distal phalanx. The ventral outlining of the distal pouch is formed by the distal ligamentum sesamoideum impar (DSIL) (Sack and Habel 1977; Sack 1991). The navicular burse is a thin fluid filled pocket that lies between the navicular suspensory apparatus and the deep digital flexor tendon (DDFT) (Sisson 1975; Sack and Habel 1977; Hoffer et al. 1989; Sack 1991; Dyce et al. 2010). Jann et al. (1991) and Gibson et al. (1990) confirmed that there is no direct anatomic connection between the navicular burse and the DIP joint, using contrast radiography. However, Bowker et al. (1993), found that there was quite some discussion about the possibility of an indirect, functional communication between the DIP joint and the navicular burse.

The ligaments keeping the sesamoid bone in place are the following: a pair of collateral ligaments that start at the depressions on either side of the distal part of P1, and go in a distal-palmar direction toward the proximal border of the sesamoid bone. These collateral ligaments “suspend” the navicular bone (Getty 1975; Kainer 1989). From each of these collateral ligaments there is a branch that originates on the processus palmaris of P3 and inserts on the axial surface of the ipsilateral cartilage of the foot (Getty, 1975). The last ligament that originates from the distal margin of the navicular bone is the ligamentum sesamoideum impar. It extends to the flexor surface of P3 and inserts onto the DDFT (Kainer, 1989). The blood supply in the hoof is realised by the medial and lateral digital arteries that descend from the medial palmar artery (Pollit 2010). The hoof is innervated by the nervi plantares/palmares digitales (Dyce et al., 2010).
2. Podotrochleitis – Navicular bone disease

Forelimb lameness from the equine foot is often derived from the distal interphalangeal (DIP) joint and the navicular bursa (bursa podotrochlearis) (Stashak 1987; MacGregor 1989; Turner 1989; Turner 1991). Navicular disease seems to be most common in horses aged between 4 and 15 years of age (Colles, 1982; Turner, 1989; Stashak, 1998). It is thought to be the cause of one third of all cases of chronic forelimb lameness (Colles 1982, Stashak, 1998). The most susceptible breeds are Quarter horses, Thoroughbreds and Warmbloods, where it occurs most in geldings (Stashak, 1998; Dyson, 2003). Hind limbs can be affected, although it has rarely been described in literature.

Because there is not just one single cause or reason, it is referred to as navicular syndrome. It has been defined as a chronic, mostly forelimb lameness, and is associated with pain deriving from the navicular bone itself or one of its associated structures such as the collateral suspensory ligaments (CSL’s), the distal ligamentum sesamoideum impar, navicular bursa, and the DDFT (Sampson et al., 2008; Dyson, 2003). Often these horses do not show any radiographic changes in the hoof; therefore it is useful to use advanced imaging such as computed tomography (CT) or magnetic resonance imaging (MRI) to better define abnormalities.

The exact pathophysiology is still unknown (Adams and Belknap, 2016). In the past, it was mostly suggested that navicular disease was caused by a “sick” navicular bone (Colles, 1979; Svalastoga, 1983; Ostblom et al., 1984; Ostblom et al., 1989). Rijkenhuizen (2006) described the changes in the navicular bone as being “oedema, vascular stasis, enlargement of the nutrient foraminae on the distal and proximal borders, cyst-like medullary areas, subchondral bone changes, changes in the flexor surface, and fragmentation of the distal border”, that could make a horse lame or uncomfortable.

More recent studies suggest that it is not only the navicular bone that can cause this syndrome, but also the surrounding soft tissue structures, such as tendinitis of the DDFT (Thompson et al., 1991; Lose, 1995; Rijkenhuizen, 2006), desmitis of the collateral suspensory ligaments, desmitis of the impar ligament or the distal annular ligament, and synovitis/bursitis of the navicular bursa or the DIP-joint can
also cause pain in the palmar foot region (Rijkenhuizen, 2006). Simple pain arising from any of the structures in the heel region due to severe bruising for example can also cause lameness and be associated with navicular disease (Dabareiner, 2015).

It appears that there might be a vascular component, and a biomechanical component that could cause the navicular syndrome (Adams and Belknap, 2016). Many researchers (Pool et al., 1989; Svalastoga et al., 1983; Svalastoga and Smith, 1983; Svalastoga and Nielsen, 1983; Pleasant et al., 1993; Wright et al., 1996) have shown that changes in the fibrocartilage of the flexor surface of the navicular bone, subchondral bone, medullary cavity, and bursal synovium are similar to changes observed in the hyaline cartilage and synovial membranes of joints with osteoarthritis (Pleasant et al., 1993; Wright et al., 1996), and is therefore a similar process to osteoarthritis (degenerative joint disease). The surface of DDFT that rubs along the navicular bone, core lesions and adhesions between the distal sesamoid bone and the DDFT, have also been observed to cause pain (Pool et al., 1989; Pleasant et al., 1993; Wright et al., 1996). A broken back hoof-pastern axis, together with underrun heels and a toe that is too long can also give excessive pressure on the navicular bone and its surrounding structures, especially the DDFT, causing lameness (Adams and Belknap, 2016).

Factors, such as poor shoeing technique (short heel and long toe), small hoof size, faulty and upright conformation, exercise on hard surfaces and a large body size are considered to play a role in this syndrome (Adams, 1974; Pool et al., 1989; Turner, 1989; Stashak, 1998). A hereditary role in this disease seems to be of importance too, as it occurs more in certain breeds, (e.g. Quarter horses, Warmbloods and Thoroughbreds), than in others (e.g. Friesans and Arabic horses) (Adams and Belknap, 2016).
Case study

1. Anamnesis
A 6 year old Quarter horse gelding was presented to the Veterinary Clinic in Merelbeke on the 19th of August 2016 for an orthopaedic examination. According to the owner, he had been lame on the front right limb (RF) for the past month. The horse had received anti-inflammatory drugs Danilon® (suxibuzon) from the vet at home. One bag of 10 grams consists of 1.5 grams of suxibuzon. He started off with 2 bags of Danilon® a day for 2 days, continuing with 1 bag a day for the remaining 5 days. He was also taken out of work and put out on the field to rest. After this treatment the horse seemed remarkably better, but after restarting light work for a week it became lame again. The horse was shoed two days before coming to the Clinic. The blacksmith had placed a rubber underneath the shoes on the front legs. It has always stood square on all four legs, and no pulsation or swelling was reported by the treating vet. The horse is mainly used for dressage and pleasure riding.

2. Clinical examination, inspection and palpation

2.1 Day 1
The first clinical examination took place. On the right front (RF) limb no pulsation or swelling was felt. The horse was moderately muscular on his back and especially its neck. The horse walks with a shortened stride on all four legs and is very stiff throughout its entire body. In walking gait on a right hand turn the horse stumbles, and on the left hand turn it is mostly just stiff. A hoof tester was used on all four feet, but the horse did not react significantly to pressure on the sole of the hoof, the frog or the hoof bulbs.
In trot on a straight line a clear lameness was seen RF. The examination was only done in trot on a straight line, as the horse was severely lame and no risks were taken.
A low distal anaesthesia RF was performed after wiping the injection area with a 70% alcohol solution. This regional anaesthesia is also referred to as a PDN block, or palmar/plantar digital nerve block, which blocks, the navicular apparatus together with the heel and toe region of the sole, and it could possibly affect the distal interphalangeal joint (DIP) or coffin joint (Fig. 7). The anaesthetic effect lasts for about 90 - 120 minutes. After approximately 15 minutes, the heels were tested for numbness by poking the hoof bulbs with a blunt screw on the end of a pole for safety. The horse was then tested again in trot on a straight line. The anaesthesia came out positive, meaning that the lameness improved or even disappeared. The horse did not switch to left front lameness, which can occur if the horse is lame on more than one limb, hence the lameness on the other limb only becomes clear once the first has been eliminated by anaesthesia. The RF distal limb at the level of the fetlock was numbed afterwards, called the abaxial or basal sesamoid nerve block, to anesthetize the palmar nerves at the base of the proximal sesamoid bones. This gave no further improvement in stiffness nor was there switching to front left (LF) lameness. The anaesthetic examinations on day 1 were only executed on the straight line in trot.
After the examination, the horse was hospitalised at the clinic until further examinations could take place in the following days.
2.1.1 Medical imaging

After the clinical examination and the regional nerve blocks on day 1, it was decided to take some x-rays of the front right foot and the horse's neck, to see if there was a spinal reason for the horse's stiffness that had not disappeared after the PDN block.

A lateromedial (LM) (fig. 1) and dorsal 55º proximal – palmarodistal oblique (D55Pr-PaDiO) (fig. 3-4) were taken of the front right foot. A mild amount of smooth and well defined new bone formation was seen on the processus extensorius of the distal phalanx (fig. 2-4). No other radiographic abnormalities were seen. This finding could not explain the clinical signs of the previous clinical examination.

Because the horse was very stiff, a left-to-right lateral radiograph was taken of the neck to rule out that the cause for the severe lameness and stiffness could derive from the neck region. A bony knob was seen at the ventral facet of the C6-C7 joint, described as moderate buttress formation. These are degenerative changes in the caudal neck area, but were not significant enough to explain the severe lameness and the positive reaction to local analgesia (fig.5-6). Because of these images and the positive PDN block, the focus was put back onto the distal limb.
2.2 Day 2
The clinical examination was performed again, giving the same results as the previous day with the same lameness and stiffness. It was then decided to examine the horse in a circle, as the radiographic images did not suggest any direct danger such as fissures/cracks or broken bones in the foot. When a horse is that lame, it is better not to take any risks in making it trot or turn in case a crack could turn into a fracture. On the soft, the horse was lame on the right front limb in both directions on the circle, but the lameness seemed slightly worse on the right hand side than on the left. On the hard surface, the horse was clearly lame RF on the left hand, and on the right hand side the horse was very stiff/short strided and stumbled.
The decision was made to do a regional anaesthesia of the bursa podotrochlearis or navicular bursa and of the distal interphalangeal (DIP) joint or coffin joint on the right front limb. By anesthetizing the bursa, analgesia of the bursal apparatus is obtained. Only occasionally (partially) the toe region of the sole is affected (fig. 6). Both anaesthetics were negative as there was no improvement in the horse’s gait.

After this, a low anaesthesia of the RF was redone (cf. day 1), and turned out to be positive again just like in the first examination. In contrary to the previous examination, this one was not done by only letting the horse trot in a straight line, but also by lunging it in both directions on both soft and hard surface. This gave a new insight into the lameness examination as the horse had now become clearly lame left front (LF) and left hind (LH) on the left hand circle.

A PDN block and examination of LF was also done and the horse was positive for this local anaesthesia. The lameness of LH had now been accentuated to a serious one.

To finish off, a PDN block of LH was performed and positive resulting in a minimal resting lameness LH, mainly on the left hand circle on hard surface. The horse now was lame on the right hind (RH) limb on the right hand circle on the hard surface.

Figure 7
Schematic representation of the analgesic regions after local anesthetic blocking of the palmar/plantar digital block (PDN), distal interphalangeal (DIP) joint and the navicular bursa.
From Schumacher et al. (2003)

2.3 Day 3
The movement was similar to day 2. The PDN block RF was positive, the horse switched to LF lameness on the left hand circle on soft surface, and on the hard surface becomes lame LF and LH, and slightly lame RH on the right hand circle.
Intrabursal anaesthesia LF was positive. On the left hand circle it became even clearer that the horse was lame on the left hind limb on soft and hard surface. On the right hand circle on the hard surface he was more clearly lame on the RH limb.

3. Conclusion

Based on the positive bursal block on the LF limb on day 3, together with positive PDN blocks in all four feet, it was clear that the horse suffered from a four limb lameness. This was possibly due to podotrochleitis or navicular bone disease/syndrome, even though the bursal anaesthesia and the DIP joint anaesthesia on the RF were negative.

4. Therapy

Intrabursal injection was given in the navicular burse of 40 mg/ml methylprednisolone (1cc) in each of all four feet. The treatment was executed in two phases, so that the total dose of corticosteroids would not exceed the dose above which complication such as laminitis may occur. The first injection phase was in the front feet, the horse came back 5 days later for the second phase in the hind feet. The foot is placed at an angle on a podoblock, the long 19 G needle (8.9 cm) is then inserted just proximal of the coronary band on the lateral hoof bulb. The needle is advanced in a parasagittal plane towards the bursa. The corticoid solution is then injected into the bursa. The injection is done with radiographic control of the placement of the needle.

After the bursal injection of the front feet, and before leaving the clinic, the horse was shoed by the blacksmith. He had put two egg-bar shoes on the hind hooves, and normal shoes with Luwex™ Perforated soles, filled up with a two-component filling (Equi-pak Soft from Vettec™) on the front feet. The advice given to the owners was that the horse should be kept indoors and only walked controlled for 6 weeks, followed by starting up light work in trot for about 4 weeks, gradually increasing workload. The owners would come back to have an MRI done if the lameness persevered or if it returned.

5. Outcome

The owners were phoned about 5 months post treatment on the 12th of January for a follow up of the horse. They described the horse as being playful and a lot suppler in its movement. The horse is being ridden again and has not been lame since the treatment. This reinforces the suspicion of the diagnosis.
Discussion

1. Incidence and clinical presentation
Navicular syndrome is thought to be the cause of one third of all cases of chronic forelimb lameness (Colles 1982, Stashak, 1998). Quarter horses, thoroughbreds and warmbloods seem to be breeds that are more at risk in developing navicular syndrome (Lowe, 1976; Stashak, 1998; Dyson, 2003). Up to now, most cases of navicular syndrome described are of a unilateral or bilateral front limb lameness type. In this case a four limb lameness was clearly stated, and related to a navicular syndrome, with pain deriving from the navicular bone itself or related structures, leading to chronic, intermediate lameness. It is documented that most cases of navicular syndrome present themselves in the front feet, unilateral or bilateral, but as seen in this case, it is also possible that the hind feet become affected. The prevalence of quadruple limb lameness due to navicular syndrome has rarely been described in recent or even older literature. This is in contrast with the prevalence seen in the UGent referral population, where F. Pille (2017) states that there are approximately 30 to 35 cases a year of quadruple lameness due to navicular syndrome. Professor F. Pille (2017) also noted that some of these horses are even presented with the lameness accentuated in one of the hind limbs. The horse can also have a very stiff gait, might stumble when trying to turn short, and its lameness is often most apparent when lunged in both directions on soft and hard surface, with the lameness worse when the affected limb is on the inside (Adams and Belknap, 2016; Waguespack and Hanson, 2010). In personal communication with my promotor about the UGent referral population, it seems that in some horses with navicular syndrome, the horse is more lame on the inside leg on the hard surface and more lame on the outside limb on soft surface.

2. Diagnosis
2.1 Local anaesthesia
If executed accurately, local anaesthesia of different regions, such as the DIP joint and the bursa podotrochlearis, can lead to accurate localisation of painful regions in the hoof and can be used as an excellent diagnostic method. In a study by Pleasant et al. (1997) it was seen that there was a significant improvement in lameness in horses with induced lameness of the navicular bursa, between 5 to 30 minutes after injecting the DIP joint with 5 ml of 2% mepivacaïne hydrochloride. If the horse is lame on multiple limbs, it is best that the first local anaesthesia is done on the lamest limb. Hereby it is possible that the horse switches its lameness to another limb, which is most often the contralateral one (McGuigan and Wilson, 2001). This was the case with the horse that was examined at the clinic. The horse started off with the most severe lameness on the right front limb. After a positive PDN block, it became lame on the left front limb. After the examination was repeated on the left front, and the right front was still anaesthetised, it became lame on the left hind, and finishing off with a switch to right hind lameness after anaesthetising the left hind too. This was an extreme case of switching of lameness after local anaesthesia.
For diagnosing a hoof lameness, first of all a palmar digital nerve (PDN) block is carried out. A short 25G needle is used to inject 3 ml of mepivacaine hydrochloride (Scandicaïne 2% ®), after a wipe with alcohol 70% on a cotton bud, medial of the palmar digital nerve of the distal limb, situated lateral and medial on the palmar side just above the hoof bulbs in the pastern cavity (Adams and Belknap, 2016). This results in anaesthesia of the navicular apparatus, both the heel and toe region of the sole, and sometimes of the DIP joint (Stashak, 1987).

Before injecting the anaesthetics in the DIP joint or the bursa, the region of injection is clipped, then thoroughly scrubbed using compresses soaked in chlorhexidine digluconate (Hibiscrub® 40 mg/ml), followed by wiping the area off with compresses soaked in alcohol 70%.

The bursal anaesthesia has to be done after the PDN block has worn off. This because the PDN block also desensitises the bursal apparatus, and therefore an overlap of both local anaesthetics is possible (Stashak, 1987). In the clinic in Merelbeke the horse is hospitalised and the bursal anaesthesia is done the day after the PDN block. A long (8.9 cm) 19 G needle and 3 ml of mepivacaïne HCl (Scandicaïne 2% ®). The needle is placed just above the coronary band on the lateral hoof bulb and advanced in a parasagittal plane towards the bursa. A radiographic image is taken after the needle placement to check if it is in the right position. The local anaesthetic is then injected into the bursa, thus desensitising the bursal apparatus (Stashak, 1987; Dyson and Kidd, 1993). This analgesia was positive in the LF limb in the horse from the case.

Anesthetizing the DIP joint in the clinic was done by using the dorsal approach, whereby the needle was inserted about 1 cm above the coronary band, into the depression that is sometimes felt at this level and the needle is kept almost parallel to the ground (Pleasant et al., 1997). Using this local anaesthetic, the DIP joint is desensitised. It is common to have an effect on the navicular apparatus and the toe region of the sole too (Dyson and Kidd, 1993). The reason why the analgesia of the RF DIP joint and bursal analgesia were both negative was unclear.

2.2 Medical Imaging
The most straightforward imaging technique for the hoof is the use of radiographic imaging. Hence, a lot of abnormalities can be seen on an X-ray, such as cyst-like lesions in the navicular bone, flexor cortex erosions, medullary sclerosis, enthesiophyt formation, fragmentation of the navicular bone and flexor cortex irregularity and thickness (Wright, 1993). The horse from the case was taken for radiographic imaging and 2 standard views were taken of the hoof, i.e. the lateromedial (LM) (fig. 2) and dorsal 55º proximal–palmarodistal oblique (D55Pr-PaDiO) (fig. 3-4). These are only 2 images that can be used, other additional images are the 60º dorsoproximal-palmarodistal oblique, the palmaroproximal-palmarodistal oblique or skyline view, the dorsopalmar view whilst full weight-bearing and the 60º dorsoproximal-palmarodistal oblique (Dyson, 2008; Stashak, 1998). The technique is of importance to get a good image, without any artefacts, so that the image can be well interpreted. Removing the shoes, cleaning the sole and using a compound with tissue-like density on the sole of the hoof (i.e. Play-Doh) can help prevent artefacts (Waguespack and Hanson, 2010).
Navicular syndrome can also derive from the surrounding structures of the navicular bone, such as pain derived from soft tissues like the DDFT or the collateral suspensory ligaments. These cannot be seen on radiographic imaging. Thus, radiographic imaging is limited, as it is only possible to see changes of more than 40% in bone density; therefore early or minimal changes, but not unimportant ones can be missed (Butler et al., 2000). Therefore other techniques, which are more costly and which require general anaesthesia, but are also more accurate, such as computed tomography (CT) (Ruohoniemi and Tevahartiala, 1999; Widmer et al., 2000; Tietje et al., 2001; Tucker and Sande, 2001, Horstmann et al., 2003; Hevesi et al., 2004) or magnetic resonance imaging (MRI) (Sampson et al., 2008), can be used. CT is used commonly to detect and assess bone pathologies, whilst MRI is used for soft tissue diagnosing. The owners of the patient described in the case were willing to have an MRI done if the horse became lame again after possible failure of the intrabursal treatment, or if the lameness returned at a later stage. The owners were called 5 months after the intrabursal treatment. They stated that the treatment had been a success, and therefore they would not yet come back for further imaging.

3. Treatment

3.1 Conservative therapy

Different studies have seen that corrective shoeing and trimming is probably one of the most common treatments for navicular disease as it may be able to help prevent further pain and thus making the horse more comfortable (Rooney, 1980; Widmer et al., 2000). The aim of the corrective shoeing and/or trimming, is to restore normal foot balance and to decrease the forces on the navicular bone, to correct foot problems, increase an early break-over, and to support the heels and therefore reduce the stress on the DDFT (Rooney, 1980; Widmer et al., 2000; Dabareiner, 2015). Heel elevation with a wedge can be used to release pressure from the navicular bone, toe shortening can be used for a better break-over.

Mostly, the egg bar shoe is used, this increases the early break-over in the toe and gives the foot good heel support (Adams and Belknap, 2016). Controversially, other studies have shown that the use of an egg-bar shoe does not significantly decrease the pressure on the navicular bone compared with normal flat shoes (Willemen et al., 1999; Dabareiner, 2015). The contradictive studies done on the effectiveness of the egg-bar shoe were mostly performed on hard surfaces, so the function of the shoes on soft surface has not yet properly been investigated. Schoonover et al. (2005) found that there was a significant improvement in lameness in horses with navicular syndrome 14 days after being shoed appropriately with heel elevation in combination with the treatment of phenylbutazone.

Rest is often recommended to help the horse adapt to the corrective shoeing and trimming, and to help reduce inflammation of the soft tissues (Stashak, 1998).

At the clinic it was advised to the owners to have the horse rest for 6 weeks after intrabursal corticosteroid treatment and then start up light work afterwards. The shoeing of the horse was also adjusted, the back feet had egg-bar shoes put on them and the front feet had normal shoes with perforated soles and a 2 component filling. The filling gives a same type of extra support mechanism of the heel region as the egg-bar shoes do, therefore no egg-bar shoes were placed on the front feet as it was more likely for the horse to pull the front shoes off.
Different Non-Steroidal Anti-Inflammatory Drugs (NSAID's) can be used to reduce pain and inflammation reaction in horses with navicular disease. These include flunixin-meglumine, phenylbutazone, carprofen, ketoprofen and firocoxib (Erkert et al., 2005; Waguespack and Hanson, 2011). Erkert et al. (2005) saw that 4.4 mg/kg of phenylbutazone and 1.1 mg/kg flunixin meglumine had a significant positive influence on lameness, when treated once a day for 4 days. The lameness was measured objectively using force plate data. Once the treatment was stopped, the lameness re-occurred. Phenylbutazone is the most common used NSAID for lameness in horses (McIlwraith, 2002; Stashak, 2002), as it inhibits the cyclooxygenase enzyme like other NSAID’s and thus inhibiting the prostaglandin cascade. By also inhibiting the platelet aggregation, it may increase the blood flow to the foot (Dabareiner, 2015). Phenylbutazone must be used with care as it can have some other adverse effects such as renal and gastro-intestinal injury, such as gastric and right dorsal colon ulceration (Meschter et al., 1990; Dabareiner, 2015). Another option is the selective cyclooxygenase (COX)-2-inhibitor called firocoxib, which seems to be fairly effective against orthopaedic and articular pain (Adams and Belknap, 2016). The use of a selective COX-inhibitor, or the use of a nonselective inhibitor doesn’t seem to make a significant difference in the development of long-term NSAID toxicosis, as a study comparing firocoxib (0,1 mg/kg PO daily) and oral phenylbutazone (4,4 mg/kg PO daily) for 14 days showed (Doucet et al., 2008).

In the case, the horse had received a treatment of suxibuzone from the vet at home, before the owners decided to bring the horse to Merelbeke. Suxibuzone is an NSAID that can be administered orally to horses with lameness. This was shown in a study by Sabaté et al. (2009), where they found that there was no significant difference in relieving lameness in horses treated with suxibuzone compared to horses treated with phenylbutazone. Suxibuzone however, was found to have a lower gastric ulceration effect compared to phenylbutazone (Monreal et al., 2004), and could therefore be a good alternative. Other drugs were found to have an anti-inflammatory effect and hence a positive effect on lameness in horses with navicular syndrome. These include polysulfated glycosaminoglycans (PSGAG’s) (Crisman et al., 1993; Dabareiner et al., 2003; Carter and Dabareiner, 2006) and sodium hyaluronate (Crisman et al., 1993; Dabareiner et al., 2003).

In this case of a four limb lameness, the Clinic in Merelbeke and the owners decided to do an intrabursal injection of the navicular bursa in each of the four feet. This was done using the same technique as a local anaesthesia of the bursa. First the area is clipped, then scrubbed with compresses soaked in chlorhexidine digluconate (Hibiscrub® 40 mg/ml), followed by wiping of the area with compresses soaked in alcohol 70%. The foot was then placed at a 55° angle on a podoblock, where after a long 19 G needle (8.9 cm) was inserted just proximal of the coronary band on the lateral hoof bulb. The needle was advanced in a parasagittal plane towards the bursa. This is done with a radiographic control of the placement of the needle. Once the placement of the needle was inside of the navicular bursa, a corticoid injection, containing 40 mg/ml of methylprednisolone (1cc), was injected in all four feet. The use of corticoid medication injected directly in the bursa podotrochlearis or in the DIP joint would reduce inflammatory reactions that might cause the pain in that region. (Verschooten et al., 1990;
This needs to be done in an aseptic way, as synovitis can be caused by a non-sterile technique (Dabareiner et al., 2003; Dabareiner, 2015). It is thought that corticoid injection in the DIP joint improves lameness in one third of the horses for an average of 2 months, whilst intrabursal injection of corticosteroids would improve lameness in about 80% of the horses for about 4 months (Adams and Belknap, 2016). Alongside methylprednisolone, triamcinolone is also a suited corticoid for injecting in the navicular burse or the DIP joint, as it is less damaging to the cartilage than methylprednisolone is (Chunekamrai et al., 1989). A dose of 6 to 9 mg of triamcinolone would be recommended (Dabareiner, 2015). It is not clearly stated in the literature what the total body dose is for corticosteroids to surely have a laminitis-inducing effect. McClusky and Kavenagh (2004) indicated that a total body dose of 20 mg of triamcinolone was considered safe, as there was no evidence that anything up to this dose induced laminitis. According to Brown (2009) the dosage guidelines (whole body dose) for triamcinolone is <18 mg and for methylprednisolone this would be 200 mg. For this reason the horse was treated in two phases in order not to exceed the maximum dose.

Combining the use of a corticosteroid injection with a treatment of NSAIDs could improve the lameness because of the combined effect locally and systemically on the inflamed area. Sometimes the combination of a corticoid with hyaluronan (HA), or polysulfated glycosaminoglycans (PSGAG’s) is used to further improve healing and quality of the intrasynovial structures (Verschooten et al., 1990; Dabareiner and Carter, 2003; Dabareiner et al., 2003; Schoonover et al., 2005). HA is a normal component of the joint and acts a natural lubricant. It seems to have an anti-inflammatory effect when injected into inflamed joints, and might therefore improve lameness when combined with a corticoid (Dabareiner, 2015). Marsh et al. (2012) evaluated 101 horses with signs of clinical navicular disease by treating them with intrabursal injections with 40 mg methylprednisolone and 10 mg hyaluronate. The horses were then evaluated by MRI. The majority of the horses (75%) went back to their intended use for about 9,5 months after treatment, and 35/101 were sound at the 10 month follow-up. Horses that reacted worst to the treatment were those that had a more advanced stage of lameness, such as i.e. adhesions from the navicular bone to the DDFT, multiple abnormalities or scar tissue proximal to the navicular bone (Marsh et al., 2012). PSGAG’s on the other hand work as “chondroprotectants” or cartilage protective agents, hence their effectiveness in joints such as the DIP joint, where they can help prevent or slow down the process of osteoarthritis (Dabareiner, 2015). Crisman et al. (1993) showed that the use of PSGAG’s through IM administration improved lameness in horses with navicular syndrome.

The use of isoxsuprine hydrochloride as a peripheral vasodilator to improve the blood flow to the navicular bone and therefore improve the condition of it, has been questioned for its effectiveness, and seems to be horse-dependent (Dabareiner, 2015). A study done by Rose et al. (1983) showed that horses treated with isoxsuprine have had a significant improvement in lameness compared to horses treated with a placebo. The starting dose is recommended at 0,6 mg/kg BID PO for 3 weeks, but can be increased to 1,8 mg/kg BID PO (Dabareiner, 2015). Biphosphonates such as tiludronate, are thought to improve bloodflow and inhibit bone resorption. A study by Denoix et al. (2003) showed promising signs.
of lameness improvement in horses with navicular disease when treated with a dose of 1 mg/kg IV of tiludronate daily for 10 days.

3.2 Surgical treatments
Horses that do not respond well to alternative, non-surgical methods as described above, but have a positive reaction to local anaesthesia of the palmar digital nerve, could be appropriate candidates for a palmar digital neurectomy. This procedure results in a long term desensitisation of the back of the foot, and therefore also the navicular region, but it does not stop or slow down any degenerative processes causing the palmar foot problems (Waguespack and Hanson, 2011; Dabareiner, 2015; Adams and Belknap, 2016). Therefore it is better to perform this surgery when it is clear that the pain is derived more from the navicular bone itself, rather than from soft tissue like the DDFT, as it then may not completely suppress the pain.

Post-operative complications are painful inflammation (neuroma formation), rupture of the deep digital flexor tendon, reinnervation, subluxation or luxation of the DIP joint and hoof infection (Waguespack and Hanson, 2011; Dabareiner, 2015; Adams and Belknap, 2016). Different techniques of performing this procedure have been reported and compared, to see which method accomplished the best results with the least neuroma formation (Dabareiner et al., 1997). It has been suggested that the guillotine technique has a smaller chance of giving post-operative complications when compared to perineural capping or laser coagulation. Also the use of a CO2 laser seemed to give more axon regrowth than did the guillotine technique (Dabareiner et al., 1997).

Post-operative care is of great importance to minimize complications (Dabareiner and Carter, 2003). Horses should be kept in a stall and only walked by hand for about a month. After that the horse can gradually put back into work. Important is to bandage accordingly, and possibly use a short treatment of corticosteroids to reduce post-operative inflammation (Waguespack and Hanson, 2011).

The prognosis of horses after a palmar digital neurectomy seems plausible in the first year after the operation, but gets worse as time progresses (Adams, 1974).

Navicular suspensory ligament desmotomy is a procedure that has been performed and recommended for horses with navicular pain in the past, but it is used far less nowadays (Dabareiner, 2015). In a study by Wright (1993), 118 horses with navicular syndrome had a navicular suspensory ligament desmotomy done. After 6 months 76% of the horses were sound, and after 36 months only 42.9% of the horses were sound.

Inferior check ligament (ICL) desmotomy is mostly used in horses with unilateral tendon problems, rather than as a treatment for navicular disease. It helps to release tension on the DDFT, thus decreasing flexor tendon pain in the foot region. It is possible though to do this surgery when the navicular syndrome is derived from the DDFT pain. Once the tension on the DDFT has been relieved, the foot will spontaneously realign itself, with a better conformation and angulation of the hoof as a result (Lose, 1995). In a study by Bell et al. (2011) seventeen horses with navicular syndrome were treated with ICL
desmotomy. Twelve of the treated horses were sound, one horse improved and four horses were lame at 6 months after surgery.

Enscopy or bursoscopy of the bursa is a quite new technique, and can be used as a diagnostic tool, but depending on the pathology causing the navicular pain, it could also be used to treat the horse (Waguespack and Hanson, 2011). A proper case selection of suited patients would be needed to see if the treatment is effective or not.

None of these surgical treatments were performed on the horse from the case presented in Merelbeke.

4. Prognosis

The prognosis is difficult to predict, as navicular syndrome is a multifactorial problem, with pain deriving from a wide range of structures in the region of the navicular bone, or from the navicular bone itself. Therefore it is not possible to give one prognosis for all navicular problems. As most of the pathologies are of a degenerative kind, most horses that are kept in work will worsen with time. In 40-50% of the cases, clinical resolution can occur (Adams, 1974). Of course the prognosis also depends on the clinical presentation of the syndrome, potential radiographical abnormalities and the treatment that is decided upon. Overall the prognosis is guarded to poor, but by using corrective shoeing, NSAID therapy and Intrabursal corticoid injection, the horse's usefulness can be improved for a longer period of time (Adams and Belknap, 2016).

5. Conclusion

Navicular disease is a common problem among a lot of middle-aged horses. It is a problem that often occurs unilateral or bilateral in the front feet, but as this case and others at UGent show, it is also a problem that occurs in the hind limbs. Research towards understanding the importance of navicular syndrome in the hind legs is still minimal, but should eventually be expanded. A complete clinical examination plays an essential part in diagnosing this disease. The under-diagnosing of navicular syndrome in the hind legs could be due to a clinical examination which was not completed with local anaesthetia or where lameness in the hind legs was missed. The diagnosis down to the level of the lesions is possible because of the advanced imaging methods that are available nowadays, even though these can become rather costly. As opposed to the advancement in imaging techniques over the past decades, the treatment of navicular disease has not seen such an improvement. There is not one treatment that cures all cases of navicular syndrome, neither can all cases be cured. The reaction to therapy is horse-dependant, which explains the guarded prognosis. Some horses will not react to any kind of therapy, whilst others may be sound after one or a combination of different strategies. It remains to be seen what the future holds for the horse in this case.
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Imaging features of a retrobulbar melanoma in a horse

by

Hannah JONES

Promotor: Dr. E. Raes
Copromotor: Prof. Dr. K. Vanderperren
Case Report
as part of the Master's Dissertation

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PREFACE

I would like to thank my promotors for their support during the writing of this case report. The case was very interesting and unique.

My parents and partner have helped me a great deal, not only with this dissertation, but also throughout my entire study. The rest of my family have been great too!
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ABSTRACT

A case of a retrobulbar melanoma was presented at the Medical Imaging department at the Faculty of Veterinary Medicine (Ghent University). The horse demonstrated exophthalmos and a soft, fluctuating swelling caudodorsal to the right eye. Radiographs demonstrated this soft tissue swelling caudal to the eye on the tangential projection of the right orbit. No bony abnormalities were detected. Computer tomography (CT) showed a well-defined, hyperdense, cavitated mass in the retrobulbar space. Histopathology of the surgically resected mass revealed a melanoma. Melanomas are common in grey horses and are usually located in the perineal region, at the base of the tail, or in different locations on the head. This case report presents an uncommon retrobulbar location of a melanoma in a grey horse and its imaging features.
SAMENVATTING

Deze casus beschrijft een geval van een paard met een retrobulbaire melanoma. Er was enkel klacht over exophthalmie en een zachte, fluctuerende zwelling boven het rechter oog. Er werden verschillende radiografische projecties genomen, waarbij enkel de skyline van het rechter oog een weke delen zwelling vertoonde. Op de andere projecties werden geen afwijkingen vastgesteld. Om de oorsprong van de massa te detecteren werd er een computer tomografisch onderzoek (CT) uitgevoerd. Hierop was een welomschreven ovoïde heterogene massa te zien in de retrobulbaire ruimte. De massa bevatte enkele grote hypodense zones. De hyperdense weefseldelen op het pre-contrastbeeld namen een milde hoeveelheid contrast op na intraveneuze toediening van een contrast medium. De massa werd chirurgisch verwijderd met behulp van de CT-beelden.

In de literatuur is beschreven dat melanomen veel voorkomende tumoren zijn bij schimmelpaarden. De prevalentie ervan is tot 80% bij schimmels ouder dan 15 jaar. Vaak voorkomende lokalisaties voor melanomen zijn het perineum, de staartbasis, de lippen en de parotis speekselklier. Metastasen zijn mogelijk, maar over het algemeen zijn deze tumoren goedaardig.

Het stellen van de diagnose is vaak vanzelfsprekend, aangezien het gewoonlijk gaat over een ouder schimmelpaard met meerdere zwarte, vaste, goed omschreven nodules op de typische lokaties. Soms is de diagnose niet zo voor de hand liggend, omdat de lokatie atypisch is, of omdat de klachten vager zijn. Een voorbeeld hiervan zijn intra-abdominale tumoren, die koliekssymptomen of vermageren kunnen geven. Specifieke melanomen van het hoofd kunnen eveneens moeilijk te diagnosticeren zijn. In dergelijke gevallen is het gebruik van medische beeldvorming belangrijk om een correcte diagnose te stellen.

In de retrobulbaire ruimte kunnen verschillende pathologieën voorkomen, dit zijn vaak ruimte-innemende processen. Voorbeelden zijn neoplasieën zoals neuroepitheliale tumoren van de retina en nervus opticus, meningiomas, melanomas, orbitale fibromas, neuroendocriene tumoren of uitbreidend vanuit de sinus en nasale adenocarcinomas of cysten. Ook hematomas die door trauma ontstaan zijn, dermoïde cysten, hydatide cysten of retrobulbaire abcessen kunnen voorkomen in deze regio. Deze processen veroorzaken exophthalmie, waarbij het oog rostraal geduwd wordt.

Men kan verschillende technieken gebruiken om de massa in beeld te brengen. Radiografie is vaak de eerste keuze om een overzicht van de regio te krijgen. Een nadeel van RX is de superpositie van de verschillende botstructuren van de schedel en beperkte informatie over de weke delen. Voor een exactere diagnose en eventueel verdere chirurgische planning en prognose kan best overgegaan worden tot bijkomende beeldvormingstechnieken.

Echografie is een veelgebruikte, niet kostelijke techniek, waarbij het dier enkel gesedeed dient te worden. Het oog en de retrobulbaire ruimte kunnen door middel van echografie goed in beeld gebracht worden. Om een idee van de uitleiding van het ruimte-innemend proces te krijgen, de agressiviteit ervan en de uitgebreidheid, kan men best overschakelen naar 3-dimensionele technieken zoals computer tomografie (CT) of magnetische resonantie (MRI). CT geeft het beste detail van botstructuren, terwijl MRI weke delen beter in beeld brengt. CT van het hoofd kan staand uitgevoerd worden. Dit is nog niet mogelijk met de huidige MRI van het paardenhoofd.
INTRODUCTION

The only symptom of the horse in the case described below was exophthalmos. This is an acquired displacement of the eyeball due to an increase of orbital contents. This is usually the result of a retrobulbar mass pushing the eyeball rostrally. The most common cause of unilateral exophthalmos in horses is a tumour. Other causes include retrobulbar abscess (Homco and Ramirez, 1995), traumatic haematoma (Boroffka and Belt, 1996), a dermoid cyst (Muñoz et al., 2007) or a hydatid cyst (Summerhays and Mantell, 1995). Primary neoplasms in the retrobulbar area are very rare. Only a handful of case reports discuss neoplasia-induced exophthalmos in horses. Orbital neoplasia can originate from tissues present in the orbita, tissues surrounding the orbita or by haematogeneous spreading. Cases of neuroepithelial neoplasms of the retina and optic nerve (Bistner et al., 1983), neuroendocrine tumours (Basher et al., 1997; Matiasek et al., 2007), orbital fibroma (Colitz et al., 2000), meningioma (Naylor et al., 2010), melanoma (Sweeney and Beech, 1983), sinus osteoma (Scotty et al., 2004), sinus and nasal adenocarcinomas or cysts (Hill et al., 1989; Davis et al., 2002; Annear et al., 2008) have been described.

Distinction of non-neoplastic versus neoplastic etiology is of prime importance for prognosis and clinical management. Medical imaging is therefore used to situate the exact location of the mass for eventual therapeutic planning. It can also give an idea of the tumour’s aggressiveness, and its extent. X-ray images are a good way to screen the head, however as the head is a complicated entity of bones, superimposition is inevitable. Hence, the use of 3D imaging techniques such as magnetic resonance imaging or computer tomography is preferable (Homco and Ramirez, 1995). Of the two, CT-scanning is less expensive, scan time is shorter and more available. This is less so the case for MRI, as it takes a longer time to produce the images, and thus is more expensive, and the horses generally have to be under general anesthesia (Tietje et al., 1995; Porter and Werpy, 2014), which is not always necessary for CT-scans. CT-scans give better imaging of bony structures, whilst MRI offers better sensitivity in portraying soft tissue (Arencicia et al., 2001; Scotty, 2005). Ultrasound imaging is quick and easy to perform, and at lower cost than CT or MRI, however the big disadvantage of ultrasound is that the waves do not pass through bone or gas filled chambers. However, it is possible to image the eye and the retrobulbar space with ultrasound (Homco and Ramirez, 1995; Whitcomb, 2002).

CT characteristics of equine cranial neoplastic processes have often not yet been determined, and further studies are necessary to determine typical features associated with different tumour types (Kinns and Pease, 2009). A study by Marx et al. (1990) described a hemorrhage with a metastatic melanoma on CT as being a heterogeneous, hyperdense mass. Other extraocular melanomas in this study did not however have a unanimous pattern. Three cases of a brain hemorrhage also were described as a heterogeneous, heterodense mass on CT image by New et al. (1983). Melanomas have been described in cats and dogs to be bright on T1-weighted MRI images, and dark on T2-weighted MRI images, whilst sarcomas are the other way around (Grahn et al., 1993).
This report describes a case of a retrobulbar melanoma in a grey horse, which outed as a soft, lightly fluctuating swelling above the right eye and minimal exophthalmos. Radiography was used to screen the head, but the CT-scan was necessary to locate and describe the mass as a pre-operation protocol.
Anatomy of the retrobulbar region
Budras (2012) describes the normal anatomy of the equine head. The retrobulbar space (figure 1) is filled with fat and demarcated laterally by the medial aspect of the zygomatic arch, medially by the lateral aspect of the coronoid process of the mandible, the temporomandibular joint, and the temporal bone. The zygomatic process formed by the temporal bone and the frontal bone demarcates the retrobulbar space laterally.

Figure 3
The normal anatomy of the surrounding soft tissue structures of the eye and retrobulbar space. Eye muscles include the retractor bulbi, medial/dorsal/lateral/ventral recti, dorsal and ventral oblique, levator palpebrae superioris. Nerves include the optic nerve (II), oculomotor nerve (III), abducent nerve (VI), trochlear nerve (IV) and different branches of the trigeminal nerve (V). The cone of the ocular muscles is surrounded by a fibroelastic periorbita. The maxillary artery and its branches also pass through the retrobulbar space, and to the ventral part of the space sits the pterygopalatine ganglion.

Imaging of the equine head: focus on retrobulbar space and adjacent structures

Radiography
Radiographs are made by using a vacuum tube that produces x-rays. The current at which the radiation is produced is measured in milliamperes (mA) and the voltage in kilovolts (kV). These parameters determine the number and the strength of the x-rays produced. By increasing the mA settings, the number of x-rays is increased, and therefore the number of x-ray photons that are able to penetrate increase. This usually results in increased blackening of the image. The higher the kV settings, the more x-rays are able to penetrate the tissues, but at the same time there is a decrease in the absorption of the x-rays in different tissues, which reduces the contrast of the image. A third parameter is the exposure time of the photons, and combining this parameter with the mA gives a term called milliamperes-seconds (mAs), which is often used. It is therefore important to have a good balance between all three parameters for the different structures to optimize the image (Adams and Belknap, 2016).

Standard projections used for radiographic imaging of the head are laterolateral (LL), dorsoventral (DV), right ventral to left dorsal oblique (RTV-LeDO), and left ventral to right dorsal oblique (LeV-RtDO) (Pease, 2013). The equine skull consists mostly of air filled cavities or soft tissue with a low radiographic density. The rest consists of a complex bony structure that results in a large amount of superimposition. This combination makes it difficult to produce clear images of the skull, and does not make it easy to interpret and evaluate the images created. Hence, it is important to radiograph in multiple projections to achieve the best possible details (Tucker and Farrell, 2001; Pease, 2013).

Radiography of the head is a valuable screening method for fractures and dental or sinus problems (Pease, 2013), but it must be borne in mind that radiography will only give a limited assessment of the mineralised tissues, as 40% change in the bone density is required before it becomes visible on x-rays (Butler et al., 2000).

Ultrasound
Ultrasongraphy uses sound waves, most frequently between 1.5 and 15 megahertz (MHz), whereby these waves bounce off different tissues in the body, travelling back to the transducer and thus creating an image from the received echo-pattern. The sound beam is completely reflected by gas filled chambers such as the lungs, but is absorbed by bony structures. Gas and bone create a shadow over other structures that lie behind them, which makes it less suitable for use in the equine head (Adams and Belknap, 2016). In contrast, ultrasound of the eye and potentially the retrobulbar space is commonly performed by placing the transducer on the cornea/transpalpebral and respectively on the swelling above the eye (Homco and Ramirez, 1995).

In some cases it may be useful to use both radiography and ultrasound as complementary imaging techniques. Ultrasound can also be used to direct biopsy needles into the desired tissue safely (Adams and Belknap, 2016). It is a low cost and relatively easy examination technique for evaluating retrobulbar pathologies in exophthalmic horses (Whitcomb, 2002).

The retrobulbar space is evaluated at a scanning depth of 12-18 cm. This region includes the optic nerve, extraocular muscles and bony orbit. The optic nerve has a cone shape and has a homogeneous echogenicity. The surrounding muscles are of a speckled hypoechoic echogenicity. The bony orbit is a smooth, hyperechoic surface (figure 2). Retrobulbar masses can also be misdiagnosed where they
have the same speckled echogenicity as the extraocular muscles. When in doubt, scanning the other eye is an option for comparison (Whitcomb, 2002). Pathologies in the retrobulbar area, such as hematomas, abscesses and tumours can be identified with ultrasound. If these masses contain fluid they will be anechoic, soft tissue will be echoic and mineralised structures will show a hyperechoic interface with acoustic shadow. Fractures or displacements of the eye or surrounding tissues will also be visible. Doppler can be used to visualise the perfusion of such masses (Scotty, 2005). Harland et al. (2000) showed that melanomas of the skin are seen as hypoechogenic regions on B-mode compared to the dermis. The amount of acoustic shadowing was significantly less for a melanoma compared to a basal cell papilloma. It was possible to get a sensitivity of 100% and 79% specificity to differentiate melanomas from basal cell papillomas by using a B-mode ultrasound.

Computed Tomography
Computed tomography scanning is a medical imaging technique that has a great advantage over other types of medical imaging, such as radiographs and ultrasound, as structures are viewed in sectional images without superimposition. In horses it can be used to image the skull, cranial cervical vertebral column and distal limbs. The size of the animal limits the use of this technique elsewhere. A custom built table in appropriate premises is necessary for using a CT scanner, where the horse is positioned in dorsal recumbency. Perfect symmetry is of the essence, as any slight deviation could cause misinterpretation of the images. The examination itself takes a short time, as the images are swiftly produced, but it is often necessary to put the horse under general anaesthesia, which includes a risk and involves higher costs (Tietje et al., 1996). In some cases however it is possible to perform the CT scan in standing position. This does not involve the risk of general anaesthesia, it is consequently
cheaper, and only takes 20 minutes to perform. However, if the horse is not kept perfectly still during the procedure, problems such as motion artefacts can result, making several rescans necessary (Scotty, 2005; Porter and Werpy, 2014). CT scans can also be used to direct biopsy needles that ultrasound cannot approach (Adams and Belknap, 2016).

Computed tomography works on the base of cross-sectional images formed by x-rays circling around the body, forming a reconstruction of different densities within the examined object. These densities correlate with a grey-scale on the image and are measured in Hounsfield Units (HU). Air has a value of -1000 HU, water 0 HU and metal such as lead +3000 HU (Adams and Belknap, 2016). Important factors for the data quality are slice thickness (1-8 mm) and measurement time (1.4-14 seconds). Computer programs then create 3D images from a series of sectional images (Tietje et al., 1996). As CT creates an image using different shades of grey, and as there are so many, it is possible to select what is called a window level and window width. By using different ‘windows’, the computer focusses on structures that comply with the most important shades of grey in these selected windows. When using soft tissue windows, the width of the window is narrowed, allowing for better contrast, but also gives a lower resolution (Kinns and Pease, 2009). A normal CT-image of the head at the height of the retrobulbar region is showed in figure 3.

Injecting a contrast medium intravenously facilitates differentiation and evaluation of soft tissue lesions (Kinns and Pease, 2009, Puchalski, 2012). This differentiation is made by identifying tissues that have an increased or decreased blood flow, or where regions have an altered vascular permeability, such as inflamed tissues or neoplastic processes. Most contrast mediums used for CT-imaging are iodine-based. These can be bound to ionic or non-ionic compounds, of which the latter causes more side effects due to their dissociation within the body (Puchalski, 2012; Crijns et al., 2016). Crijns et al. (2016) and Carmalt and Montgomery (2015) describe the intravenous application of contrast as costly and impractical for horses, as such large volumes are required due to the sheer size of the animal. These studies look at the possibility of giving the contrast medium intra-arterially, instead of the usual intravenous administration. The change in administration could serve as an alternative to decrease the total contrast
medium dosage in the animal. The intravenous protocol dosage varies from 160-250 mg/kg body weight of iodinated contrast medium. These studies concluded that there was not a significant difference seen in image quality comparing the two protocols. Thus intra-arterial contrast medium administration could be of future use in horses.

Magnetic Resonance Imaging
With magnetic resonance imaging or MRI, a powerful magnet is used to align the hydrogen atoms in the body. When it is switched off, the hydrogen atoms relax into their normal position. This relaxation and alignment of the hydrogen atoms produces radio waves that can then be detected by very sensitive equipment. The frequency at which these waves are produced depends on the strength of the magnetic field. These waves are then transformed into an image, but this takes a lot longer than with a CT scanner. The strength of the magnetic fields produced is measured in Tesla (T). Using a high field MRI (1.0-3.0 T) results in better resolution, shorter scan times and lower incidence of motion artifacts, nevertheless most practices would acquire a low field MRI (<0.3T) as it is less costly to run. Manso-Diaz et al. (2015) showed that there was no significant difference between using low-field magnets compared to high-field, so they considered the use of low-field imaging adequate for the equine head. It was especially useful for defining space-occupying lesions, as the MRI images allow clear differentiation of soft tissue types. Horses always have to be put under general anaesthesia for MRI examinations of the head, which is a disadvantage compared to CT which can also be done on a standing horse. Limited availability and greater costs are reasons why the use of MRI as an equine imaging technique is still so limited (Arencibia et al., 2001; Holmes, 2014).

T1-weighted images give a better spatial resolution and definition of the eye and its orbit compared to T2-weighted images. Pathologies that have an increased fluid content, such as edema, inflammation, infection or tumours will include regions of hyperintensity and are best evaluated with T2 sequences (Gilger, 2016). The soft tissue anatomy is better on MRI than on CT or other imaging techniques, as it provides a superior contrast resolution (Arencibia et al., 2001; Holmes, 2014).

Arencibia et al. (2000) described MRI images of the normal anatomy of an equine head. They used a strength of 1.5 Tesla. Figures 4 and 5 show the normal anatomy on an MRI image at the height of the eyes and retrobulbar region.
Imaging features of different pathologic entities of the retro-bulbar space

Most pathologies in the retrobulbar space result clinically in exophthalmos of the eye, as the space is not large and any space-occupying lesion will cause a displacement of the eye. The displacement can be caused by tumours, infectious processes, hematomas and cysts. This chapter contains a few examples of these retrobulbar processes with their description on medical imaging.

Tumours can originate from the bony orbit, the periocular tissues, or through haematogenous spreading (Matiasek et al., 2007), neuroepithelial tumours of the retina and optic nerve (Bistner et al., 1983), neuroendocrine tumours (Basher et al., 1997; Matiasek et al., 2007), orbital fibroma (Colitz et al., 2000), meningioma (Naylor et al., 2010), and melanoma (Sweeney and Beech, 1983). Sinus osteoma (Scotty et al., 2004) together with sinus and nasal adenocarcinomas or cysts (Hill et al., 1989; Davis et al., 2002; Annear et al., 2008) can break through into the retrobulbar space because of their aggressive nature, or deform the skull and therefore the retrobulbar space. CT can identify a neoplastic process as a soft tissue mass, but the exact diagnosis of the tumour type often has to be made by histological examination (Lacombe et al., 2010). On MRI in dogs and cats, Grahn et al. (1993) described that melanomas were bright on T1-weighted images and dark on T2-weighted images, whilst sarcomas were the opposite.
Neoplastic processes

*Equine melanomas*

Melanocytic proliferations or melanoma is the term used to describe a benign tumour of melanocytic origin in animals. In horses, it is most common in grey horses. It is believed that it occurs more in grey horses as there is a problem with the melanin metabolism and its transfer in the melanocytes. This is likely to be associated with the progressive greying/whitening of the hair with age, with the result of an excess accumulation of intra-cellular pigment (Metcalf et al., 2013; Adam and Belknap, 2016). These neoplastic findings are most commonly found in certain breeds such as Arabians, Lippizaners, and Percherons, but this may be simply linked to the fact that these breeds have more grey horses. The prevalence of melanomas in grey or white horses from these breeds is up to 80%. Melanomas also occur in non-grey horses, though are less frequent and more likely to show a malignant behaviour (Phillips and Lembcke, 2013). Melanomas, such as other types of neoplastic proliferations, usually occur in older horses. They can start to form in horses as young as 3 to 4 years old, though this is definitely rare (Adams and Belknap, 2016). In general, melanomas are benign, grow slowly and often do not metastasise in grey horses. In solid coloured horses, just like in humans, melanomas are often malignant and metastasis is more common (Seltenhammer et al., 2003). Benign melanomas possess well-differentiated and heavily pigmented melanocytes, whilst malignant tumours have increased pleomorphism with variable pigmentation and indistinct margins (Phillips and Lembcke, 2013).

The formation of melanomas is commonly found in the perineum, the base of the tail, the prepuce, the lip-commissures and the head and neck area. Less commonly they are found in the parotid gland, ears, eyelids and limbs. Only one article by Sweeney and Beech (1983) describes a case of a retrobulbar melanoma in a horse. Metastases are possible, but rare, from these primary regions, and mostly end up in the lymph nodes, though they can also settle in different organs (Phillips and Lembcke, 2013).

Most appear to be coalescent but well circumscribed, and are multiple, with a nodular aspect. They increase in size and number with time. On section, melanomas have a black and firm aspect (Seltenhammer et al., 2003; Adams and Belknap, 2016).

The diagnosis of a melanomas is usually made upon the appearance of the tumours and the signalment of the horse. In cases where the horse is not grey, and the diagnosis of a melanoma is not obvious, a biopsy can provide a more definite diagnosis (Phillips and Lembcke, 2013). In cases where the tumour is situated in an atypical location, such as the retrobulbar space, intra-abdominal or intrathoracical, medical imaging can be of great use.
Tietje et al. (1996) described a specific case of headshaking, where the history of the horse and clinical examination could not provide a definite diagnosis. By executing a CT scan of the head, a heterodense mass was found around the parotid gland (figure 6). A biopsy was taken and a histological diagnosis of a melanoma was obtained.

![Figure 6](image)

Melanomas have been reported to be homogeneous, hyperdense structures compared to surrounding muscles on CT scans in a retrospective case study of 13 horses with melanomas situated in the head. Some did contain hypodense or mineralised areas (Dixon et al., 2016).

A study done by Marx et al. (1990) reviewed several cases of melanomas, both primary and metastatic, to describe their appearance on MRI images. To enable one to judge images of different body parts, hyperintense tumours were described as equal to or greater than fat intensity, and hypointense tumours were equal to or less than muscle intensity. Fifty-four percent of melanomas in this study were hyperintense on T1-weighted images and hypointense on T2-weighted images. Only 29% of the melanomas were the inverse, as is common in most tumours. This hyper-attenuation of the melanoma could possibly be the result of the large amounts of melanin (Dixon et al., 2016).

**Orbital fibroma**

An article describing a case report on an orbital fibroma claims that there has been no previous report of such a case in a horse. This horse showed an acute swelling above the left eye with slight exophthalmus and resistance to retropulsion. Skull x-rays showed an orbital mass, and ultrasound showed a hypoechoic encapsulated lesion. A fine needle aspirate was performed by guided ultrasound, giving a non-diagnostic cellular debris (Colitz et al., 2000).

**Neuroendocrine tumour**

Matiasek et al. (2007) describe a case of a neuroendocrine tumour in the retrobulbar space. They found a hyperechoic soft tissue mass that was also hypointense on MRI images compared to the retro-orbital fat tissue. Through histological examination it was diagnosed as a neuroendocrine tumour.
**Meningioma**

Naylor et al. (2010) found a hyperintense mass compared to the extra-orbital muscles in both T1 and T2-weighted images on MRI. This mass was associated with the optic nerve, and was therefore very likely a meningioma.

Manso-Diaz et al. (2015) described the MRI characteristics in equine head disorders. One horse had a well-defined, ovoid and homogeneous contrast-enhancing intraconal soft tissue mass, which was situated in the retrobulbar space, resulting in exophthalmos, and associated with the optic nerve. This mass was hyperintense to muscle on both T1- and T2-weighted images. It was later defined as a meningioma.

**Infectious processes**

Infectious agents such as bacterial (guttural pouch empyema, bacterial cellulitis), mycotic (guttural pouch mycosis), parasitic (Echinococcus spp.) pathogens can cause exophthalmos. Periodontal and periapical abscesses, sinus infections, and foreign bodies could also cause swelling of the retrobulbar region and therefore exophthalmos. Cases of a hydatid cyst and a dermoid cyst are very rare. One study by Summerhays and Mantell (1995) describes the rare case of a middle-aged Thoroughbred with a retrobulbar hydatid cyst. This is caused by a tapeworm called Echinococcus spp, which forms very slow growing cysts, containing a large amount of scolices (larval stage). This horse showed a mild exophthalmos for a period of 3 years, which worsened with time. Lateral radiographs of the head were normal, but the mass was visible on ultrasonography. These images were used to catheterise the cyst and remove it surgically.

**Dermoid cyst**

Dermoid cysts in any location are uncommon in horses, but Muñoz et al. (2007) describes a case report of a young Andalusian with exophthalmos and a soft swelling of the supraorbital fossa after a blunt head trauma. An anechoic mass of 5 cm diameter in the retrobulbar cavity was seen on ultrasound. An ultrasound guided centesis of the cyst resulted in a brown, serous fluid. This anechoic image together with the fluid obtained made the diagnosis of a neoplastic process less likely and therefore the cyst-like lesion was on top of the differential diagnosis. Histological diagnosis after removal confirmed a dermoid cyst.

**Trauma: haematoma**

Trauma leading to fractures or hematomas can also be a cause for retrobulbar swelling. Hematomas are the second densest structures after bone on CT and appear as heterogeneous, hyperdense lesions (Lacombe et al., 2010, Dixon et al., 2016). A report on a retrobulbar hematoma in a Dutch warmblood mare showed a homogenous mass with a density of -32.6 Hounsfield Units (HU). A small and irregular hypodense spot of +104.7 HU was seen in the mass. On ultrasound (US) the mass was hypoechoic and well circumscribed. The irregular spot turned out to be hyperechoic with acoustic shadowing and was therefore thought to be a calcification or a foreign body inside the hematoma. The bony orbit seemed to be intact. An US-guided biopsy was performed on the mass and 80 mL of haemorrhagic fluid was obtained (Boroffka and Belt, 1996).
Anamnesis and clinical examination

A 16 year old warmblood gelding of 640 kg was presented to the Department of Medical Imaging of domestic animals at Ghent University on 28/02/2017. The gelding had a soft, fluctuating swelling caudodorsal to his right eye that had been present and had increased in size over a period of 3 years. He had mild exophthalmos of the right eye. No blindness was suspected, as the optic reflexes were normal. The horse was also lame and had a swelling on his right front carpus. Radiographic images were taken from the head and the carpus, but the focus of this case will be kept to the retrobulbar swelling.

Radiographic examination

At first, the horse was sedated with a combination of 0.5 ml Detomidinehydrochloride (Detogesic® 10 mg/ml) and 0.5 ml Butorphanol (Torbugesic® 10 mg/ml).

A left to right lateral image (figure 7), a ventrodorsal projection of the right eye (skyline) (figure 8), and a standard ventrodorsal image (figure 9) was taken. Only on the ventrodorsal skyline image was a moderate bulging of the retrobulbar fat visible. No further bony abnormalities were seen on these radiographs. This did not allow a satisfactory diagnosis for the swelling, so the owners were advised to have a CT-scan done of the cranium. The horse was hospitalized at the clinic in Merelbeke.
CT examination
The day after the horse was hospitalised, a CT-scan was organized for the cranium. The horse was put under general anaesthesia, placed on a table and its head immobilized in order to get a good image.

A well-circumscribed ovoid mass was seen which measured 9.8 cm in height x 6.3 cm in width x 7.2 cm in length. It was located at the medial aspect of the right zygomatic arch and lateral aspect of the coronoid process of the right mandible. It extended from the level of the right temporomandibular joint to the caudal aspect of the right retrobulbar space. It created a mild compression on the extraocular muscles rostrally and a mild displacement of the right globe abaxially was visible. The mass was heterogenous with multiple large hypodense cavities (10-20 HU). The tissular part of the mass was hyperdense on pre-contrast CT (85-100 HU: figure 13 left) and mildly contrast enhancing (100-120 HU: figure 13 right). No adjacent bony abnormalities were detected (figures 10-13).
Figure 10
Dorsal plane of the cranium (bone window). The right retrobulbar region, which is normally filled with fatty tissue (white arrowhead left) is filled with a heterogenous mass. Note the absence of bone destruction associated with this mass.

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Figure 11
Parasagittal CT-scan image of the right eye (soft tissue window) with the heterogenous mass (yellow arrow) seen caudally from the eye.

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Figure 12
The retrobulbar mass (yellow arrow) on a post contrast dorsal plane image in a soft tissue window. Star showing the right eye
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Figure 13
(Left) Pre-contrast image of the mass. The heterogenicity (cyst-like) of the mass is very clear, together with its size on transverse view. (Right) Post-contrast image with mildly contrast enhancing soft tissue. White arrowhead marking the contrast visible in blood vessels.
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Differential diagnosis
On the basis of the clinical examination and the images, a differential diagnosis was obtained. The heterogeneous, hyperdense, well-delineated ovoid mass without signs of bone destruction can be classified as benign. As this was a case of an older grey horse, which had several melanomas around the tail base, the most likely differential diagnosis was a melanoma. It is a very unusual location for a melanoma, but as no biopsy was taken, it was not possible to rule out a hematoma, abscess or other soft tissue neoplasm.

Treatment
The horse was put under general anaesthesia to have the mass surgically removed. Using the CT images, the exact location of the mass was clear, and so the surgeons were able to remove it via a retrobulbar incision. After the excision, the mass resembled the clinical appearance of a melanoma, due to its firmness and black colour shown in figure 14. This was confirmed by histopathological examination of the mass.

Figure 14
The removed melanoma
H. Jones 2017
DISCUSSION

The exophthalmos in this case was due to a retrobulbar process. Retrobulbar processes in horses are rare enough, and this case of it being a melanoma made the location of this case quite unique. The horse was grey and 16 years old, both factors predisposed for developing melanomas. The horse also had melanomas around the perineal region and under the tail base, which are more common places for them to grow.

The medical imaging techniques used included the routine x-ray of the head as a screening method. There were no abnormalities to be seen, except for the soft tissue swelling on the skyline image above the right eye. The CT-scan was performed to create a 3D image of the retrobulbar process, defining the outline of the mass and its lack of aggressiveness in surrounding tissues. With this extra information surgical planning could then take place. An MRI scan for the equine head is not available at the Faculty in Merelbeke, and therefore a CT-scan was performed. MRI, however, would have given us a better idea of the composition of the mass.

Ultrasound could have been used to locate the mass and its outlines. The possibilities of doing an ultrasound were there at the time, and this would have been a less costly option for the owners to diagnose the retrobulbar mass. CT does give a lot more detail and the images can be used to perform surgery, and if the owners are willing to go for surgery anyway, then CT is the way forward doing as few tests as possible whilst providing the most information.

An ultrasound or CT-guided biopsy or fine needle aspirate (FNA) could also have been used to diagnose the type of tumour, as it was not known for sure before the operation that the mass was a melanoma. The assumption was there because of the horse’s history, breed, age and other melanomas present, but histological tests on a biopsy or FNA would have shown with certainty. This, together with the medical imaging could give an almost definite diagnosis of the mass pre-surgery, making the surgical planning more straight forward and complete.

Most melanomas described in literature have a homogeneous, hyperdense appearance on CT compared to surrounding muscles, with possible hypodense cavities. The image pattern of the melanoma described in this study is quite similar, as it was described as being a hyperdense mass with several large hypodense cavities, with the one difference of being heterogeneous. The median attenuation of the melanomas described in the 13 case reports by Dixon et al. (2016) was 113.5 HU on CT, just slightly higher than in this case where it was 85-100 HU. The mild contrast enhancement on CT (100-120 HU) images of the melanoma in this case was also quite similar to what has been described in other literature case reports. The mild contrast enhancement indicates an increased blood flow through this particular area. This is often the case in neoplastic processes (Puchalski, 2012; Crijns et al., 2016). As melanomas are often benign tumours that grow slowly, they will unlikely be as strongly vascularised as invasive malign tumours.

In this case, a melanoma was assumed likely due to the signalment of the horse, presence of numerous other melanomas in the perineal region, and the appearance of the soft tissue mass on CT imaging. However, other causes of exophthalmos cannot be excluded without histopathological examination, as other neoplastic processes and hematomas can have a similar presentation on CT images. Hemorrhages can have a hyperdense appearance on CT, due to the high amount of cellular debris,
which can give a similar image of hyperattenuation due to a high melanin concentration in melanomas (Dixon et al., 2016).

In this case the histopathological findings were a well circumscribed, firm, black mass. It had cavities filled with a more liquid substance. These cavities were clearly seen on the CT images by the Department of Medical Imaging of the domestic animals at UGent.

To conclude it is safe to say that retrobulbar processes in horses are uncommon, and retrobulbar melanomas are extremely rare. It would be interesting to follow up more of these cases from the anamnesis and clinical examination, through to medical imaging, excision and then histopathology to report the comparisons of the images and presentation of the process macro- and microscopically.
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