Universidade de Évora - Escola de Ciências e Tecnologia

Mestrado Integrado em Medicina Veterinária

Relatório de Estágio

Sacroiliac Dysfunction - Diagnosis and treatment approaches: a clinical study

Maria Joana da Gama Lobo Paula Martins

Orientador(es) | Susana Monteiro
Peter Wiemer

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O relatório de estágio foi objeto de apreciação e discussão pública pelo seguinte júri nomeado pelo Diretor da Escola de Ciências e Tecnologia:

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Susana Monteiro (Universidade de Évora) (Orientador)

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Sacroiliac Dysfunction - Diagnosis and treatment approaches: a clinical study

Summary

The present work entails all the activities performed and assisted during the externships at Lingehoeve Diergeneeskunde, under the guidance of Peter Wiemer, and at Paardenkliniek Venlo, under the guidance of Liana Peters.

The first part of this report partakes a descriptive statistic of the caseload. It is divided into different areas of the equine medicine and a small theoretical background is included for contextualization of a representative case chosen for each area of practice.

The second part consists of a monography, involving a bibliographic revision of sacroiliac dysfunction associated with poor performance in sports horses, followed by a clinical study on the diagnostic and treatment approaches to this condition, based on the caseload assisted during the externship at De Lingehoeve, to provide a synthesis of the signs associated with this condition and assess the validity and success of the treatments instated.

Keywords: equine, clinical, sacroiliac dysfunction, orthopaedics.

Disfunção Sacroilíaca – Abordagens diagnósticas e terapêuticas: um estudo clínico

Resumo

Este trabalho relata as atividades realizadas e assistidas ao longo dos estágios curriculares realizados no hospital *De Lingehoeve Diergeneeskunde*, sob orientação do Dr. Peter Wiemer, e na clínica *Paardenkliniek Venlo*, sob orientação da Dr.ª. Liana Peters.

A primeira parte deste relatório apresenta uma estatística descritiva da casuística. Foi incluído um breve resumo teórico para cada área da medicina de equinos, para contextualização dos casos selecionados considerados relevantes para cada uma destas áreas.

A segunda parte é composta por uma monografia de revisão bibliográfica acerca da disfunção sacroilíaca associada com perda de performance em cavalos de desporto, seguida um estudo clínico das abordagens diagnósticas e de tratamento desta condição, tendo como base de dados a casuística acompanhada durante o estágio em De Lingehoeve, e que pretende, para além de providenciar uma síntese dos sinais clínicos e imagiológicos associados a esta condição, avaliar a validade e sucesso dos tratamentos instituídos.

Palavras-chave: equino, clínico, disfunção sacroilíaca, ortopedia.

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List of Abbreviations and Acronyms

ASM - Airway Smooth Muscle
AL-DDFT – Accessory Ligament of the Deep Digital Flexor Tendon
BAL – Bronchoalveolar Lavage
BCS – Body Condition Score
BE – Base Excess
Bpm – Beats per minute
CLs – Cruciate Ligaments
CNS – Central Nervous System
CRT – Capillary Refill Time
CT – Computerized Tomography
DDFT – Deep Digital Flexor Tendon
DIP – Distal Interphalangeal joint
DMPLO – Dorsomedial – Palmar lateral oblique
DLLO – Dorsolateral – Lateral oblique
DLPMO – Dorsolateral – Palmar medial oblique
DP – Dorsal – palmar
DSIL – Dorsal Sacroiliac Ligament
DSPs – Dorsal Spinous Processes
ECM – Extracellular matrix
ECVS – European College of Veterinary Surgeons
EFD – Energy Flux Density
EFE – Epiploic Foramen Entrapment
EGUS – Equine Gastric Ulcer Syndrome
EHV – Equine Herpesvirus
EMS – Equine Metabolic Syndrome
EOTRH – Equine Orthodontic Tooth Reabsorption and Hypercementosis
ESWT – Extracorporeal Shockwave Therapy
FEI – Fédération Équestre Internationale
Fi – Absolute frequency
Fr – Relative frequency
IA - Intraarticular
IAD – Inflammatory Airway Disease
ICU – Intensive Care Unit
IFHA – International Federation for Horseracing Authorities
IM – Intramuscular
IV - Intravenous
IR – Insulin Resistance
IRAP – Interleukin-1 Receptor Antagonist Protein
IRU – Increased Radionuclide Uptake
ISELP – International Society of Equine Locomotor Pathology
ISIL – Interosseous Sacroiliac Ligament
KWPN – Royal Dutch Sport Horse
L6 – Sixth Lumbar vertebra
LL - Laterolateral
LM – Lateromedial
LS - Lumbosacral
MC – Metacarpus
MCP – Metacarpophalangeal joint
MMP – Matrix metalloproteinase
MT – Metatarsus
MTP – Metatarsophalangeal joint
NMS – Neonatal Maladjustment Syndrome
NSAIDs – Non-steroidal Anti-inflammatory Drugs
NSE – Nephrosplenic Entrapment
OA – Osteoarthritis
OIE – Office International des Epizooties
PAS – Perinatal Asphyxia Syndrome
PIP – Proximal Interphalangeal joint
PO – *per os*
PRP – Platelet-Rich Plasma
PSSM – Polysaccharide Storage Myopathy
RAO – Recurrent Airway Obstruction
RER – Recurrent Exertional Rhabdomyolysis
RNVS – Registratiecommissie of Nederlandse Veterinaire Specialisten
RU – Radionuclide uptake
S1 – First Sacral Vertebra

SI – Sacroiliac

SID – Sacroiliac dysfunction

SIJ – Sacroiliac joint

SL – Suspensory Ligament

SB – Suspensory branch

SDFT – Superficial Digital Flexor Tendon

Te - Tetanus

TeNT – Tetanus Neurotoxin

TGF β-1- Transforming Growth Factor β1

TMPS – Trimethoprim (TMP) Sulfamethoxazole

TS – *Tuber sacrale*

VSIL – Ventral Sacroiliac Ligament

WHO – World Health Organization

1. Introduction

This externship report, written for obtention of the master's degree in Veterinary Medicine by the university of Évora, describes all the activities preformed during the externship periods that occurred from 29th of November to the 30th of January, at De Lingehoeve Diergeneeskunde (Lienden, NL), and from the 1st of February to the 21st of March, at Paardenkliniek Venlo (Venlo, NL).

During the externship at De Lingehoeve, the extern assisted all the veterinarians that are part of the equine team. Because it was given the opportunity to choose which fields of medicine the extern would follow closely, and given the predilection for biomechanical anomalies and orthopaedics, the extern spent most of the externship shadowing the International Society of Equine Locomotor Pathology (ISELP) certified orthopaedic surgeons, Katja Winderickx and Henk van der Veen. The extern was also able to assist the surgeries performed at the hospital, by diplomate by the European College of Veterinary Surgeons (ECVS) in large animal surgery Julie Brunsting and Registratiecommissie of Nederlandse Veterinaire Specialisten (RNVS) diplomate Peter Wiemer and was responsible for the afterhours care of the in-patients, as well as assisting in any emergency cases that came overnight.

At Paardenkliniek Venlo, a sports-oriented equine hospital, the expected caseload did not correspond to reality due to various factors, from the coronavirus pandemic to the equine herpesvirus outbreak that occurred in Europe during the Sunshine Tour. Therefore, most of the cases observed in this clinic related to prophylactic procedures such as vaccinations and samples' collection for the control of the outbreak mentioned above. Still, the extern was able to observe some orthopaedics' cases and a few internal medicine ones. It was also possible to learn and practice the system used in the Netherlands and United Stated of America for radiographic classification for pre-purchase examinations and exportation purposes. This clinic also comprised an ambulatory service, which treated and followed mainly dermatological and orthopaedic cases.

In the first section of this paper, a review and comparison of the caseload in the two externships, including a description of a few relevant cases in each field of medicine, will be depicted. The second section will be constituted by a monography on sacroiliac dysfunction in horses, corroborating the subject with the existing literature relevant up to the moment of submission of this document, together with a descriptive analysis of the cases observed and followed at De Lingehoeve, under the supervision of veterinary surgeons Katja Winderickx and Henk van der Veen. This section intends to address this underdiagnosed condition in horses, clarifying the clinical signs and diagnostic methods, the available options of treatment essential for the management of this disorder, as well as the prognosis for these animals' future.

2. Caseload

2.1. Description of the clinics

2.1.1. De Lingehoeve Diergeneeskunde

De Lingehoeve Diergeneeskunde is a veterinary clinic in the heart of the Netherlands. The main establishment treats small animals, horses and farm animals. There are also mobile clinics in North and South Holland for the equine ambulatory service. Peter Wiemer, Henk van der Veen and Katja Winderickx are the equine department partners of De Lingehoeve. On the first of January 2021, an official merger with the veterinary clinic Dier-N-Artsen, in Oosteind, North Brabant, took place. There are a total of 13 equine vets working directly for De Lingehoeve, 7 of which work for the main facility and are responsible for the emergency and weekend patients, on a rotative schedule.

The main building in Lienden, where the offices are located, is the headquarters of the company. It has a fully stocked pharmacy and storage room, that also supply all the vets operating in the ambulatory service, The imaging department is composed of an X-ray exam room, an ultrasound room, a CT scan facility, with an induction/recovery box, a building for scintigraphy exams with several boxes for keeping the animals after subjection to the radiation, and an endoscopy/standing-surgery room. There is an examination area equipped with a stock, another one with extracorporeal shockwave therapy equipment, also used during lameness exams (for nerve blocks), a fully equipped surgery room with two recovery boxes, an Intensive Care Unit (ICU), a riding arena and two rounds (with hard and soft surfaces) for pre-purchase and orthopaedic exams, an on-site farrier, a dentistry room, a waiting room and waiting boxes, a barn with several boxes for non-critical and surgery patients and several paddocks for the turnout of the in-patients. The clinical also provides on-site housing for the duration of the externship.

2.1.2. Paardenkliniek Venlo

Paardenkliniek Venlo is a veterinary clinic, located in Venlo, Limburg, Netherlands, specialized in first- and second-line equine medicine. This clinic is known nationally and internationally in the field of pre-purchase examinations. The clinic has an approved pre-purchase' veterinarian, certified for carrying out X-ray examinations of stallions, PROK (Project Röntgenologisch Onderzoek KWPN) inspections and inspections for insurance companies. The staff is composed of seven veterinarians and collaborates with a certified ECVS surgeon, that comes to the clinic to perform the scheduled surgeries, a certified equine dentist and a physiotherapist/osteopath. The clinic offers various therapeutic and diagnostic possibilities. In addition to consults at the clinic, the veterinarians also carry out first-line work at the clients' houses. There is an emergency service available 24/7, with the on-duty veterinarian scheduled on a rotation basis.

The clinic has a pharmacy and storage facility regularly restocked, an examination area, an examination stock room, two barns with boxes for hospitalization of patients, equipped with CCTV for monitoring the critical patients, a surgery room with a recovery box, a building with an olympic-size riding arena and areas for straight-line and rounds lameness exams and two treatment rooms, for extracorporeal shockwave therapy and lameness investigations (nerve blocks).

2.2. Medical and surgical caseload

This section intends to describe all the activities performed during the externships, quantifying the cases observed on each area of expertise and highlighting particularly relevant cases for each of them, supporting the findings with the available literature. The selection of these cases was based on its clinical and scientific importance, as well as the extern's personal preference.

A total of 417 cases/procedures were registered at De Lingehoeve. The table 1 presents the distribution of that caseload regarding the medical field associated with it. The table 2 allows for a more detailed analysis of the variety of cases within the Internal Medicine caseload.

Table 1: Caseload distribution through the medical fields (Fi - absolute frequency; Fr - relative frequency in %; n=417).

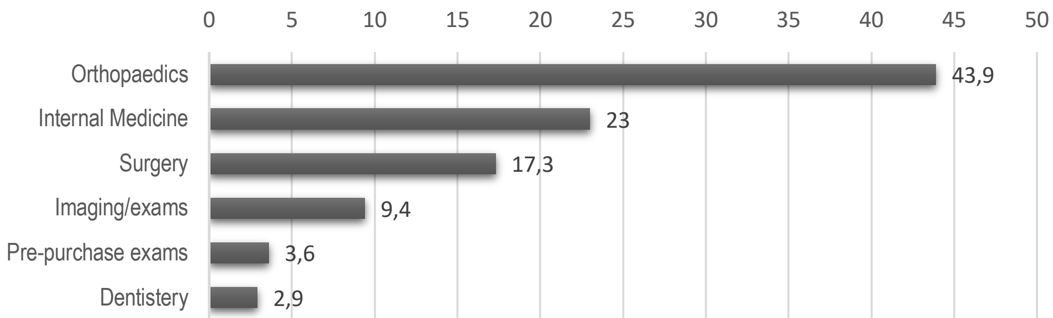
Field of Medicine	Fi	Fr %
Orthopaedics	183	43,9
Internal Medicine	96	23,0
Surgery & Wounds	72	17,3
Imaging/Exams	39	9,4
Pre-purchase exams	15	3,6
Odontology	12	2,9
Total	417	100

Table 2: Caseload distribution within the Internal Medicine field (F'i - absolute frequency; F'r - relative frequency in %; n=96)

Internal Medicine	F'i	F'r %
Gastroenterology	58	60,4
Euthanasia	11	11,5
Endocrinology	3	3,1
Respiratory airways	10	10,4
Ophthalmology	2	2,1
Neonatology	2	2,1
Infectious diseases & Prophylaxis	5	5,2
Dermatology & Oncology	5	5,2
Total	96	100

The graphic 1 allows to verify that there was a greater number of orthopaedic cases observed in comparison to the other areas of expertise, followed by a high percentage of internal medicine ones. These findings can be attributed to the extern's preference in following the two ISELP certified veterinarians working at De Lingehoeve. The surgical cases characterized the third most frequent area of services performed at this hospital that was assisted by the extern.

Graphic 1: Caseload distribution through the fields of medicine (Fr %) (n=417)



483 cases/procedures were followed at Paardenkliniek Venlo. The table 3 contains a descriptive analysis of its distribution through the various medical fields. At this practice the extern didn't observe any odontology cases, so this category was excluded from the count. Table 4 details the caseload observed within Internal Medicine cases.

Table 3: Caseload distribution through the medical fields (Fi - absolute frequency; Fr - relative frequency in %; n=483).

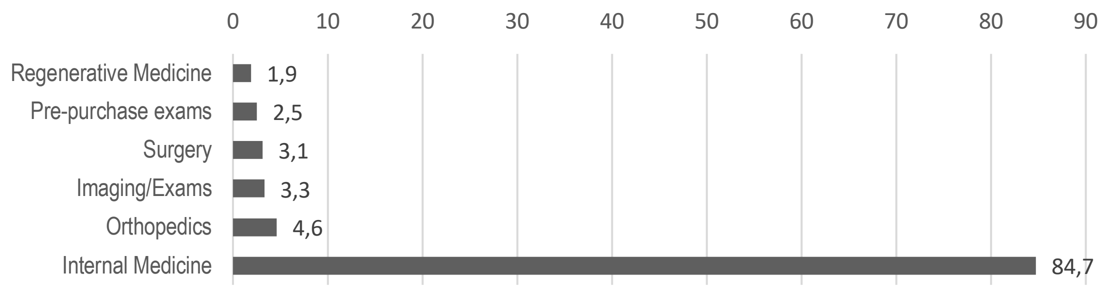
Field of Medicine	Fi	Fr %
Internal Medicine	409	84,7
Orthopaedics	22	4,6
Imaging/ Exams	16	3,3
Surgery	15	3,1
Pre-purchase exams	12	2,5
Regenerative medicine	9	1,9
Total	483	100

Table 4: Caseload distribution within the Internal Medicine field (F'i - absolute frequency; F'r - relative frequency in %; n=409)

Internal Medicine	F'i	F'r %
Gastroenterology	15	3,7
Euthanasia	1	0,2
Endocrinology	1	0,2
Respiratory airways	4	1
Neonatology	2	0,5
Infectious diseases & prophylaxis	378	92,4
Urology	1	0,2
Metabolic disorders	7	1,7
Total	409	100

The graphic 2 depicts the higher incidence of internal medicine cases, compared to any other category, already exposed on table 3, with the orthopaedics cases being the next most frequent one, but accounting for only 4,6% of the cases observed.

Graphic 2: Caseload distribution through the fields of medicine (Fr %) (n=483)



The big discrepancy between the internal medicine caseload and the rest is justified by the EHV outbreak occurred during the length of this externship. As portrayed on tables 3 and 4, the internal medicine cases made up for 84,7% of the caseload, with Preventive medicine procedures representing 92,4% of those. Being the normal focus of this practice on sports medicine and orthopaedics, the caseload regarding this subject does not represent the normal caseload distribution of Paardenkliniek Venlo.

The next chapters in this section will further explore the distribution of the caseload on both clinics and highlight a few cases of relevance inserted in each category, supported by a short literature revision on the subject.

2.2.1. Orthopaedics & Pre-purchase exams

Considering the reduced percentage of orthopaedics-related cases at Paardenkliniek Venlo (7,1% - 4,6% of orthopaedic cases and 2,5% of pre-purchase exams), only the approach observed in the first practice will be further detailed.

The orthopaedics consults and pre-purchase exams will be listed in the same section, not only because they share similarities on the clinical approach and they were dealt by the same veterinarians, but because the pre-purchase exams also intend to assess the horse's fitness and locomotor ability. This section represents most cases observed during the externship at De Lingehoeve – 47,5% (43,9% were lameness consults and 3,6% match the pre-purchase consults), reflecting the owners' vigilant attitude towards their animals' comfort and performance changes.

The orthopaedic consults include not only the clinical evaluation of the horse's movements, considering the anamnesis and the motive for the consult given by the owner, but also a thorough investigation of the cause for the found changes, and once a diagnosis is reached a detailed treatment plan is presented to the owner and, with his approval, instated as soon as possible.

The pre-purchase exams share the same thorough clinical evaluation of the horse's locomotor apparatus with the purpose of detecting any slight alterations to the expected locomotion patterns or to the physical appearance of its body constituents. Most of these consults also comprise some complementary exams, such as radiological imaging, to rule out any pre-existing conditions that might be go unnoticed during the clinical evaluation. As part of the pre-purchase exam, a quick check-up on some of the apparatuses' functions is also performed and a full-body inspection for any existent asymmetries and swellings that might indicate any structural impediment to the horse's performance.

2.2.1.1. Orthopaedic consults

The approach for the orthopaedic consults begins with a static evaluation of the horse. This includes its posture, demeanour, weight distribution, visible swellings and wounds and overall appearance. At this time, the anamnesis of the animal is gathered, along with the motive for the consult. The visual inspection might require for further investigation of any suspicious area, by means of palpation and passive manipulation. Next, the dynamic evaluation of the horse begins, with the entire exam being recorded by an assistant. The owner is asked to hand walk his horse in a straight hard-surface line, while the veterinarian observes it walking from and to him/her, trying to detect any irregularities that might be evident from these perspectives. The owner is then asked to repeat the same straight line, this time trotting the horse – this is performed twice, to ensure every little change in its movement is detected. The vet may choose to alternate his position from front/behind perspective to lateral view while trying to assess the asymmetry in the movement (withers drop, *tuber coxae* drop, head drop/lift, rotation of the limbs at impact and/or push-off, etc.). If necessary, it may be requested that the horse is made to rotate around itself over both the left and right hands, as well as perform a series of eight-shape paths, to exacerbate any instability or pain when the back and joints are under stress. The dynamic evaluation is then focused on the horse's performance when lunging. First, the horse is made to walk on a hard surface round pen, to both sides, and then trot in the same sequence. In cases where the lameness is already evident at the walk, the trotting on the hard surface may be excessive, since it may cause unnecessary discomfort or pain to the animal. The examination of the horse's locomotion on a soft surface follows the same sequence as the hard surface one, except for the fact that it may be necessary to examine the horse at different gaits, such as gallop/canter, seeing as this can be useful to differentiate between conditions that present similar clinical signs. At this point, another static manipulation of the horse takes place, this time trying to detect any exercise-induced complaints or changes, including mobilization of the head, neck, back, croup and tail. Further clinical investigation is often needed, such as flexion tests or hoof pressure tests. Other means of diagnosis can also be used, in order to achieve a definite diagnosis, or at least narrow down the areas requiring further investigation. This is the case of the perineural or joint blocks, in which a positive response translates in a partial or total dissolution of the lameness. The final step in the diagnostic process revolves around imaging studies of the suspected sites of injury or pathology. These studies can be performed with several techniques, being the x-ray and the ultrasound imaging the most frequent. If a diagnosis cannot be reached with these techniques, there might be a need for a more sensitive one, either with Computerized Tomography (CT) or scintigraphy. According to the statistical work, the ultrasound was satisfactorily sensitive in approximately 78,9% (138/175) of the cases where imaging studies were performed. Although x-rays were also taken for the imaging study on each case, it rarely offered enough information on its own to settle for a diagnosis, apart from the cases involving fractures, osteoarthritis or overriding spinous processes syndrome ("kissing spines"). The CT and the scintigraphy exams also included referral patients from other clinics; these cases were considered for the statistical purposes on the Imaging category on *Table 1*, but they were not accounted for in this orthopaedics section.

Table 5: distribution of the caseload regarding the type of consult, the motive for consult and the imaging techniques used (Fi; n=183) *the n represents the number of horses followed, not the number of consults/procedures.

Caseload	Fi
Horses (n*)	**183**
Type of consult	**217**
1st consult	87
control	97
2nd opinion	4
pre/post-surgery	5
imaging	20
ridden consult	4
Imaging exams	**241**
x-ray	69
ultrasound	154
diagnostic US	*138*
CT	13
scintigraphy	5
Motive for consult	
lameness	121
stiff neck/back	21
swollen limb	7
trauma	5
imaging	20
ataxic	2
other	7

Table 6: distribution of the caseload regarding the final diagnosis (Fi; Fr %; n=277)

Diagnosis	Fi	Fr
Osteoarticular problems		
OA PIP/DIP	26	9,4
Prox. sesamoid bones	3	1,1
Carpus/Metacarpus	4	1,4
Elbow	2	0,7
Shoulder	3	1,1
Cervical synovitis/capsulitis	33	11,9
Kissing spines	8	2,9
lumbosacral	6	2,2
SI	32	11,6
Hip	11	4
Stifle	31	11,2
Spavin	4	1,4
Fractures	3	1,1
Soft tissue problems		
Bicep's tendonitis	3	1,1
SL desmopathy/enthesopathy	35	12,6
SB desmopathy	12	4,3
DDFT/SDFT tendinopathy	17	6,2
AL-DDFT tendonitis	6	2,2
Sesamoideum ligs. desmopathy	9	3,3
CLs distal limb	5	1,8
Scutocompedal desmopathy	2	0,7
Supra/interspinal desmopathy	5	1,8
wounds	3	1,1
peroneus tertius tear	2	0,7
Other		
laminitis	2	0,7
keratoma	3	1,1
phlebitis	3	1,1
PSSM	4	1,4
Total	**277**	**100**

Once a presumptive or definitive diagnosis is reached, the veterinarian in charge establishes a treatment plan that is presented to the client, together with therapeutical alternatives whenever existent, so that an informed choice of treatment made. A total of 277 specific diagnosis were made, as illustrated on *Table 6*, which suggests that there is often more than one single condition affecting a horse at the time of diagnosis (277 diagnosis in a population of 183 horses). Depending on the suggested approach to each individual problem, the veterinarian may institute the chosen treatment right at the end of the consult. The therapeutical options range from rest, combined with prescribed exercise, to intralesional, intraarticular or/and systemic administration of pharmaceuticals, and may also include regenerative medicine therapies, as enumerated on *Table 7*.

Table 7: Distribution of the therapeutical plans instated after diagnosis (Fi; n=277); IA – Intraarticular, IRAP – Interleukin-1 Receptor Antagonist Protein, PRP – Platelet-Rich Plasma **the n represents the number of conditions diagnosed and treated*

Therapeutical management	Fi
Rest	27
Exercise	7
Orthopaedic shoeing	26
Antibiotics	5
NSAIDs/Analgesics	25
IA/intrathecal injection	73
Mesotherapy	9
Extracorporeal Shockwave Therapy (ESWT)	26
High-power laser therapy	1
Tildren	1
IRAP	2
PRP	2
Surgery	13
None/No information	57
Euthanasia	3
Total	**277**

Amongst the regenerative medicine therapies (Simplicio et al., 2020) available at De Lingehoeve, the Extracorporeal Shockwave Therapy was the most sought out when treating tendon and ligament injuries, giving the extern the opportunity not only to observe, but also to implement this therapeutical method.

The extracorporeal shockwave therapy (ESWT) was initially developed for dissolving human urolithiasis, but the findings that it interfered with the bone density of the pelvis lead to its relevance as an adjuvant therapy in musculoskeletal disorders. (Chao et al., 2008; Bosch et al., 2009; MacKay et al., 2020; Simplicio et al., 2020)

The ESWT works by concentrating high-energy acoustic pressure waves into one focal point, considering they travel with little dissipation through the tissues. (Kersh et al., 2006; Chao et al., 2008; Yocom & Bass, 2019) These waves reach both high positive and negative pressures, rapidly changing between them, generating mechanical forces that will act directly and indirectly in the tissues (Kersh et al., 2006; Yocom & Bass, 2019). Once the tensile forces of the wave exceed the dynamic forces of the water, an indirect mechanical force is created - cavitation -, leading to the development of gas bubbles in the interstitial fluid, which later collapse and culminate in localized damage of the tissues

(Chao et al., 2008; Bosch et al., 2009; Yocom & Bass, 2019). That is why the energy flux density, and the number of pulses can be regulated in most available equipment, and it is important that its settings are determined by a knowledgeable veterinarian, so that cavitation occurrence is minimized by controlling the total energy applied to the tissues. The highest energy uptake occurs in areas where different types of tissue exist, such as the soft tissues' attachments to the bones, producing maximum effects. (Yocom & Bass, 2019)

Chao et al., 2008, have showed that rats' tendons treated with a lower EFD (0,36 mJ/mm2) had a higher cell viability than the ones treated with higher EFD and promoted tenocyte proliferation, in addition to an increased collagen synthesis by the tenocytes. It was also shown that it stimulates the mRNA expression of the types I and III collagen, corroborating the hypothesized theory on the increase in collagen synthesis by the tenocytes. This synthesis of collagen fibrils by the fibroblast stimulation has been previously studied by Caminoto et al., 2005, who found that the presence of a higher number of mitochondria in the smaller calibre fibrils support the claim of their synthesis stimulus.

Furthermore, ESWT is also responsible for the increased concentration cytokines such as TGF β-1, promoting its production and expression at transcriptional level. The TGF β-1 has a proinflammatory role in the first phase of tissue healing, promoting the secretion of collagen and increasing the expression and deposition of extracellular matrix proteins, together with the presence of less inflammatory cells during the proliferative phase of healing, making the TGF β-1 of the probable triggers of the ESWT positive effects on tendon and ligament injuries. (Caminoto et al., 2005; Kersh et al., 2006; Chao et al., 2008; Simplicio et al., 2020)

ESWT is also known to increase angiogenesis and induce neovascularization, improving healing and decreasing the localized pain, being the formation of the neovessels visible at approximately four weeks after the first treatment. (Kersh et al., 2006; Yocom & Bass, 2019; Simplicio et al., 2020)

The study by Caminoto et al., 2005, in accordance with others regarding the use of ESWT for treatment of suspensory ligament desmitis and measuring the ultrasonographic images of the ligament injuries subjected to ESWT treatment, concluded that the treated ligaments had a superior decrease in size and the injury site within the ligament had significantly decreased in area, in comparison to those in the control group, for the same period. Furthermore, an analysis of samples of suspensory ligaments treated with ESWT revealed there was a greater amount of small-sized collagen fibrils, compared to the number of fibrils observed in control samples.

The proximal suspensory ligament enthesopathy, at the attachment on the MC/MT III, was the main recipient of this therapy and the condition with the most positive outcome at the end of treatment, what may be justified by the finding mentioned by Yocom & Bass, 2019, regarding the greatest energy and consequently greater results at the interface between different tissues (in this case, bone and ligament).

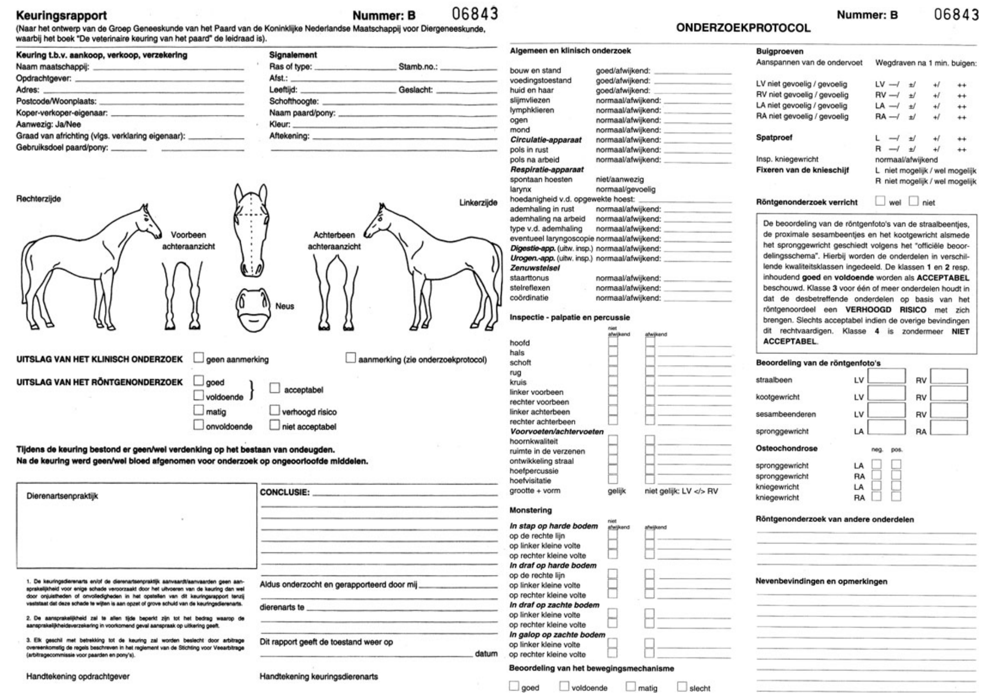
2.2.1.2. Pre-purchase examinations

The meticulousness of the pre-purchase examination depends on the horse's aptitude as well as the prospective buyer's objectives for it (leisure, middle to high-level competition, breeding, etc.), not forgetting the horse's economical value and the client's financial availability.

In the Netherlands, the pre-purchase examinations follow a standardized protocol in order to synthetize the information collected, making it similar in contents for all animals examined and easier for all the stakeholders to interpret. This consists of a clinical and imaging evaluation of the horse. As mentioned before, the clinical component includes a quick evaluation of the cardiorespiratory (audible murmurs, arrythmias, any cause of breathing impairment such as hemiplegia, etc.), visual (any detectable alteration that might affect the animal's depth perception and sight), neurological (movement anomalies that change the execution of the natural movements and gaits of the horse), dermatological (presence of masses, hair quality and distribution, wounds and scars), orthodontic (lesions on the oral mucosa, fractured teeth, abnormal dentition or any condition that might cause discomfort or pain) and gastrointestinal systems (intestinal motility, laparotomy incision scars), as well as a general morphological assessment of the body components (asymmetries, standing position, hoof morphology, etc.). The imaging component is fundamentally radiological, and its thoroughness may vary depending on the reasons identified above. It can also be motivated by any suspicions that may arise during the clinical exam.

The basic set of x-rays taken during the examination is made with 10 different projections, obtaining a total of 22 pictures of the animal's distal limbs: a DP and a LM of the fetlock and pastern areas of all limbs (MCP/MTP, PIP, DIP), a DLPMO and a DMPLO to assess the quality of the fore proximal sesamoid bones, a DP of the carpus, a LM, a DP, a DLPMO and a DMPLO of the hocks, and a LM of the stifles. Additional projections of specific regions may be requested, if there is a suspicion or a known history of condition(s), not visible in this set of images, or if requested by the client (this can be the owner or the prospective buyer). A more exhaustive evaluation might include different projections of the previous regions, skyline projections of the feet, to assess the navicular bones' quality, neck and back x-rays (LL), to rule out cervical remodelling, kissing spines, between other conditions, that might affect the horse's performance. A blood sample is collected and stored for a minimum period of one year after the collection date.

Lastly, the pre-purchase report is filled with the animal's identity and physical description, the code for the blood sample tracking, all the information gathered during the examination, the x-rays' grading, and the veterinarian's opinion of the animal's fitness for sale, as well as any observations that are considered pertinent, as shown on the sample below (*Fig. 1*).



Keuringsrapport **Nummer: B** 06843

(Naar het ontwerp van de Groep Geneeskunde van het Paard van de Koninklijke Nederlandse Maatschappij voor Diergeneeskunde, waarbij het boek "De veterinaire keuring van het paard" de leidraad is).

Keuring t.b.v. aankoop, verkoop, verzekering
Naam maatschappij:
Opdrachtgever:
Adres:
Postcode/Woonplaats:
Koper-verkoper-eigenaar:
Aanwezig: Ja/Nee
Graad van africhting (vlgs. verklaring eigenaar):
Gebruiksdoel paard/pony:

Signalement
Ras of type: Stamb.no.:
Afst.:
Leeftijd: Geslacht:
Schofthoogte:
Naam paard/pony:
Kleur:
Aftekening:

UITSLAG VAN HET KLINISCH ONDERZOEK ☐ geen aanmerking ☐ aanmerking (zie onderzoekprotocol)

UITSLAG VAN HET RÖNTGENONDERZOEK ☐ goed ☐ voldoende } ☐ acceptabel; ☐ matig ☐ verhoogd risico; ☐ onvoldoende ☐ niet acceptabel

Tijdens de keuring bestond er geen/wel verdenking op het bestaan van ondeugden.
Na de keuring werd geen/wel bloed afgenomen voor onderzoek op ongeoorloofde middelen.

Dierenartsenpraktijk

CONCLUSIE:

1. De keuringsdierenarts en/of de dierenartsenpraktijk aanvaardt/aanvaarden geen aansprakelijkheid voor enige schade veroorzaakt door het uitvoeren van de keuring dan wel door onjuistheden of onvolledigheden in het opstellen van dit keuringsrapport tenzij vaststaat dat deze schade te wijten is aan opzet of grove schuld van de keuringsdierenarts.

2. De aansprakelijkheid zal te allen tijde beperkt zijn tot het bedrag waarop de aansprakelijkheidsverzekering in voorkomend geval aanspraak op uitkering geeft.

3. Elk geschil met betrekking tot de keuring zal worden beslecht door arbitrage overeenkomstig de regels beschreven in het reglement van de Stichting voor Veearbitrage (arbitragecommissie voor paarden en pony's).

Aldus onderzocht en gerapporteerd door mij
dierenarts te
Dit rapport geeft de toestand weer op
datum

Handtekening opdrachtgever
Handtekening keuringsdierenarts

ONDERZOEKPROTOCOL **Nummer: B** 06843

Algemeen en klinisch onderzoek
bouw en stand goed/afwijkend:
voedingstoestand goed/afwijkend:
huid en haar goed/afwijkend:
slijmvliezen normaal/afwijkend:
lymphklieren normaal/afwijkend:
ogen normaal/afwijkend:
mond normaal/afwijkend:
Circulatie-apparaat normaal/afwijkend:
pols in rust normaal/afwijkend:
pols na arbeid normaal/afwijkend:
Respiratie-apparaat
spontaan hoesten niet/aanwezig
larynx normaal/gevoelig
hoedanigheid v.d. opgewekte hoest:
ademhaling in rust normaal/afwijkend:
ademhaling na arbeid normaal/afwijkend:
type v.d. ademhaling normaal/afwijkend:
eventueel laryngoscopie normaal/afwijkend:
Digestie-app. (uitw. insp.) normaal/afwijkend:
Urogen.-app. (uitw. insp.) normaal/afwijkend:
Zenuwstelsel
staarttonus normaal/afwijkend:
stelreflexen normaal/afwijkend:
coördinatie normaal/afwijkend:

Inspectie - palpatie en percussie (niet afwijkend / afwijkend)
hoofd
hals
schoft
rug
kruis
linker voorbeen
rechter voorbeen
linker achterbeen
rechter achterbeen
Voorvoeten/achtervoeten
hoornkwaliteit
ruimte in de verzenen
ontwikkeling straal
hoefpercussie
hoefvisitatie
grootte + vorm gelijk niet gelijk: LV </> RV

Monstering (niet afwijkend / afwijkend)
In stap op harde bodem
op de rechte lijn
op linker kleine volte
op rechter kleine volte
In draf op harde bodem
op de rechte lijn
op linker kleine volte
op rechter kleine volte
In draf op zachte bodem
op linker kleine volte
op rechter kleine volte
In galop op zachte bodem
op linker kleine volte
op rechter kleine volte

Beoordeling van het bewegingsmechanisme
☐ goed ☐ voldoende ☐ matig ☐ slecht

Buigproeven
Aanspannen van de ondervoet — Wegdraven na 1 min. buigen:
LV niet gevoelig / gevoelig LV —/ ±/ +/ ++
RV niet gevoelig / gevoelig RV —/ ±/ +/ ++
LA niet gevoelig / gevoelig LA —/ ±/ +/ ++
RA niet gevoelig / gevoelig RA —/ ±/ +/ ++

Spatproef L —/ ±/ +/ ++; R —/ ±/ +/ ++
Insp. kniegewricht normaal/afwijkend
Fixeren van de knieschijf L niet mogelijk / wel mogelijk; R niet mogelijk / wel mogelijk

Röntgenonderzoek verricht ☐ wel ☐ niet

De beoordeling van de röntgenfoto's van de straalbeentjes, de proximale sesambeentjes en het kootgewricht alsmede het spronggewricht geschiedt volgens het "officiële beoordelingsschema". Hierbij worden de onderdelen in verschillende kwaliteitsklassen ingedeeld. De klassen **1** en **2** resp. inhoudend **goed** en **voldoende** worden als **ACCEPTABEL** beschouwd. Klasse **3** voor één of meer onderdelen houdt in dat de desbetreffende onderdelen op basis van het röntgenoordeel een **VERHOOGD RISICO** met zich brengen. Slechts acceptabel indien de overige bevindingen dit rechtvaardigen. Klasse **4** is zondermeer **NIET ACCEPTABEL**.

Beoordeling van de röntgenfoto's
straalbeen LV RV
kootgewricht LV RV
sesambeenderen LV RV
spronggewricht LA RA

Osteochondrose (neg. / pos.)
spronggewricht LA
spronggewricht RA
kniegewricht LA
kniegewricht RA

Röntgenonderzoek van andere onderdelen

Nevenbevindingen en opmerkingen

Figure 1: Pre-purchase examination report sample, retrieved from https://library.wur.nl/WebQuery/file/lom/lom_t43df8407_001.html

2.2.2. Internal Medicine

Considering the discrepancy in the number of cases within internal medicine at Paardenkliniek Venlo (over 90% of the cases represented prophylaxis and infeccious diseases), only the ones regarding prophylactic measures and management of infeccious diseases followed at this practice will be further analysed in this section.

In this section, aside from the exceptions mentioned above, all the non-surgical cases observed by the extern were included, except for the orthopaedics-related cases and odontology procedures. The section was sub-divided is various medical specialties: Gastroenterology, Dermatology and Oncology, Endocrinology, Respiratory airways conditions, Ophthalmology, Neonatology and Infectious Diseases and Prophylaxis.

2.2.2.1. Gastroenterology

This Internal Medicine sub-department dealt with the most cases, most of them colic syndrome cases, and some Equine Gastric Ulcer Syndrome (EGUS) cases were also observed.

Most of the colic cases dealt with turned into surgical cases, due to the severity of the presentation, and all of them were hospitalized for a minimum of two days in the hospital facilities, either on ICU or the regular in-patient unit. The management of the colic patients required a constant monitoring of the vitals along with scheduled treatments (nasogastric intubation, pain management, motility induction, hydration, etc.) until stabilization, followed by a slow re-introduction to normal feed and pharmacological withdrawal until discharge.

Table 8: Aetiologic distribution of colic cases (Fr %; n=52); NSE – Nephrosplenic Entrapment; EFE – Epiploic Foramen Entrapment

Type of colic	Fi	Fr
Sand colic	11	21,2
Stomach impaction	2	3,8
Strongyle's infection colitis	3	5,8
Caecum Impaction	6	11,5
Colon displacement	7	13,5
Pelvic flexure impaction	8	15,4
Jejunum obstipation	1	1,9
Non-specific enteritis	3	5,8
NSE	3	5,8
EFE	4	7,7
Congenital malformation	1	1,9
Colon torsion	3	5,8
Total	**52**	**100**

As enumerated on *Table 8*, the main aetiology associated with colic syndrome diagnosed at De Lingehoeve was sand impaction (21,2%; n=52), followed by non-sand pelvic flexure impaction and colon displacement.

Colic syndrome refers to any acute and painful disturbance with abdominal origin, with its aetiology and associated lesions being the principal means of categorizing it. A colic episode can be broadly traced back to an obstruction, a strangulation, a displacement, an infarction, or ulceration/rupture of any of the gastrointestinal organs as well as enteritis, peritonitis and ileus. (Tinker et al., 1997) According to Salem et al., 2016, colic remains one of the most common causes of mortality in equine populations, which agrees with the statements in Leblond et al., 1995, and Egenvall et al., 2006, mentioned by Scantlebury et al., 2011, with Tinker et al. indicating it as the cause of 28% of the annual horse deaths.

Many cases may present as an isolated colic episode, due to a specific cause in time, but recurrent colic symptoms manifestation is often reported and becomes a management frustration to vets and owners. (Hart & Southwood, 2010; Scantlebury et al., 2011) Various studies mentioned by Scantlebury et al., 2011, proved that horses which previously had a colic episode are at increased risk of suffering future episodes of colic, whether with the same or different aetiology and severity, standing with agreement with the results of Tinker et al., 1997, that inferred that a horse suffering a colic episode had a chance higher than 1/10 of having a further episode. One of the reported causes for recurrency in colic episodes is the stereotypic behaviour of crib-biting/windsucking. (Scantlebury et al., 2011; Escalona et al., 2014) Considering that this may be an indicator of a gastrointestinal dysfunction or even of a management problem related to feeding and/or exercise (Scantlebury et al., 2011), it is important to address the primary cause of the behaviour in order to diminish the chances of recurrency.

Many of the successfully resolved colics are the simple left or dorsal displacements, without strangulation. The development of these displacements is often associated with alterations in the colon's motility and microbiota, which lead to the formation of excessive gas in the left colon, leading to its dorsolateral displacement. (Albanese & Caldwell, 2014) Cribbing behaviour, recent exercise changes and increasing concentrate feeding in the previous weeks, amongst other factors, were all considered as higher risk factors to the development of left dorsal displacement colics (Albanese & Caldwell, 2014), with evidence showing that crib-biting/windsucking behaviour is a risk factor for the development of simple colonic obstruction and distention colic (SCOD) (Escalona et al., 2014), and with Hillyer et al., 2002, mentioned by Albanese & Caldwell, 2014, pointing as risk factors for the development of SCOD simple pelvic flexure impaction and simple left and right dorsal displacements.

The left dorsal displacement of the large colon is a frequent inducer of colic (Lindegaard et al., 2011) and is closely associated with nephrosplenic entrapment, due to the dorsolateral displacement of the dorsal and ventral (ascending) colon, that then become entrapped between the left kidney and the spleen. (Abutarbush & Naylor, 2005; Hardy et al., 2010; Fultz et al., 2013; Muñoz & Bussy, 2013; Albanese & Caldwell, 2014; A. M. Gillen et al., 2019) Although no distinctive approach is made, the large colon can be equally entrapped between the spleen and the left abdominal wall (Abutarbush & Naylor, 2005). In rare occasions, small colon entrapment between the kidney and spleen has been diagnosed, as indicated by Albanese & Caldwell, 2014, in reference to Dart et al. 1992; Goodrich et al. 1997.

As far as predisposing factors, larger framed geldings, specifically middle-aged ones, are the most likely to develop this kind of colic, although the exact cause cannot be indicated. (Abutarbush & Naylor, 2005; Fultz et al., 2013; Muñoz & Bussy, 2013; Albanese & Caldwell, 2014)

The NSE produces a mild to moderate painful colic (Muñoz & Bussy, 2013) and an exploratory laparotomy has been appointed as most accurate way of diagnosing this condition (Abutarbush & Naylor, 2005; Fultz et al., 2013), even though the clinical presentation together with transrectal palpation and ultrasonographic evaluation have been considered sufficiently accurate to produce a definite diagnosis. (Abutarbush & Naylor, 2005; Hardy et al., 2010; Lindegaard et al., 2011; Fultz et al., 2013; Albanese & Caldwell, 2014) The clinical signs usually include abdominal pain, which can go from mild to severe, influenced by the gas distention, the location of the displaced colon and any secondary developments such as gastric distention, or congestion and oedema of the colon, if a substantial amount of time has passed since the onsetting of the condition. The cardiovascular constants are within the normal range, due to a simple non-strangulating obstruction, but can rise if a higher intensity pain is endured. (Hardy et al., 2010; Albanese & Caldwell, 2014)

While ultrasonographic evaluation of the left dorsocranial quadrant is helpful to confirm a diagnosis, with a portion of the distended large colon preventing the observation of the spleen and left kidney (Abutarbush & Naylor, 2005; Hardy et al., 2010; Albanese & Caldwell, 2014), there are other causes to colonic distention responsible for the inability to properly identify the kidney by ultrasound, thus the necessity for performing transrectal palpation. (Abutarbush & Naylor, 2005; Lindegaard et al., 2011; Albanese & Caldwell, 2014) On rectal palpation, the colon is usually found on the left, with gas distention, with or without impaction, and can be followed into the nephrosplenic area direction, with the colon taenia running above the nephrosplenic ligament; at the same time, it is no longer possible to feel the spleen nor the kidney on palpation. (Abutarbush & Naylor, 2005; Hardy et al., 2010; Lindegaard et al., 2011; Albanese & Caldwell, 2014)

There are many treatment options for a nephrosplenic entrapment colic, both medical and surgical approaches being equally safe and successful in its resolution. (Abutarbush & Naylor, 2005; Hardy et al., 2010; Lindegaard et al., 2011; Fultz et al., 2013; Gillen et al., 2020) The meta-analysis performed by Gillen et al., 2020, compared the chances of survival after two different conservative treatment methods – rolling and exercise (lunging) – with the chances after surgical intervention, concluding that neither had significative different odds of successful resolution, but pointed out exercise associated with the highest odds of the treatment being successful. Before, surgical treatment was believed to be the gold-standard for both diagnosis and treatment, through the performance of a midline celiotomy (Hardy et al., 2010; Fultz et al., 2013; Gillen et al., 2019), or more recently by standing left flank laparoscopy (Muñoz & Bussy, 2013; Albanese & Caldwell, 2014). Surgical resolution, in addition to a higher cost, entails several disadvantages, with a longer recovery period, a need for a trained surgeon and specialized equipment, and a negative effect on the horse's resale value for having had an exploratory laparotomy performed. (Abutarbush & Naylor, 2005; Fultz et al., 2013) Recently, the medical treatment has become the predilection as the initial approach for most cases, whenever the clinical presentation and the horse's individual characteristics are favourable. (Hardy et al., 2010; Fultz et al., 2013; Gillen et al., 2019) The medical management includes conservative palliative care – analgesia and fluid therapy with food restriction -, exercise, IV administration an α1-adrenergic receptor agonist (phenylephrine), rolling the horse under general anaesthesia, or even a combination of these options. (Abutarbush & Naylor, 2005; Hardy et al., 2010; Lindegaard et al., 2011; Fultz et al., 2013; Muñoz & Bussy, 2013; Albanese & Caldwell, 2014; Gillen et al., 2019; Gillen et al., 2020) The success rates of phenylephrine administration in association with exercise were calculated in several studies, obtaining different resolution rates: 33% (Abutarbush & Naylor, 2005), 72% (Gillen et al., 2019) and 100%

(Lindegaard et al., 2011), and the conclusion of the retrospective study by Fultz et al., 2013, showed a 63% efficacy of this treatment combination. Phenylephrine hydrochloride is a sympathomimetic agent used for its ability to cause splenic contraction, hence reducing its overall volume, which allows for correction of the colon's position (Albanese & Caldwell, 2014; Gillen et al., 2019), but they have not always been found to increase the success rate of the medical management of NSE. The criteria for surgical resolution include the presence of gastric reflux in association with severe abdominal pain, great abdominal distention, pregnant mares, the presence of any signs of severe colic and critical systemic impairment and cases where the conservative approach has been unsuccessful. (Abutarbush & Naylor, 2005; Lindegaard et al., 2011; Gillen et al., 2020)

Two of the three cases followed during this externship were successfully resolved with a conservative approach, with the third one's clinical presentation indicating that emergency surgery had the best chance of survival. The first two cases presented at the clinic, a 23-year-old gelding and a 10-year-old draft mare, respectively with heart rates of 44 and 40, body temperatures of 38,1ºC and 37,9ºC, CRT < 2", motility on all quadrants, with tympanic sounds ("metallic PINGs") on percussion and auscultation of the left abdomen, alert and showed moderate signs of pain, such as weight-shifting, scraping the floor, and looking to the flank from time to time. At transrectal palpation, a big structure filled with gas, identified as the colon, was felt on the left abdomen, and the spleen and kidney space were no longer palpable on the nephrosplenic space. No ultrasound was performed to confirm the presumptive diagnosis. Because and early intervention has a higher chance of success, the horses were given intravenous NSAIDs (flunixin meglumine) at an analgesic dose (1,1mg/kg), as well as a spasmolytic and analgesic combination (5mL/100kg bwt of Buscopan compositum®) and lunged for 15 minutes in the arena. After two hours, the horses were re-examined for vital parameters, assessment level of discomfort and another transrectal palpation was performed to further assess the evolution of the entrapped colon. Both horses were put under surveillance, with feed restriction, and closely monitored for any changes. The 23-year-old gelding required another jogging session, four hours after the first, in order to "free" the entrapped portion of the colon, with almost immediate relief. Both cases remained in the hospital ICU for two days, with constant monitoring, and then moved to the general in-patient area where they were slowly re-introduced to normal food amounts, until they were discharged. The third case, a 9-year-old frisian gelding, presented at the clinic with a heart rate of 52, a body temperature of 38,8ºC, a CRT > 2" and pale mucosae, reduced motility in all quadrants, distended abdomen, showing signs of severe pain – very depressed, tried to lay down and kicked the abdomen multiple times. Due to the severity of clinical signs, a transrectal examination was not safe to perform, and the ultrasonographic images did not suffice for a definite diagnosis, although a considerable amount of gas was present that prevented the identification of the left kidney and spleen; the stomach was distended. Surgery was advised and with the owner's permission, an exploratory laparotomy was performed. In addition to the incarcerated colon, displacement of the pelvic flexure was present, its mucosa was oedematose, and it had secondary gastric distention. The incarceration was resolved, the displacement corrected without need for resection since the viscera were motile, and the gastric tension was relieved with the nasogastric tubing performed prior to induction. After surgery, the animal stayed in ICU for post-surgical care and observation, for a period of 14 days, before being discharged.

2.2.2.2. Dermatology and Oncology

During the externship period, a total of four oncological cases were observed (*Table 2*): an ovarian tumour, two equine sarcoid cases and a mast cell tumour at the basis of the tail.

The most common skin neoplasia in equids is the equine sarcoid. This fibroblastic tumour has been reported worldwide and affects all equid species. (Taylor & Haldorson, 2013; Knottenbelt, 2019; Funiciello & Roccabianca, 2020; Ogihara et al., 2021) Even though it is a multifactorial condition, the equine sarcoid is associated with various risk factors, such as the proximity to cattle and the presence of vectors such as flies close by, skin trauma and genetic haplotype. (Taylor & Haldorson, 2013; Funiciello & Roccabianca, 2020) It is known that the infection by bovine papillomavirus (BPV)-1 or BPV-2 is connected to the development of equine sarcoids, with the majority of DNA in tested sarcoids tracing back BPV-1 (Taylor & Haldorson, 2013; Funiciello & Roccabianca, 2020; Ogihara et al., 2021), and infected equids are theorized to be able to spread the BPV to others through contact. (Funiciello & Roccabianca, 2020)

Even though sarcoids are non-metastatic tumours (with exception of the malignant form) they are very invasive locally, extending all the way to the muscular layer in some cases. (Funiciello & Roccabianca, 2020) Sarcoids are a soft tissue tumour derived of atypical fibroblasts proliferation. (Ogihara et al., 2021) Because of the skin tropism, they can appear at any skin site of the body and on each location might exhibit different characteristics. (Taylor & Haldorson, 2013; Knottenbelt, 2019; Ogihara et al., 2021) Sarcoids are classified into six different types, according to their macroscopic appearance and clinical development, that will influence the choice of treatment as well as the outcome (Taylor & Haldorson, 2013; Knottenbelt, 2019; Funiciello & Roccabianca, 2020; Ogihara et al., 2021); these are synthetized in Table 9.

Table 9: Brief description of the six types of equine sarcoids, based on their macroscopic appearance and clinical behaviour, adapted from *Taylor & Haldorson, 2013; Funiciello & Roccabianca, 2020; Ogihara et al., 2021.*

Type of Sarcoid	Description
Occult	Alopecic, nearly circular shape, with or without hyperkeratosis, usually flat
Verrucose	Wart-like appearance, hyperkeratotic skin, may be nodular/raised
Nodular	Firm, delimited, spheric nodules, subcutaneously located
Fibroblastic	Ulcerated and fleshy, with fibroblastic infiltration; pedunculated or broad-based
Mixed	The above-mentioned characteristics are present in the same lesion, in variable proportions; more aggressive progression
Malevolent/Malignant	Rare; aggressive and highly invasive locally nodular and fibroblastic, with subcutaneous involvement and might spread to deeper planes and vessels

The clinical recognition of an equine sarcoid is normally accurate, especially when multiple tumours are present, but a definite diagnosis is only possible through histopathological analysis, which is not always recommendable unless a complete excisional biopsy of the suspected sarcoid is performed, due to the risk of activating a latent BPV infection and exacerbating the proliferation by surgical trauma. (Taylor & Haldorson, 2013; Knottenbelt, 2019; Funiciello & Roccabianca, 2020). Therefore, a list of all the differential diagnosis should be studied before making any diagnostic and treatment decisions. This list includes granulation tissue formation, folliculitis, habronemiasis and other cutaneous tumorous masses, such as fibromas/fibrosarcomas, lymphomas, squamous cell carcinomas, mast cell tumours and melanomas. (Taylor & Haldorson, 2013; Funiciello & Roccabianca, 2020)

The treatment options can go from chemotherapy, radiotherapy and immunotherapy to the excision of the tumour by conventional surgery, cryotherapy, diathermy, laser or by ligation of pedunculated sarcoids, among others. (Taylor & Haldorson, 2013; Knottenbelt, 2019) Independently of the choice of treatment, the sarcoids are associated with a high recurrency risk, especially after surgical removal. (Funiciello & Roccabianca, 2020; Ogihara et al., 2021)

A brief description of an equine sarcoid case of a nine-year-old Shire gelding, presenting with a sarcoid-like structure in the ventral chest, between both forelimbs, is now summarily described. The mass had an ulcerated centre and pedunculated appearance, earning the presumptive diagnosis of an equine sarcoid of the fibroblastic type, with a diameter of roughly four centimetres. Because of the horse's size, a standing-anaesthesia surgery for excisional removal was elected as the treatment option, with the sarcoid removed with 1,2 cm margins. As portrayed in the histopathological report below (*Fig. 2*), the excised piece of skin had 5,6 x 3,6 x 0,4 cm dimensions, presenting an irregular process in its centre over an area of 3,3 x 2,4 cm. Macroscopically, it has a solid appearance, with decolorated borders, and according to the transection cuts, it appeared to have been fully excised. Microscopically, the submitted skin fragment consisted of partly normal structures. Locally, it had transitions to skin with active epidermis, under which a neoplastic proliferation of fibroblastic cells was present. These findings correspond to the microscopic aspects of a sarcoid. The resection margins were free of tumorous tissue.

De Gezondheidsdienst voor Dieren

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UITSLAG LABORATORIUMONDERZOEK

Blad 2 van 3

Inzendnummer : GP2021–00223
Volgnummer uitslag : 1, EINDUITSLAG
Datum ingeschreven : 13/01/2021
Datum uitslag : 14/01/2021
Inzender : DAP–88425
Voor informatie : 0900–1770
Behandeld door : dr. E. van Garderen

DGC De Lingehoeve – Gezelschapsdieren
Veldstraat 3 A
4033 AK Lienden
Nederland

Betreft resultaat onderzoek van de door u ingezonden monsters.

Datum monstername : Onbekend
Diersoort : Paard
Aantal : 1

Klinische bevindingen dierenarts

Verdacht sarcoid op singelplaats. Volledige chirurgische verwijdering, marges 1,2 cm. Randen schoon?

Macroscopische kenmerken

(BS)
Spoelvormig omsneden huid van 5,6 x 3,6 x 0,4 cm met centraal een onregelmatig proces over een gebied van 3,3 x 2,4 cm. Op sneevlak solide, beige. Doorsnede ingesloten in cassette A en B. Lijkt geheel verwijderd.

Microscopische kenmerken

Het ingestuurde huidfragment bestaat voor een gedeelte uit normale pre–existente structuren. Plaatselijk gaat dit over in huid met een geactiveerde epidermis met diepe rete pegs, waaronder een neoplastisch proliferatie van spoelvormige cellen aanwezig is. Dit zijn de microscopische aspecten van een sarcoid. De neoplastische spoelvormige component blijft beperkt tot de dermis. De resectieranden zijn vrij van dit tumorweefsel.

Conclusie

Het ingestuurde huidfragment bevat inderdaad een sarcoid. De resectieranden zijn vrij van dit tumorweefsel.

Verzonden aan:
dierenarts : DAP–88425 DGC De Lingehoeve – Gezelschapsdieren Lienden
rekening naar : DGC De Lingehoeve – Gezelschapsdieren

Deze uitslag mag uitsluitend in zijn geheel worden gereproduceerd. Aanbevelingen en interpretaties vallen buiten de accreditatie door de RvA. Het door GD geaccepteerde materiaal is getoetst aan de geldende acceptatievoorwaarden. Toetsing vindt plaats aan de hand van metingen bij ontvangst en/of op de door de inzender aangeleverde inzendgegevens. De resultaten hebben alleen betrekking op het geanalyseerde monster.
Q: Betreft door de GD uitgevoerd en door de RvA geaccrediteerd onderzoek (L120)
Zie onze ProductenDienstenCatalogus voor een toelichting op de (conformiteit/gelijkwaardigheid van de) methode.

Figure 2: Histopathological report on excised sarcoid from Topgun (Shire, 9yo gelding), on 12th of January 2021

2.2.2.3. Endocrinology

The three endocrinology cases (*Table 2*) followed at de Lingehoeve were related to Insulin Dysregulation/Equine Metabolic Syndrome (EMS). The procedures performed in these cases consisted in insulin resistance tests after administration of a glycated solution for diagnosis of EMS, and one scheduled follow-up of an earlier diagnosed case of EMS.

Equine Metabolic Syndrome (EMS) is a concept first adopted by veterinary medicine in 2002, when Johnson proposed a parallel between the human and veterinary manifestation of a similar condition, based on the World Health Organization (WHO) terminology. (Johnson, 2002; Frank et al., 2010; Frank, 2011) EMS has been getting more attention in recent years, mainly due to its increased manifestation, triggered by recent feeding practices and horse production industry. (Frank, 2011; Warnken et al., 2016) It is a complex syndrome, characterized by dyslipidaemia with increased regional or generalized adiposity (obesity), insulin resistance (IR) and hyperinsulinemia, dysregulated adipokine concentrations and strong predisposition to laminitis. (Johnson, 2002; Frank et al., 2010; Frank, 2011; Morgan et al., 2015; Morgan et al., 2016; Bertin & Laat, 2017) Other components of EMS include systemic inflammation and seasonal arterial hypertension. (Frank, 2011)

Horses with EMS do not show any sex predisposition and, although no specific breeds are directly linked to the development of the disease, pony breeds and coldblooded horses are statistically more represented, with ponies more prone to the development of obesity and manifestly susceptible to laminitis. (Johnson, 2002)

Obesity is defined by the WHO as increased body weight influenced by excessive fat deposition, but there is no universal consensual definition for equine populations, being regularly identified using body condition scores. Nevertheless, its worldwide prevalence is increasingly high. (Morgan et al., 2016; Bertin & Laat, 2017) The link between obesity and insulin resistance has been well described before in other species; it is believed that obesity represents the main risk factor leading to insulin dysregulation and consequently to EMS. The fat distribution in affected horses is usually focused in areas such as the neck and the rump, although obese horses are generally overweight, and the owners struggle in reducing their weight with dietary management; mares can experience irregular oestrous and low success breeding rates, and sometimes exhibit increased adipose tissue in the udder, while geldings sometimes have a swollen oedematous preputium with adipose tissue expansion. (Johnson, 2002; Frank et al., 2010; Frank, 2011) Although the pathophysiology of EMS remains unclear (Morgan et al., 2015; Warnken et al., 2016; Bertin & Laat, 2017), Morgan et al., 2015, have suggested that adipose tissue acts as an adipokines-secreting organ and when there is fat tissue in excess, it alters the adipokine concentration levels, which will, together with a dysregulated local glucocorticoid metabolism and generalized inflammation, interfere with insulin signalling on fat and muscle tissues, ultimately resulting in insulin resistance. It is now known that the insulin dysregulation surpasses tissular resistance to insulin, with the entero insular axis, along with the role of carbohydrates ingestion in incretin production, as key participant in insulin secretion and hyperinsulinemia development. (Morgan et al., 2015; Bertin & Laat, 2017)

Insulin resistance is in the centre of the pathophysiology of EMS, with the development of hyperinsulinemia, a consequence of compensated insulin resistance, directly linked to the occurrence of laminitis. (Morgan et al., 2015; Morgan et al., 2016; Warnken et al., 2016; Bertin & Laat, 2017) IR represents the failure of the tissues in responding to the insulin in circulation intended to regulate the blood glucose levels, while hyperinsulinemia is a broader term used to refer to an excessive concentration of circulating insulin, that can either be a compensatory response to IR or a transitory response to other stimulus such as carbohydrate ingestion. (Morgan et al., 2015; Warnken et al., 2016; Bertin & Laat, 2017) Two studies (Asplin et al., 2007; Laat et al., 2010), mentioned by Bertin et al., 2017, have successfully induced laminitis in healthy horses through the administration of exogenous insulin and consequent development of hyperinsulinemia. Therefore, IR and hyperinsulinemia may be a part of two different processes leading to the development of laminitis. (Morgan et al., 2015; Bertin & Laat, 2017) Affected animals show hyperinsulinemia at rest and have an exaggerated hyperinsulinemic response to glucose challenge (IV or ingested). (Frank et al., 2010; Morgan et al., 2015)

Laminitis is a clinical manifestation of EMS and, as mentioned above, a consequence of prolonged hyperinsulinemia. Contrary to other systemic inflammatory disorders such as pasture-derived laminitis, its occurrence is most likely related to vascular impairment, not to inflammation. Several hypothesis as to the occurrence of these impairment occurs have been suggested, with one being the high insulin concentrations that interfere with the capillary tone, which in turn diminishes the blood supply to the hoofs , while other studies have suggested that insulin itself has a detrimental effect in the lamellae. (Morgan et al., 2015) In horses with EMS, laminitis may have a milder way presentation, with the typical divergent growth rings, that indicate hoof growth has been previously disturbed, present in “sound” horses (Frank, 2011), or the horse may be in fact bilaterally lame. (Frank et al., 2010)

A clinical evaluation of specific horses, such as those clinically obese, belonging to any predisposed breed and with symptomatic laminitis can be sufficient for the diagnosis of EMS, although insulin resistance should always be confirmed through the tests available to the practitioner; the main challenge of an early diagnosis of EMS before the onset of clinical manifestations, such as laminitis, persists, therefore a variety of laboratory tests are available for diagnosis of insulin and glucose dysregulation, even though an ideal test is yet to be established. (Frank et al., 2010; Frank, 2011; Morgan et al., 2015; Warnken et al., 2016; Bertin & Laat, 2017) These tests perform quantitative measures of basal insulin concentration in fasted or non-fast horses, blood glucose concentration in fasted horses or increased insulin concentration after oral or IV challenge. (Frank et al., 2010; Warnken et al., 2016). The fasting blood glucose concentration detects any hyperglycaemic state, that may suggest a defective insulin response, but can simultaneously be indicative of any causes non-EMS related, such as stress, feeding, iatrogenic origin or other systemic diseases. (Frank et al., 2010; Frank, 2011; Bertin & Laat, 2017) In turn, the dynamic tests are more sensitive than basal screening tests and allow for the evaluation of the glucose-insulin interaction (Frank et al., 2010; Frank, 2011; Morgan et al., 2015; Bertin & Laat, 2017). The dynamic tests consist in digestible carbohydrates administration in order to provoke an hyperinsulinemic state and evaluate the glycaemic control, but oral administration of either sugar or glucose help determine the postprandial insulin response, including the evaluation of the enteroinsular axis. (R. Morgan et al., 2015)

The oral sugar test is performed after a minimum period of 6-hour fast (Frank et al., 2010), with oral administration of syrups with a high concentration of sugars, as is the case of corn or maple syrup, at a dose of 15mL per 100kg of bodyweight, with 1mL of the syrup providing up to 1g of glucose-based carbohydrates. Blood is drawn 60 to 90 minutes after the administration of the syrup to measure the serum concentration of insulin and/or glucose. A horse is considered insulin-resistant when serum insulin concentration is superior to 60 mIU/mL after 60-90 minutes. (Frank, 2011; Morgan et al., 2015; Bertin & Laat, 2017)

The oral glucose test is an alternative to the oral sugar test, consisting of an oral administration of a glucose/dextrose powder (1g/kg) either with a small amount of feed or through a nasogastric tube. Two hours (120 minutes) postprandially, serum insulin is measured and a concentration >80 µIU/mL (or >85 µIU/mL according to Morgan et al., 2015) can be considered diagnostic to EMS. (Morgan et al., 2015; Bertin & Laat, 2017)

The core of EMS treatment is weight loss managed with mainly diet and exercise plans. In refractory cases or as a short-term intervention, pharmacological management of the syndrome may be helpful. Calorie-restrictive diet and exercise have proved effective in increasing insulin sensitivity. A diet consisting of a reduced calorie intake, with food rich in fibre and poor in non-structural carbohydrates (exclusion of concentrate feed and treats from diet) such as forage, should be instated, amounting to the equivalent to 1,5% of the ideal bodyweight per day. (Frank, 2011; Morgan et al., 2015; Morgan et al., 2016) Strategies for reducing pasture consumption should be implemented, for example, decrease of turnout periods, access to paddocks with sand or small amounts of grass, use of a grazing muzzle. (Frank, 2011) Exercise is an essential tool in reducing body weight and increasing insulin sensitivity and should start as soon as the laminitis symptoms have disappeared, building up to at least 30 minutes of high intensity cardio (trot or canter), at a frequency of four to seven times a week. (Frank, 2011; Morgan et al., 2015; Morgan et al., 2016) Insulin-resistant horses after weight loss sometimes require adjuvant medical therapies, though the unequivocal evidence for the success of any pharmaceutical intervention is still needed. (Frank, 2011; Morgan et al., 2015; Morgan et al., 2016) Metformin is a biguanide known to have anti-hyperglycaemic effects as well as to promote some degree of tissue sensitivity to insulin, in human medicine. This drug inhibits gluconeogenesis and lipogenesis and stimulates lipolysis and oxidation of fatty acids; it may also interfere with small intestine absorption of glucose, which can explain its positive effects at the early stages of laminitis. Although its efficacy is debatable and in need of further analysis, the use of metformin for short-term management of IR is horses is still recommended, especially in cases where diet and exercise alone have showed less promising results. (Frank, 2011; Morgan et al., 2015)

One of the cases followed during the externship was a 3-year-old Shetland pony mare, referred to the hospital with a previous suspicion of EMS (*Table 10*).

Table 10: brief description of the EMS case (3yo Shetland mare) followed at de Lingehoeve

Anamnesis	Doesn't lose weight, has two distinct growth rings on the forefeet, indicative of previous episodes of laminitis (unnoticed by the owner), suspicion of EMS
Clinical evaluation	Weight: 201kg; BCS: 4/5; severe lameness on the hard surface, to both hands
Laboratory testing	Lipemie-index negatief 1) Hemolyse-index negatief 2) Glucose 8.8 3.5 - 5.6 mmol/l + Insuline (CLIA) 50 mU/l + 3) *Glucose: 8.8 (3.5 – 5.6 mmol/L); Insulin: 50 mIU/L (>28mIU/L is the reference for insulin dysregulation in this case)*
Advice/Therapy	Metformin for three months (20mg/kg PO b.i.d.); laminitis-specific shoeing; low-calorie and low-sugar feeding, preferably a hay-only feeding option for the first months; no access to pasture or if impossible to restrict access, use of a grazing muzzle; once laminitis is resolved, start with exercise program

2.2.2.4. Respiratory airways disorders

A total of 10 cases/procedures were conducted at de Lingehoeve through the length of the externship, as demonstrated on *Table 2*. These procedures involved the imaging evaluation of the upper respiratory airways and sinuses through endoscopic techniques, a bronchoalveolar lavage (BAL) and the diagnosis and follow-up of lower respiratory tract diseases such as Equine Asthma (*Table 11*).

Table 11: Distribution of respiratory tract-related procedures (n =10)

Procedure	Fi
BAL	1
Sinoscopy	4
Rhinoscopy	2
Bronchoscopy	2
CT	1
Total	**10**

The term "Equine asthma" is now the suggested to refer to both Inflammatory Airway Disease (IAD) – mild to moderate equine asthma -and Recurrent Airway Obstruction (RAO) – severe equine asthma. Horse with severe equine asthma present no evidence of respiratory infection, but the clinical presentation represents a chronic lung inflammatory disease, with chronic cough, mucus presence, nasal discharge, dyspnoea and poor performance, which occur after the horse is exposed to airborne antigens or other organic particles present in dust. (Laan et al., 2006; Bedenice et al., 2008; Barton & Gehlen, 2016; Tessier et al., 2017; Bond et al., 2018; Couetil et al., 2020) Severe equine asthma is the most common lower airway in horses, particularly warmbloods, with age and stabling playing a critical role in the incidence and severity of the condition, and it is likely that genetic predisposition plays a role in its development. Thus, severe equine asthma can be a reason for the end of the career of the sport horse. (Barton & Gehlen, 2016; Tessier et al., 2017; Couetil et al., 2020)

The horse's pedigree, the feed management and the weather, together with the allergen count, at the time of the appearance of clinical signs should therefore be considered risk factors for the development of equine asthma. (Couetil et al., 2020)

Severe equine asthma is characterized by neutrophilic bronchiolitis that associates with nasal discharge, bronchoconstriction, excessive production of mucous and airway remodelling and wall thickening. (Laan et al., 2006; Tessier et al., 2017; Bond et al., 2018; Couetil et al., 2020) Clinical history is key to reach the diagnosis, especially when reversible respiratory impairment episodes occur, after exposure to known triggers. (Couetil et al., 2020) Several recurrent episodes of airway inflammation lead to smooth muscle hyperplasia, with its increase proportional to severity of the disease (Bullone et al., 2017), and airway remodelling, that once present render the disease irreversible, although periods of remission may occur over time. (Bullone et al., 2017; Tessier et al., 2017)

On thoracic auscultation, the animal may exhibit increased breathing sounds, with abnormal sounds – wheezes, crackles - present in more severe forms of equine asthma. (Couetil et al., 2020)

The endoscopy is very useful for upper and lower airway examination, allowing to assess the severity of the inflammation and the presence of associated lesions. (Koblinger et al., 2011; Couetil et al., 2020) Koblinger et al., 2011, have shown that there is a strong correlation between the presence of tracheal and bronchial mucus and the percentage of neutrophils in the BAL fluid, reinforcing its value as a mean of diagnosis. The endoscopic material can also be used to perform the BAL and collect the BAL fluid, to further confirm the diagnosis.

Contrary to human medicine, cytological and microbiological evaluation of BAL fluid (and tracheal washes) is now considered a gold-standard for the diagnosis of lower respiratory tract diseases in horses, together with the clinical and functional examinations, namely of equine asthma, be it IAD or RAO. (Barton & Gehlen, 2016; Couetil et al., 2020) The presence of neutrophilia in the collected fluid is a primary indicator of inflammation in severe equine asthma, being the result of neutrophilic migration to the airway lumen, which leads to the obstruction of the airways in a late phase. Neutrophils have a key role in the host defences, acting as an early responder to external insults, after macrophage activation. (Laan et al., 2006; Barton & Gehlen, 2016; Couetil et al., 2020) Controversially, horses with acute sign of severe equine asthma may have a low neutrophil percentage in BAL fluid. It is theorized that this occurrence is due to the excessive mucus that accumulates in the small airways, sequestering the neutrophils, thus preventing their detection in BAL fluid and tracheal washes. (Barton & Gehlen, 2016; Couetil et al., 2020) The neutrophil apoptosis at the right time is vital to the resolution of the inflammatory process, since the self-induced spherocytosis will trigger the macrophages to change from a pro-inflammatory to an anti-inflammatory profile. (Couetil et al., 2020) This makes the macrophages, in association with the neutrophils, the primary effector cells of the innate immune system, representing the first barrier of defence on the surface of the lungs. The inflammatory response developed by these cells will later set the development of an adaptative immune response. (Laan et al., 2006)

The clinical signs of severe equine asthma, particularly the dyspnoea, will show significant and rapid improvement after the administration of bronchodilators, which in association with anti-inflammatory treatment, will help with disease control. (Bullone et al., 2017; Tessier et al., 2017; Couetil et al., 2020) However, if the environmental factors are not addressed, this improvement of the clinical signs will not persist for long, reinforcing the importance of environmental management for the control of this chronic disease. (Couetil et al., 2020) It is not yet fully understood the anti-remodelling effects of the asthma treatments currently employed, but Bullone et al., 2017, studied the effects of fluticasone and/or salmeterol in the reversibility of airway smooth muscle (ASM) and extracellular matrix (ECM) remodelling in an equine model, concluding that the reversal of ASM remodelling is particularly influenced by the mechanisms mediated by corticosteroids and the inhibition of bronchospasms led to a reduction of bronchial extracellular matrix components.

The BAL performed during the externship was part of the diagnostic route performed to confirm a suspected case of severe equine asthma. The horse was a 11-year-old Arabian gelding, presenting at the hospital with complaints of intermittent cough and nasal discharge for almost a year.

Table 12: Examination findings of the 11yo gelding, presented for consult in 04/01/2021

Anamnesis	Nasal discharge – unilateral, but sometimes bilateral; ±1 year duration
	Cough – intermittent and worsens with exercise
	Stays indoors, with shavings bedding and eats hay
Clinical findings	Auscultation normal, no nasal discharge present
Imaging findings	White mucus in the trachea, normal sinus openings
Further procedures	BAL

The anamnesis of the horse, in association with the clinical and imaging findings of the airways (*Table 12*), supported the initial suspicion of equine asthma, therefore a BAL was performed, and the BAL fluid sent to the University of Utrecht for analysis. The results of the BAL fluid analysis can be observed in *Fig. 3*.

Universiteitskliniek voor Paarden

Yalelaan 112
3508 TD Utrecht
Tel 030-2531111

Universiteit Utrecht

Uitslagformulier Broncho-Alveolaire spoeling (BAL) Extern

Naam Eigenaar	Van Steenis	
Naam Paard	Forelocks-Verary	
Naam Dierenartsenpraktijk	Lingehoeve	
Laboratoriumnummer preparaat	C309901	
Datum beoordeling	6 januari 2020	
Datum bericht aan inzendend dierenarts	6 januari 2020	
Beoordelend dierenarts	Cornélie Westermann	Referentie-bereik
Kwaliteit preparaat	Goed	
Macrofagen	31%, actief (gevacuoliseerd), ook redelijk veel meerkernigen en reuscellen	30-60%
Lymfocyten	43% lymfocyten	30-70%
Segmentkernige granulocyten	24%	< 5%
Mastcellen	2%	< 2%
Eosinofiele granulocyten	0%	< 2%
Opmerkingen	Beeld van severe equine asthma	

Figure 3: Fluid analysis results, performed at the University of Utrecht, regarding the BAL performed on the 11yo gelding

According to the report, the findings of the cytological analysis on the BAL fluid match those of severe equine asthma patients, with a percentage distribution of 31% of active macrophages, 43% of lymphocytes, 24% of segmented granulocytes and 2% of mast cells. Considering this report, along with the clinical findings, a combination of anti-inflammatory (Prednisolone 450mg PO s.i.d., for 10 days, then 300mg PO s.i.d. for 10 days, then 300mg PO every other day, for 10 days) and bronchodilator (Clenbuterol 15mL (375mg) PO b.i.d., for 10 days, then stop for 10 days and then repeat again for 10 days) therapies was recommended for the medical management of this case. Simultaneously, environmental changes were suggested, such as a better quality of shavings (with less dust) for the bedding, testing of the hay for spores and moulds commonly known as triggers, wetting the hay before feeding it and, because the permanence in a paddock or pasture was not possible, a more frequent turnout during the day was suggested. The horse was better after two months and the owner advised to restart with the prednisolone scheme if there was a relapse.

2.2.2.5. Ophthalmology

The two ophthalmologic cases observed by the extern, at De Lingehoeve, are listed on *Table 13*.

Table 13: Distribution of the ophthalmology cases observed, and the therapeutics instated for each of the cases (n=2)

Diagnosis	Fi	Intervention/Treatment
Melting ulcer	1	Surgical debridement & Atropine + Serum + Gentamycin protocol
Squamous cell carcinoma (SCC) of the nictitating membrane	1	Enucleation
Total	2	_

Keratomalacia, more commonly known as corneal melting or melting corneal ulcer, is a condition provoked by an imbalance of tissue maintenance processes of the diseased cornea, result of an exaggerated proteolytic activity that leads to liquefactive necrosis of the stroma with loss of keratocytes and progressive ulceration. (Ollivier et al., 2003; Brooks, 2004; Guyonnet et al., 2020) Depending on the severity, this condition can lead to visual impairment and even loss of the eye. (Greenberg, 2019; Guyonnet et al., 2020)

Matrix metalloproteinases (MMPs) and serine proteinases play a key role in the turnover and remodelling of the healthy stromal extracellular matrix, with their activity normally balanced by proteinase inhibitors present in the cornea and the precorneal tear film. (Ollivier et al., 2003, 2007; Brooks, 2004; Matthews, 2009; Greenberg, 2019; Guyonnet et al., 2020) When there is a corneal injury, the imbalance between proteases and protease inhibitors, in favour of proteases, leads to the pathological degradation of the stroma collagen and proteoglycans. (Ollivier et al., 2003; Brooks, 2004; Ollivier et al., 2007; Matthews, 2009; Greenberg, 2019; Guyonnet et al., 2020) This event is known to be secondary to bacterial and/or fungal infection but can also occur in sterile corneal ulceration processes. (Matthews, 2009; Greenberg, 2019; Guyonnet et al., 2020) Microorganisms produce exogenous proteases, and inflammatory cells, epithelial cells of the cornea and fibroblasts are responsible for producing and releasing endogenous proteases, all of which will star the degradative process of the cornea surface. (Ollivier et al., 2003, 2007; Greenberg, 2019; Guyonnet et al., 2020)

Two MMPs – MMP-2 and MMP-9 – are of key importance in the processes of remodelling and degradation of the stromal collagen (Ollivier et al., 2003; Brooks, 2004; Ollivier et al., 2007), even though their origin and purpose differ at corneal level. MMP-2 is synthesized by keratocytes, and its function is to monitor the healthy cornea, and is locally activated whenever damaged collagen molecules are detected; MMP-9 is produced by epithelial cells and polymorphonucleated neutrophils in response to corneal injury. (Ollivier et al., 2003, 2007) The close contact between the cornea and the preocular tear film, makes the proteolytic activity in the tear film considerably increased in eyes with ulcerated corneas.(Brooks, 2004; Ollivier et al., 2007) In simple ulcer processes, the proteolytic activity in the preocular tear film is initially high but decreases as the healing process progresses, whereas in melting ulcers, the protease levels remain raised, contributing to the rapid progression of the ulcer. (Ollivier et al., 2007)

The diagnostic process of a melting ulcer begins with the clinical assessment of the affected eye – evaluation of the corneal ulcer in terms of severity and the existence or absence of malacia (abnormal softening of the tissue), assessment of sight and presence of uveitis, attempt to pinpoint a cause for the development of such condition, with anamnesis and close examination of the corneal surface (presence of foreign body), and evaluation for the presence of infection. A thorough ophthalmic examination, with the help of a light source (direct ophthalmoscope or slit lamp), should be performed. The reflexes should also be evaluated as an indicator of the potential vision impairment. (Greenberg, 2019) The appearance of the melting ulcer is usually associated with the main source of the proteinases. If originated from the epithelial cells or stromal keratocytes, the ulcer will present as clinically clear, and the progression of the ulceration will be slow. If, on the other hand, there is a major PMN cell infiltration, normally associated with infection, the ulcer will be more severe, and the cornea will have an opaque white appearance; some areas of the stroma may even melt away, if PMN cells reach the stripped stromal layer. (Brooks, 2004)

Medical management of this corneal disease is often enough, given an early diagnosis and appropriate treatment. (Ollivier et al., 2003; Greenberg, 2019) Understanding the pathophysiological processes that lead to the development and consequent aggravation of this condition is key in the success of treatments instated, with the main objective of the therapy being the normalization of the protease-protease inhibitors balance by regularizing the proteolytic activity in the tear film; based on this premise, protease inhibitors have been used as the primary topical therapy in ulceration cases, specially to control the stromal breakdown. (Ollivier et al., 2003; Brooks, 2004; Ollivier et al., 2007; Matthews, 2009; Guyonnet et al., 2020) Protease inhibitors should be applied topically in the affected eye at least every two hours until the healing process is clearly advanced, with reduction of pain, and a contracted or static ulcer with smooth epithelium margins; the treatment frequency can be then reduced to four to six times a day. (Ollivier et al., 2007; Greenberg, 2019) Protease inhibitors used for this effect include ethylene-diamine-tetracetic acid (EDTA), N-acetylcysteine (NAC), doxycycline (or oxytetracycline), ilomostat (a thiol agent) and autologous equine serum. (Brooks, 2004; Ollivier et al., 2003, 2007; Greenberg, 2019) According to the study by Ollivier et al., 2003, EDTA reduced proteolytic activity in tear film by 99,4%, whereas ilomostat reduced it by 98,9%, NAC by 98,9%, doxycycline by 96,3% and the equine serum by 90,0%. A combination of these different protease inhibitors may be beneficial, because of their different mechanisms of action. (Ollivier et al., 2007) Because the autologous serum inhibits both MMPs and serine proteases, it is often the component of choice, but can be used in combination with the other components mentioned that are zinc and calcium chelates – EDTA and tetracyclines. (Greenberg, 2019)

Topical antibacterial therapy is also an important component of the treatment of keratomalacia. The choice of antibiotics is empirical is most cases, based on the likely pathogen, the drugs available at the time and the severity of the condition, even though an antibiogram would be the ideal approach for a successful solution. (Brooks, 2004; Ollivier et al., 2007; Guyonnet et al., 2020) Initially, the chosen antibiotics should be of broad-spectrum and, if the epithelial barrier is absent, a preference for hydrophilic antibiotics like the aminoglycosides and the β−lactam penicillins/cephalosporins should be given, considering these will reach higher concentrations at stromal level quicker; a maintenance of higher concentrations of these antibiotics in the stroma usually eliminates most bacterial and fungal populations after two to three days of continuous administration. (Brooks, 2004; Matthews, 2009) The antibiotics may be used alone or in combination, depending on the infection-causing agents. (Brooks, 2004)

When secondary anterior uveitis is present, medical management also includes the use of topical atropine, in order to induce cycloplegia, help with pain control and stabilize the blood-aqueous barrier, and systemic administration of nonsteroidal anti-inflammatory drugs to help with discomfort and inflammation (Brooks, 2004; Greenberg, 2019; Guyonnet et al., 2020) If, despite adequate medical therapy, the condition progresses or if corneal perforation is detected at the moment of presentation, surgical intervention may be warranted. (Guyonnet et al., 2020)

To better comply with the treatment plan, especially given the high frequency of application of the topical medication above mentioned, the veterinarians may opt for the placement of a sub-palpebral lavage system; a protective mask may be also used to prevent self-trauma and aggravation of the condition. (Matthews, 2009; Greenberg, 2019)

The approach to the melting ulcer case followed at de Lingehoeve is now briefly presented. A 3-year-old KWPN gelding presented at the hospital with a severe melting ulcer on the right eye, already with corneal perforation. Together with the owner, it was agreed that immediate surgical intervention would give the better odds of success. A superficial keratectomy was performed together with a conjunctival flap (bridge flap) to cover the defect, an eye-lavage system was placed and the eye was closed with a temporary tarsorrhaphy, to protect the eye and help secure the lavage system. The animal was hospitalized for better monitoring of the evolution.

A medical treatment protocol was established, comprising topical antibiotic (gentamycin – Soligental), atropine and autologous serum administration, and systemic NSAIDs (phenylbutazone – Butagran equi). Apart from atropine, which was only applied one time a day, the topical medication was applied every two hours, and EDTA diluted in sterilized saline was used before and in between application of each component through the lavage system; Phenylbutazone was administered twice daily on the first day, at a dosage of 4,4mg/kg per occasion, then changed to a dosage of 2,2mg/kg per occasion from second to third day. After three days, the tarsorrhaphy sutures were removed and a re-evaluation of the corneal surface and ulcer area was performed. The sub-palpebral lavage system was changed, and the topical treatment protocol was adapted to a frequency of every four hours, in a total five applications a day (from 8h00m to 00h00m); the phenylbutazone treatment was discontinued. This time, the eye was left open, as the injury was healing successfully, with the borders having a smoother appearance, and the animal showing increased tolerance for treatment (which was interpreted as reduction of pain).

2.2.2.6. Neonatology

Considering the externship at de Lingehoeve took place before the season had officially started in the Netherlands, a single case of a critical new-born foal was followed at this facility (*Table 2*). In Paardenkliniek Venlo, one neonate foal requiring intensive care was presented to the clinic (*Table 4*). Both these cases were diagnosed as Neonatal Maladjustment Syndrome.

Neonatal maladjustment syndrome (NMS) is one of the most common disorders affecting new-born foals. (Floyd, 2020) Neonatal encephalopathy or, more commonly, dummy foal syndrome, are other terms used to refer to a collection of neurological symptoms that occur to some new-born foals immediately after the postpartum. (Toribio, 2019) In 1972, Rossdale defined NMS as a condition resulting of disturbed stability of the adaptation processes of the cardiovascular and nervous systems, a description still accurate to this day. Previously, all non-infeccious conditions of new-born foals with neurological symptoms were considered to be part of the same syndrome, with no regard for the pathophysiological components that lead to each of the diseases, using terms like hypoxic ischemic encephalopathy, hypoxic ischaemic syndrome and perinatal asphyxia syndrome (PAS) to describe the condition. (Rossdale, 1972; Carr, 2014; Toribio, 2019) It is, however, known that this syndrome also occurs is foals that have not experienced any hypoxic event, having an array of possible causes, not all related to hypoxic–ischaemic injuries. (Toribio, 2019; Floyd, 2020)

As mentioned, NMS has been previously attributed to hypoxic-ischaemic injury at foaling, mainly because the condition is often observed in foals that have had an abnormal delivery, like dystocia or a red-bag delivery. The hypoxia triggers a series of events that will lead to cell death, with neurological, urinary and gastrointestinal systems being the most affected. (Carr, 2014; Toribio, 2019; Floyd, 2020) Still, metabolic and endocrine disturbances, and more recently disequilibrium in neuroactive steroids, may also be the cause for EMS development. (Toribio, 2019; Floyd, 2020)

Neurosteroids have a stress-relieving action during pregnancy and counterbalance the excess of glucocorticoids on foetal brain programming. (Toribio, 2019) In dummy foals, the progestogen concentration stays high after foaling, contributing to the neurological symptoms commonly observed, because in addition to the interference with the protective neurosteroids, the increased progestogen concentrations act as a neuroprotective mechanism after ischaemic episodes. (Toribio, 2019; Floyd, 2020)

Risk factors for the NMS can be of maternal (systemic inflammation and/or infection processes, ischaemia/hypoxia episodes), foetal (congenital anomalies, twin pregnancy, dysmaturity/prematurity, sepsis, dystocia, umbilical cord torsion/compression) or placental (placentitis, premature placental separation) nature. (Toribio, 2019)

The clinical manifestation of NMS can occur from zero to 72 hours after birth, with the neurological signs representing the most frequently observed. (Floyd, 2020) The foal may appear to be dysmature, exhibiting the characteristics of a premature foal (small stature, silky coat, floppy ears, dropped lip, tendon laxity, incomplete joint ossification) although being born to term (>320 days) (Rossdale, 1972; Carr, 2014), show disorientation, lack of affinity to the mother, poor suckle reflex (or lack of), ataxia, apparent blindness, head-pressing, abnormal respiratory pattern and expiratory noises (hence the other term used to refer to these foals – barkers), hypothermia, dehydration, increased muscle tone, tremors and even seizures. (Rossdale, 1972; Toribio, 2019; Floyd, 2020) Because various systems are involved, gastrointestinal (meconium retention colic, enteritis, diarrhoea, ileus, nasogastric reflux), renal (oliguria or anuria, oedema secondary to fluid retention), pulmonary (secondary bacterial pneumonia to pharyngeal dysfunction and milk aspiration, apnoea) cardiac (dysrhythmia) and hepatic signs can be detected. (Rossdale, 1972; Toribio, 2019; Floyd, 2020) Secondary sepsis, due to failure of passive immunity transfer, is a frequent consequence that will aggravate the signs previously mentioned. (Rossdale, 1972; Toribio, 2019)

Laboratory findings in foals with NMS include hypoxaemia, acidaemia, hyperlactataemia, azotaemia, hypoglycaemia, haemoconcentration (Rossdale, 1972; Toribio, 2019), but the majority is secondary to the onsetting of a systemic disease, like sepsis or shock (Toribio, 2019), making the core of the diagnosis of NMS the history and clinical presentation, and the exclusion of infeccious and congenital diseases. (Rossdale, 1972; Toribio, 2019)

Survival rates on foals with NMS vary with the severity of symptoms and with the development of secondary complications, but with early and appropriate supportive care there is a higher chance of survival. (Toribio, 2019; Floyd, 2020) Treatment relies mostly on hydration, nutrition, prevention of secondary conditions such as sepsis, encouraging maternal bonding and control and relief of neurological signs. If failure of passive immunity transfer is proved, plasma administration is necessary to raise the foal's odds of surviving. Tissue perfusion through intravenous fluid therapy of a low-sodium fluid is usually beneficial. The foal's temperature should be closely monitored and, normothermia can be achieved and maintained with the help of heating lamps, hot water bags and heated fluid therapy. Nutritional support consists in enteral feeding, most often through a nasogastric tube placement, seeing as these foals normally have a poor suckle reflex and bottle-feed them or trying to nurse from the mare may lead to aspiration pneumonia; it is important to check for milk reflux before every feed. Broad-spectrum antimicrobial therapy should be instated as soon as suspicion of infection arises or if the foal is at a high risk for sepsis. Foals that are recumbent or apparently close to a comatose state may need respiratory support, with administration of intranasal oxygen, and frequent sternal positioning. If meconium retention is suspected, an enema could be performed. (Rossdale, 1972; Toribio, 2019; Floyd, 2020)

The aforementioned cases were hospitalized and received nursing care as described above. The first foal (Frisian, Fig. 4) presented to the hospital one day after birth, with signs of dysmaturity – was born to term, but had silky coat, floppy ears, slightly cyanotic oral mucosa, sunken eyes, dropped lip, protruded tongue, tendon laxity -, and neurological compromise – apparent blindness, ataxic movements, occasional tremors, lack of suckle reflex, mostly recumbent and pedalling when laying down. His body temperature was 37,1ºC, his heart rate was 56bpm, arrhythmic, his breathing rate 52bpm, with expiratory noises and abnormal pattern, poor reflexes, and couldn't stand on its feet for long. Because of the severity of the signs, the animal was hospitalized with its mother and an over-the-wire catheter was immediately placed – the foal had a positive passive immunity transfer test, so there was no need for plasma infusion; fluid therapy was initiated to correct the dehydration and maintain an open vascular access. Prophylactic broad-spectrum antimicrobial therapy (amikacin and penicillin) was also started.

Figure 4: new-born frisian foal, presented to the clinic with signs of NMS, such as floppy ears, silky coat, sunken eyes, dropped and cyanotic lip and tendon laxity, recumbent position and difficulty laying sternal

The nursing care for this foal had budget impediments, translating in less-than-optimal monitoring of the blood gasometry, biochemical, and hemogram changes. At the moment of hospitalization, the blood analysis revealed that a septic process had already started and, although palliative support was given, after six hours the clinical signs aggravated – the foal was comatose, had several seizures, had a body temperature of 36,3ºC (with heat lamps and heated fluids), milk reflux on the nasogastric tube, and is lactate was 11,2 mmol/L (opposed to 4,5mmol/L at the moment of admission). The owners were informed of the foal's negative evolution and, taking in consideration the cost of maintaining an animal with a low chance of survival, they chose to stop with the foal's treatment and opted for euthanasia.

2.2.2.7. Prophylaxis & Infectious diseases

The prophylactic procedures included in this area were performed in its entirety at the Paardenkliniek Venlo (*Table 14*), and included vaccinations, coprological exams with subsequent deworming, filling out of Féderation Équestre Internationale (FEI) passports, blood collection for exportation and nasopharyngeal swabs for Equine Herpesvirus (EHV) detection, making up a total of 367 cases/procedures.

Table 14: Distribution of prophylactic procedures in Paardenkliniek Venlo (Fr %; n = 378). EHV – Equine Herpesvirus, Te – Tetanus

Prophylaxis & Infeccious diseases	Fi	Fr (%)
Vaccinations	297	78,5
- *Strangles (S. equi equi)*	*85*	*22,5*
- *EHV*	*202*	*53,4*
- *Influenza + Te*	*10*	*2,6*
Streptococcus equi equi infection	7	1,9
Coprology exams	4	1,1
Pre-export blood analysis	8	2,1
FEI Passports	2	0,5
Genital swabs	3	0,8
EHV-1 swabs	53	14
Abortion/pregnancy emergency	4	1,1
Total	**378**	**100**

Equine influenza is an infectious disease, highly contagious (particularly to immunologically naïve animals), provoked by the equine influenza virus (H7N7 and H3N8 subtypes) from the Orthomyxoviridae family, associated with moderate to high morbidity, and is considered one of the most important respiratory diseases in the equine industry. Even seemingly asymptomatic animals can excrete viral particles, when inadequately vaccinated, and are frequently responsible of major outbreaks. Influenza outbreaks have been causing severe economic setbacks in the horse industry and competitions through the last decades, making it one of the main targeted diseases in vaccination programmes around the world. (Heldens et al., 2010; Wilson et al., 2010; Cullinane et al., 2020) The international spread of this disease is often a consequence of movement of horses from endemic countries, making the establishment of an international standardized vaccination program a key step in the control of this disease. For this purpose, the Office International des Epizooties (OIE) together with FEI and the International Federation for Horseracing Authorities (IFHA) established a science-supported foundation for the ideal time period for vaccination against equine influenza, to be applied to animals before shipment, in order to minimize the risks of transmission in competitions. This led to a normalized vaccination protocol that is currently enforced worldwide, especially in European, American and Oceanian continents, where vaccination against influenza virus is mandatory for all entering equids. (Cullinane et al., 2020) In Europe, for foals born from vaccinated mares, the conventional times for primary vaccination in foals consist of two vaccines applied in a 4 – 6 weeks interval, followed by a booster vaccination after approximately 6 months. The immunity after the third vaccine is then maintained by annual revaccination. FEI, however, suggests vaccinating the horses every six months. (Heldens et al., 2010) It is routine to vaccinate the mares in the last two months of gestation, in order to protect the mares during the peripartum and ensure passive immunity transfer through colostrum. It is known that maternal antibodies interfere with the response of foals to vaccination, justifying the different periods suggested for vaccination between foals from vaccinated/nonvaccinated mares. (Wilson et al., 2010) The study performed by Wilson et al., 2010, demonstrated that the maternally induced antibodies for both influenza and tetanus remained detectable in foals until the age of 6 months, supporting the claim of their interference with the vaccination of foals from vaccinated mares. The study also showed that foals from vaccinated mares did not develop a sufficient response to primary vaccination. In contrast, for immunologically naïve foals, primary vaccination should start at three months of age.

Despite the vaccination against equine influenza being currently mandatory for all competing horses, the recommendations as for booster vaccinations before exportation or competition are still disparate between the OIE, FEI and IFHA. While OIE recommends immunization 90 to 21 days prior to shipment, IFHA suggests a booster vaccination 60 to 14 days before export, and FEI demands all horses participating in their events to be immunized within six months (180 days) and 21 days before arriving at the event's premises, but never the seven days prior to arrival. According to the study by Cullinane et al., 2020, which intended to provide a scientific background for the different intervals mentioned before, concluded that, of all the time intervals recommended, vaccination 14 days prior to shipment allowed sufficient time for all the horses to seroconvert, especially when recombinant vaccines are in use (they have a late antibody response, when compared to subunit or inactivated vaccines), which should be preferred as their antibody response allows for distinction of infected from vaccinated animals; there was no significant benefit between the 21 or 14-day wait. Furthermore, they also suggest that for animals older that four years, or having received four or more doses of the vaccine, a booster vaccination 90 or 60 days prior to shipment brings little to no benefit in antibody levels, when compared to animals with a boost vaccination 180 days prior to shipment. Meanwhile, for younger animals (< 4-years-old) it is beneficial to require a boost closer to shipment, at 90 days prior to export, rather than at 180 days.

The vaccine currently used in the Netherlands is the Equilis Prequenza Te, a vaccine that protects from both influenza and tetanus infection, being able to protect against clinical disease and viral excretion after the primary vaccination schedule, until the revaccination date. Regarding tetanus, this vaccine induces an immunity duration of 24 months, being therefore suggested that an alternation between Prequenza and Prequenza Te should be adopted after the first three Prequenza Te vaccines. (Heldens et al., 2010)

The procedures related to suspected/confirmed infeccious diseases followed by the extern at both the facilities are listed in the table below (*Table 15*):

Table 15: Distribution of infeccious diseases cases presented during the externships by causing agent (Fi; n = 62)

Infeccious agent	Fi
Streptococcus equi equi	5
Equine Herpesvirus (suspected + quarantine)	54
Clostridium tetani	1
Rhodococcus equi	1
Multiresistant Pseudomonas aeruginosa	1
Total	**62**

Tetanus is a worldwide-occurring neurological disease, often fatal, caused by *Clostridium tetani* infection, specifically by the three exotoxins it produces and releases into the host – tetanospasmin (neurotoxin), tetanolysin (haemolysin) and a non-spasmogenic toxin –, with the equid species particularly susceptible to the disease. With *Clostridium tetani* being a ubiquitous microorganism, and its spores highly resistant in the environment, persistent in the soil for years, tetanus is relatively common in non-immunized animals; it is also an impending threat for humans, especially in developing countries. The bacterium is strictly-anaerobe and commensal of the gastrointestinal tract – it is under anaerobic condition that it sporulates and produces the exotoxins, establishing the disease. (Kay & Knottenbelt, 2007; Popoff, 2020)

The microorganism usually infects the host via wounds, but surgical wounds retained foetal membranes in mares and umbilical cord of neonates may also play part as an entry way. The produced toxins are released after sporulation and reach the central nervous system (CNS), namely the spinal cord, through blood or are directly transmitted from peripheral nerves. The clinical onset of the disease starts when the tetanospasmin binds (irreversibly) with the receptors present in the CNS, blocking the neurotransmitter release in the nerve terminals. Tetanolysin will facilitate tissue colonization and further promote the necrotic development of the tissues at the infection site, while the non-spasmogenic toxin is associated with impairing the signal transmission in neuromuscular junctions. These effects will provoke spastic paralysis – uncontrolled muscle spasms and contractions, hypersensitization and hyperesthesia and ultimately convulsions, characteristic of this disease. The disease will often lead to cardiorespiratory arrest and death. (Kay & Knottenbelt, 2007; Popoff, 2020)

Clinical signs of tetanus consist of erratic muscle contractions that ultimately lead to tonic, involuntary, prolonged muscular contractions and tetanic spasms. When spastic paralysis is detected, its characteristic presentation, together with the suspicion or history of a wound, is enough to make an presumptive diagnosis. Only at early stages can tetanus be misdiagnosed or confused with myopathies and other diseases affecting the neuromuscular system. (Popoff, 2020) This condition has two possible manifestations, systemic/generalized and localized, with the systemic process affecting the mastication muscles at first, progressing then to the muscles of the trunk and limbs. The consequential trismus will hinder the opening of the mouth and thus the feeding ability of the animal. At a late state, the extensor muscles of the neck and back will suffer from spastic paralysis, leading the animal to adopt an opisthotonic position, with the limbs permanently stiff and raised tail ("wooden horse"). Ultimately, respiratory impairment is prominent, caused by the spastic paralysis of the diaphragm, laryngeal muscles and any other respiratory muscles, which will likely lead to the horse's death. If tetanus develops in an acute form, the spastic paralysis is quickly established, followed by convulsions and sweating; in one to two days, death can occur. However, if it sets in a subacute form, the clinical signs can develop over a course of 1 to 3 weeks. In this case, the chance of recovery is higher. Commonly identified as early signs are hyperesthesia and prolapse of the third eyelid, along with difficulty in swallowing and eating. The animals carry an anxious and pained expression, with tachypnoeic and painful breathing. While death is still the likely outcome, voluntary eating and drinking are regarded as good indicators of survival. (Popoff, 2020)

There is no method of producing a definitive diagnosis for tetanus, either *ante* or *post-mortem*, with the findings not being pathognomonic for the condition; not even the presence of C. tetani at a wound site would be a strong enough indicator for its diagnosis. (Kay & Knottenbelt, 2007; Popoff, 2020)

A few treatment options are often instated when suspicion of tetanus infection arises. The treatment is usually focused on the elimination of the agent as well as neutralization of the exotoxin produced and stopping the progression of the clinical signs. Together with an intensive supporting nursing care aimed at pain relief, nutrition and hydration status, and muscle relaxation, the treatment will delay the spread of the toxin to the respiratory muscles while allowing the animal to recover, hence avoiding the fatal outcome. (Kay & Knottenbelt, 2007; Popoff, 2020)

Whenever a wound is detected, especially an infected one that might have been the entry way for the agent to enter the host, the cleaning and debridement are essential – allowing oxygenation of the wounded tissues will eliminate the anaerobe environment necessary for the bacterial sporulation. Systemic antimicrobials like penicillin and metronidazole are usually the treatment of choice (although inefficient against the toxins and disease, they kill the vegetative form of the clostridium species). The usage of high doses of anti-tetanic serum (TeNT immunoglobulin) is recommended every time tetanus infection is suspected, since it neutralizes the circulating unbound exotoxins preventing its binding to more gangliosides and effectively stopping the progression of the clinical signs. The affected animals should be put in a stimuli-free room (dark, quiet, cotton buds in the ears, cushioned when possible), the hydration and nutrition should be maintained, even if parenteral measures are necessary, and in some cases urinary catheterization and assisted faecal evacuation need to be performed, in order to prevent secondary disorders. (Kay & Knottenbelt, 2007; Popoff, 2020)

The prevention of this disease depends mainly on the enforcement of the vaccination protocol, like the one mentioned above, since elimination of a ubiquitous pathogen from the environment is virtually impossible.

The observed tetanus infection was of a six-month old foal, presented at the clinic with severe signs of tetanus, particularly impaired breathing, tachypnoea, stiffened limbs and tail, tremors, protruded nictitating membrane, trismus and hypersensitivity to stimuli. The foal had a previous diagnosis of a *Streptococcus equi equi* (*S. equi*) infection (ongoing), and the owner interpreted the clinical signs as a relapse. The clinical signs along with an history of a limb wound that closed without any specific treatment and no vaccination was sufficient for a presumptive diagnosis of tetanus. The foal was immediately put in a box that allowed the elimination of stimuli (mostly light and sound) and given anti-tetanic serum in high levels. The floor of the box was padded to avoid further injuries. Because trismus was present and normal feeding was not possible, a watered feed was given; the animal was still capable of spontaneous drinking. Penicillin was also administered, along with diazepam to achieve muscle relaxation. Defecation and urination were visibly impaired but not impossible, therefore urinary catheterization and manual rectal evacuation were postponed. The breathing was laboured and did not improve with the diazepam administration, the foal had a purulent nasal discharge and, on auscultation, regional crackles and rhonchi were detected – these signs could be attributed to the *S. equi* infection previously diagnosed and, although unrelated to tetanus, were seen as aggravating circumstances to the prognosis. Despite minor improvements regarding the animal's posture (less rigid) and voluntary nutrition and no further clinical signs detected, the breathing did not improve, being already under great distress by the Streptococcus infection, which ultimately led to the foal's death after less than 24 hours of hospitalization.

2.2.3. Dentistry

A total of 12 dentistry cases were followed at De Lingehoeve, detailed in the table below (table 16). Apart from routine consults, the most observed cases related to older horses with various stages of progression of Equine Odontoclastic Tooth Reabsorption and Hypercementosis (EOTRH).

Table 16: caseload of odontology cases (Fi; n = 12)

Motive	Fi
Routine check-up/rasping	6
Tooth fracture	2
EOTRH	3
Tooth extraction – follow-up	1
Total	**12**

EOTRH is a severe and painful syndrome that affects mostly the incisors and canine teeth of older horses, mostly above 14 years of age, with the breed apparently a predisposing factor (thoroughbreds and warmbloods are at a higher risk of developing the condition), and it was firstly described by Staszyk, in 2008. (Pearson et al., 2013; Lorello et al., 2016; Rehrl et al., 2018; Pearce, 2020)

It was firstly proposed that EOTRH was secondary to periodontal disease, but it is now believed that, despite its presence constituting a risk factor for the development of this syndrome, EOTRH is equally likely to be influenced by continuous excessive dentistry. (Staszyk et al., 2008; Pearson et al., 2013) The mechanical forces acting on the dental-periodontal interface, which remain unaffected by the horse's age whereas the reserve crown considerably diminishes (consequence of wear), will overstress the periodontal ligaments - this can be considered the provocative event that triggers the processes that initiate the EOTRH syndrome. (Staszyk et al., 2008; Pearson et al., 2013; Lorello et al., 2016) The alterations in the reserve crowns and in the angulations of the incisor teeth of older horses, together with the enlarged interproximal spaces, contribute to explain the development of this syndrome in animals over 14 years of age. (Staszyk et al., 2008; Pearson et al., 2013). The tooth age contributes to the aetiology, and because the 03s are subjected to greater biomechanical forces, due to the lack of buttress on the caudal aspect provided by adjoining teeth when compared to the 01s and 02s, it makes them the most affected by this syndrome. When canine teeth are also affected, other localized or systemic disorders may contribute and trigger the onset of this disease. (Lorello et al., 2016; Rehrl et al., 2018)

The intra-alveolar aspect of the teeth and adjoining periodontium are the most affected in this syndrome, with the initial inflammation of the periodontium representing the initial lesion that will trigger the common resorptive lesions of the calcified tissues and the exuberant deposition of cementum – hypercementosis. The sprinkling found radiographically on the cemental surface more likely represents early signs of reabsorption, rather that enlarged blood-vessels. (Staszyk et al., 2008; Rehrl et al., 2018)

The occurrence of tooth reabsorption and reparative reaction (hypercementosis) are sequential in time for each lesion but may be nonsynchronous within the entire tooth, that will gradually present many combinations of replacement, inflammatory reabsorption and reparative reactions. This will define the appearance of the affected teeth and also explains the various presentations found in horses with EOTRH. (Staszyk et al., 2008; Rehrl et al., 2018; Pearce, 2020)

Regarding its clinical presentation, EOTRH is characterized by teeth with bulbous enlargement, irregular appearance, usually lytic; periodontitis, gingival recession/hyperplasia or gingivitis and abnormal incisor position are often observed, along with peripheral "carious-like" lesions. (Pearson et al., 2013; Lorello et al., 2016; Rehrl et al., 2018; Pearce, 2020) The affected horse may also show oral pain, with some teeth mobile, missing and/or fractured. (Rehrl et al., 2018)

The treatment of choice remains the extraction of both clinically and radiographically affected teeth, for any horse showing signs of oral and dental pain, with standing sedation and regional anaesthesia. A long-term oral antibiotic protocol – 28 days of Trimethoprim Sulfamethoxazole (TMPS) 24mg/kg, b.i.d. – may be concomitantly instated, in order to control secondary infections (Pearson et al., 2013; Lorello et al., 2016), as well as anti-inflammatory therapy to assist in post-surgery pain management. Most horses have a positive long-term response to the incisors' extraction, even resuming normal eating habits, including hay consumption and grazing, as proven by Lorello et al., in their study in 2016.

A case of a progressing EOTRH syndrome was chosen to illustrate the procedures carried out in this situation: a 24-year-old Arabian gelding, first presented to the hospital three years prior (December 2017) with complaints of difficulty with eating hay and weight loss, gingival receding and diastemas between incisors (more evident in the lower incisors), along with a bone-like mass on the 203's root region. On clinical examination, the animal had in fact signs of EOTRH, with an abnormal position and bulbous enlargement of the 203, slight mobility on the 303 and 403, gingivitis and periodontitis, painful on manipulation (Fig. 5).

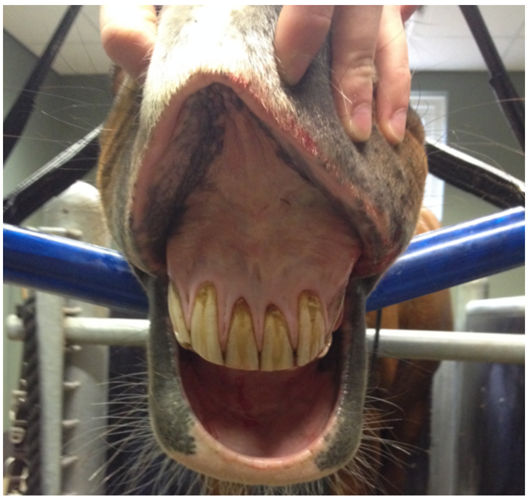


Figure 5: maxillary incisors of 24yo gelding affected with EOTRH. Note the gingival swelling and the diastemas with food content, and the more severely affected 203, causing an asymmetry (compare to contralateral incisor) on frontal view

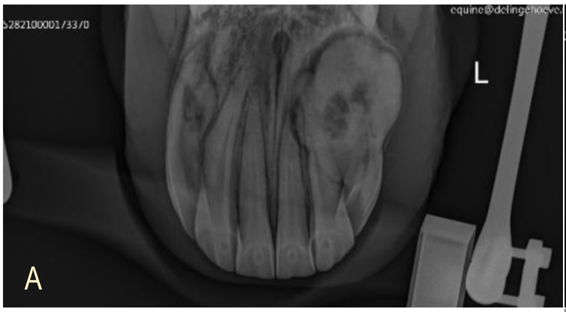


Figure 6 (A): intraoral radiograph demonstrating maxillary incisors with advanced signs of EOTRH, the 203, displaying exuberant hypercementosis and shifted position; the 103 has already a bulbous enlargement on its apex as well as resorptive reaction, and the 101 and 102 display loss of periodontal ligament space, replaced with surrounding alveolar bone.

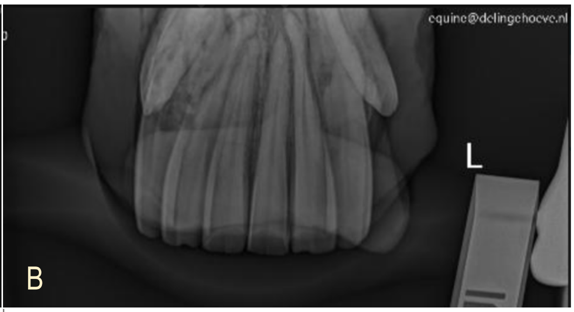


Figure 7 (B): intraoral radiograph demonstrating mandibular incisors with reabsorption lesions and loss of periodontal ligament space. The 303 and 403 reveal hypercementosis processes (markedly more advanced on the 403) on their apexes, accompanied by resorptive lesions

On intraoral radiographic examination, the lesions were even more apparent than on external evaluation, going in accordance with the findings reported in the literature, and distinct in stage of progression – heterogenic density of the roots, shifting of the teeth's positioning, few widened periodontal ligament spaces, osteomyelitis on the alveolar bone and resorptive reactions and hypercementosis (Pearson et al., 2013; Rehrl et al., 2018; Pearce, 2020) – as can be observed on Figs. 6 and 7.

Based on clinical and radiographic findings, and after discussion with the owner, the treatment consisted in the extraction of the three most affected teeth (103, 203 and 403) with standing sedation (butorphanol + detomidine) and regional anaesthesia (maxillary nerve blocks and inferior alveolar nerve blocks) and local infiltration with procaine. The horse was hospitalized for two days after the intervention, to monitor its response and adaptation. The animal was discharged without complications and close monitoring of the remaining incisors was advised, with the knowledge that the progression of the syndrome was irreversible.

After approximately three years (January 2021), the owner returned with the horse to De Lingehoeve, for a new clinical examination and a radiographic study, to assess the progression of the EOTRH and the necessity of a second intervention.

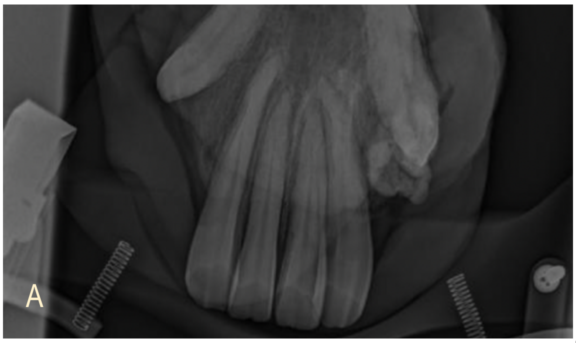


Figure 8 (A): mandibular intraoral radiograph demonstrating the swollen gingiva surrounding the extracted 303, sign of severe stage of EOTRH. Inflammatory resorption on the roots of the 301 and the 401 is also noted, with loss of periodontal ligament space filled with bone replacement. The 304 (canine) is now affected.

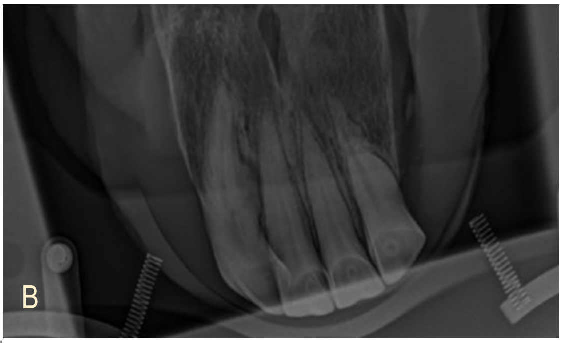


Figure 9 (B): maxillary intraoral radiograph demonstrating the progression of EOTRH on the remaining incisors, particularly the bulbous appearance of the 102 and shortening of its root (in comparison to fig. 6) and the shortening of the 202, that now presents with resorptive reaction on its apex.

On clinical examination, the 303 was severely deformed, fractured and mobile, and came out whilst manipulated. Radiographs were taken to further evaluate the horse's teeth and, in addition to intraoral radiographs, a dorsolateral-lateral oblique (DLLO) radiograph of the animal's mandibula was taken, to assess the necessity of extraction of the 304, as shown on Figs. 8, 9 and 10.

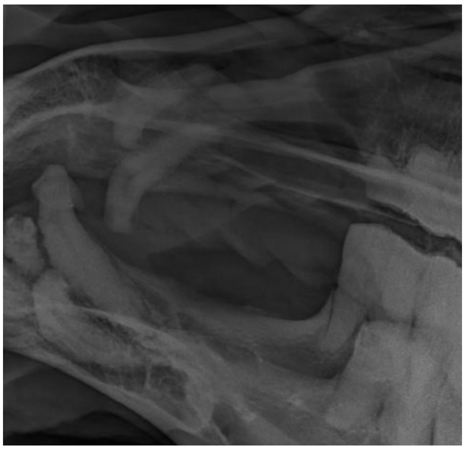


Figure 10: DLLO radiograph of the horse's mandibula, evidencing a major apical reabsorption reaction at the 304's root

After conferencing discussing the options with the owner, it was opted to extract the canine (304), before its progressive degeneration could inflict more pain or cause secondary infections, in order to provide the most comfortable life possible to this senior horse. The tooth was extracted using the same approach as to the previous intervention and, after one-day hospitalization, the animal was discharged to resume its normal life. A new odontology consult is to take place later this year (2021), to control the long-term outcome of these procedures, as well as evaluate the health of the few remaining incisor teeth.

2.2.4. Surgery

Considering De Lingehoeve is a referral hospital, with an ECSV Large animal surgery diplomate working fulltime, in addition to two other senior veterinary surgeons who perform surgeries, the surgical caseload of the facility is extensive. As mentioned before, the extern had the opportunity to choose and pursue the areas considered of most interest, aside from emergency procedures, which translated in a non-representative surgical caseload of the facility.

As portrayed on Table 17, over 50% of the surgical caseload related to orthopaedic procedures (~33% were arthroscopies to remove fragments or "chips", ~14% matched articular and non-articular wounds and ~4% were soft-tissue surgeries orthopaedic-related). The second most frequent cause of surgical intervention was colic, going in accordance with the broad colic syndrome caseload registered at the practice and mentioned in section 2.2.2.1., holding approximately 21% of the surgical cases, followed by orchiectomy surgeries (~12%).

Table 17: surgical caseload followed by the extern at De Lingehoeve (Fi, Fr %, n = 73)

Surgical cases	**Fi**	**Fr %**
Frontal bone sequestrum	1	1,4
Arthroscopy (OCD)	24	32,9
Tenoscopy	1	1,4
Fasciotomy + neurectomy	2	2,7
Septic articular wound	5	6,8
Limb wound	5	6,8
Rectovaginal fistula & anoplasty	1	1,4
Umbilical hernia	2	2,7
Colic (laparotomy w/ or w/o enterectomy) *	15	20,5
*Laparoscopy	(1)	-
Orchiectomy	9	12,3
Sinus flap	1	1,4
Distichiasis	1	1,4
Eyelid wound	1	1,4
Conjunctival (bridge) flap	1	1,4
Enucleation	1	1,4
Submandibular abscess	1	1,4
Sarcoids	2	2,7
* The same case required a 2nd intervention, by laparoscopy, not accounted for statistically		
Total	73	100

The surgical case chosen to illustrate one of the surgical procedures performed at De Lingehoeve was of a colic patient, diagnosed with a small intestines epiploic foramen entrapment (EFE) and submitted to two separate surgical interventions – one emergency laparotomy to resolve the entrapment and a posterior laparoscopy to close the epiploic foramen by applying a 3D mesh construct.

The epiploic foramen (EF), equivalent to what is referred to in Human medicine as the Winslow foramen, corresponds to an funnel-shaped opening from the peritoneum sac to the omental vestibule bordered by the caudal vena cava, the portal vein, the caudal lobe of the liver and the pancreas. (Bergen & Martens, 2019; Bergen et al., 2021) Although it is more anatomically correct to refer to this structure as "omental foramen", the term 'epiploic foramen' is broadly used and accepted. The omental vestibule refers to the space leading to the omental bursa delimited by the minor omentum, the stomach and the liver. (Bergen et al., 2021) Epiploic foramen entrapment (EFE) relates to the relatively common condition where herniation of intestines through this EF occurs. (Bergen & Martens, 2019; Bergen et al., 2021)

Small intestinal EFE is, according to Archer et al. (2004), the second most common motive of strangulation of small intestines in horses going through laparotomy and its prevalence varies through different sources, being reported to represent around 5% (Bergen & Martens, 2019; Bergen et al., 2021), 5% to 7,7% (Archer et al., 2004) or 0,5 to 10% (Schambourg et al., 2019) of all surgically treated colics, being a main differential diagnosis in all suspected small intestine colic cases. In contrast, there have been only a few reports of EFE involving large intestines (large colon and caecum). (Bergen & Martens, 2019; Bergen et al., 2021) Various predisposing factors to the occurrence of this EFE have been previously studied and determined, although their presence is not essential to its occurrence. The classic patient is a mature gelding, although there have been reports of at least two immature animals (Schambourg et al., 2019), with otherwise no age predisposition, Thoroughbred and of greater height. (Archer et al., 2004; Schambourg et al., 2019) At the same time, animals that have suffered from colic episodes in the 12 months prior (Schambourg et al., 2019) and that exhibit the stereotypical behaviour of crib-biting/windsucking are at a significantly higher risk of developing EFE, with Albanese et al. (2013) reporting cribbers to be 72 times more likely to .develop a EFE than those who do not crib. (Archer et al., 2004; Albanese et al., 2013; Escalona et al., 2014; Bergen & Martens, 2019; Schambourg et al., 2019; Bergen et al., 2021)

Crib-biting/cribbing or windsucking is an oral stereotypical behaviour with a reported prevalence in domesticated horses varying from 2,1 to 10,5% (Archer et al., 2004; Escalona et al., 2014) that involves the grasping of a surface with the incisor teeth and then pulling back (cribbing) by flexing the ventral neck muscles, which causes retraction of the larynx caudally and causing air to pass to the cranial oesophagus, producing a distinctive grunting noise. (Archer et al., 2004; Albanese et al., 2013; Escalona et al., 2014)

Bergen and Martens (2019) have theorized that the anatomy of the EF, the abdominal wall, diaphragm and liver movements, and the intra-abdominal pressure changes during cribbing play the initiating role in the development of EFE in horses. Also, the described ‘funnel shape’ of the EF explains the left-to-right occurrence of most small intestinal EFE, which allows for the entrance of the intestines through the opening of the omental vestibule, that then move left to right in direction of the smaller EF, becoming incarcerated; it is also believed that this movement causes the rupture of the greater omentum. (Bergen et al., 2021)

The diagnosis of EFE can be confirmed by ultrasonographic evaluation of the space correspondent to the EF location on the right cranial abdomen - the quadrant scanned for obtention of duodenum and liver images -, that appears with distended intestinal loops, usually with thickened walls. (Bergen et al., 2021)

Although a jejunum-only entrapment can occur, the ileum is also involved in the majority of EFE cases, which can more frequently call for a jejunocaecostomy after the solving of the incarceration, when compared to other small intestinal injuries. (Freeman & Schaeffer, 2010; Bergen et al., 2021) Because horses that undergo intestinal resection are predisposed to the development of post-operative reflux (POR), especially those requiring a jejunoileostomy or a jejunocaecostomy, and undergoing intestinal resection and development of POR strongly influence the prognosis, EFE is associated with a reduced post-operative short-term and long-term survival. (Freeman & Schaeffer, 2010; Archer et al., 2011; Freeman et al., 2014; Bergen et al., 2021) The complications associated with a worse prognosis and with non-survival are related to the timing of intervention and to intraoperative complications, therefore an early diagnosis and fast surgical decision are key to the success of the intervention and the recovery. Sooner the EFE is detected, the more likely it is for the entrapped tissues to recover their normal perfusion and motility, avoiding resection and shortening the duration of the surgery. Despite this information, there is still a poor survival rate for horses that underwent EFE colic surgery. (Freeman & Schaeffer, 2010; Bergen et al., 2021)

Even though the risk factors leading to the occurrence of EFE are not eliminated with treatment, the condition is associated with low recurrency rates, which can be explained by the spontaneous closure of the EF, consequence of inflammation and formation of adhesions, after surgical intervention in 30-40% of the cases. (Freeman & Schaeffer, 2010; Bergen & Martens, 2019)

A recent technique has been proposed in order to close the EF, that can be performed either during the first EFE colic surgery or in a second intervention, by laparoscopy. (Bergen et al., 2016; Bergen & Martens, 2019; Bergen et al., 2021) Bergen et al. (2016) have performed a successful experimental study in 6 horses, in which they closed the EF by applying a modified version of an existing polypropylene mesh (3D Max Mesh) used in human medicine. The modified mesh construct is extensively detailed in the publication, with its unique "diabolo" shape made to match the anatomy of the EF and omental vestibule and allow for its introduction during a standing right flank laparoscopic intervention – the success rate was of 100%. (Bergen et al., 2016; Bergen & Martens, 2019; Bergen et al., 2021) This technique is of particular interest in horses that show the stereotypical behaviour of cribbing/windsucking, but introduction of the mesh construct has also proven effective when performed at the time of the initial exploratory laparotomy (Bergen & Martens, 2019; Bergen et al., 2021), but it is suggested that, in times when the surgeon is uncomfortable with the procedure or if the events of the intervention bear a poor prognosis, the application of the mesh should be postponed to about one month after surgery and done so laparoscopically. (Bergen & Martens, 2019) The authors Bergen and Martens (2019) have performed a laparoscopic exploration of the EF in 34 horses and at the time the laparoscopy was performed after the first laparotomy intervention, only 32% of the EF had spontaneously closed, which resulted in 23 horses having the mesh construct applied to their EF without complications.

The case followed by the extern was a 12-year-old warmblood gelding, that presented to the hospital in the 26th of December as an emergency colic case, very painful and little responsive to medical treatment (Buscopan and Flunixin). The animal had a heart rate of 56 bpm, rectal temperature of 38,1ºC, slightly diminished borborygmi, the mucosae were pink and moist and the CRT <2". A blood sample was drawn for a quick blood analysis, which revealed an Hct of 45% (37 – 47%) and the lactate was 2,8mmol/L (moderate hyperlactatemia; <2 mmol/L – normal, 2 – 4mmol/L moderate, >4mmol/L – severe hyperlactatemia). An abdominal ultrasound was performed which revealed several distended small intestine loops on the right cranial abdomen. According to the owners, the horse often exhibits cribbing/windsucking behaviours. With the approval of the owners and the suspicion of EFE, this horse became an emergency exploratory laparotomy case. The animal was then prepared for surgery: the mouth was washed, a nasogastric tube was placed to check for gastric reflux and to avoid aspiration, an intravenous catheter was placed, and prophylactic antibiotic therapy administered (15mg/kg bwt IM of Benzylpenicillin procaine + 4mg/kg bwt IV of Gentamicin + 5g diluted in 26,5mL of water for injection IV of Ampicillin). The animal was then conducted to the induction room, sedated with butorphanol + detomidine (0,7mL + 0,7mL) and induced with 13 mL of Ketamine + 7 mL of Midazolam. An endotracheal tube was placed once the animal was down, and the animal was lifted to the operation table, where it was put in dorsal recumbency and secured in position, and a NaCl solution was started. The endotracheal tube was connected to a closed airway circuit and the Isoflurane was turned on together with the Oxygen at 100% for general anaesthesia maintenance. The surgical field was clipped then scrubbed with water and chlorhexidine one time and then shaven; then it was prepped with three consecutive scrubs of Iodopovidone solution alternated with disinfection with 70% alcohol, with a duration of 2 minutes each, and sterile surgical cloths were placed.

An incisional mid-line section was performed, over the Linea Alba to access the abdominal cavity. After exploration, a small intestinal EFE was confirmed, particularly a jejunum and ileum EFE, that was freed manually. The entrapped viscera were motile and soon regained normal perfusion colours, avoiding the need for a resection. A small tear in the omentum was detected and promptly closed with a simple running suture. Once all intestinal structures were assessed, the peritoneum was closed with a simple running suture, the Linea Alba with the Israelsson technique (Israelsson & Jonsson, 1994), the subcutis with a simple running suture and the skin with an interlocking running suture. A sterile cloth was secured over the suture line, to prevent external contamination. The animal had an assisted recovery that went uneventful. Given the quick surgical response and the favourable intraoperative findings, the animal was hospitalized to be closely monitored through the next ten days, to be then discharged. The closure of the EF was scheduled for four weeks post-discharge.

The day after surgery, the horse was comfortable, its mucous membranes, rectal temperature and heart rate were within normal limits, intestinal borborygmi were detected even if slightly diminished, and it was passing faeces. The instated prophylactic antibiotic protocol was resumed for next days – the horse was administered benzylpenicillin procaine (3 days at a dosage of 15mg/kg bwt IM s.i.d) and gentamicin (5 days at a dosage of 4mg/kg bwt IV s.i.d.), along with a 3-day protocol of anti-inflammatory therapy that started post-surgery (Flunixin meglumine at a dosage of 1,1 mg/kg bwt IV s.i.d.). On the third day post-surgery, it began passing pasty faeces, therefore the horse was offered hay in small portions, throughout the day. Up to the 4th of January, when the animal was discharged, the animal continued exhibiting the windsucking behaviour.

On the 10th of January, the horse returned to the hospital for an emergency consult showing colic symptoms. His heart rate was 44 bpm, the temperature 37,6ºC and he had moderate gut sounds on auscultation, with no signs of abdominal distension. A blood sample was drawn. On transrectal palpation, a large impaction on the right colon was felt and on ultrasonographic evaluation a few distended small intestinal loops were present, but motile. The blood analysis revealed a pH of 7,4 and a base excess (BE) of -1,5 (metabolic acidosis), a Hct of 37% and lactate of 0,88. Based on these findings, the case was treated as a simple colonic obstruction case, by placing a nasogastric tube to administer 3L of paraffin and 2L of water. The following morning, during rounds, there were faeces coated with paraffin on the bedding and the animal was visibly more comfortable. A transrectal palpation was performed and confirmed the solution of the impaction. Considering the animal was scheduled to undergo a new intervention in a couple of weeks, and the occurrence of a new colic episode in this short period, a decision to keep him hospitalized and advance the date of the second procedure was made.

On the 15th of January, the new chosen date for the laparoscopic intervention, the animal was showing some signs of abdominal discomfort that were attributed to the presence of a large amount of gas in the caecum, after a period of 12-hour fasting. A Butylscopolamine + Metamizole (Buscopan compositum) injection was administered at the recommended dosage of 5mL/100kg IV, and the animal's comfort improved. Later the same day, the animal was prepared for the standing sedation laparoscopic intervention. The animal had a catheter placed, was restrained in a stock and sedated with 0,7mL of Detomidine + 0,7 mL Butorphanol; the sedation was maintained with bolus administrations of the two drugs. The tail was properly bandaged and secured, and the right flank was clipped (from the 12th intercostal space to the *tuber coxae*). The surgical field was then scrubbed with iodopovidone and disinfected with 70% alcohol alternating between them for a total of three times, similarly to what was described for the preparation of the laparotomy surgical field. Immediately before surgery, the animal was administered benzylpenicillin procaine (15mg/kg bwt IM) and ampicillin (5g diluted in 26,5mL of water for injection IV), as well as flunixin meglumine (1,1mg/kg bwt IV). Local analgesia was achieved by infiltration with lidocaine at the portal sites.

Before the procedure began, the mesh construct was prepared using two oval shaped polypropylene meshes (3DMax Mesh) to form the "diabolo-shaped" structure thoroughly described by Bergen et al., 2016. The laparoscope portal was then made, positioned midway through the anatomical references used to create the surgical field. After directing the laparoscope cranially in the direction of the liver, EF and omentum vestibule locations, a second portal – the instrument portal – was made ventrally to the laparoscope portal, where the applicator tube containing the mesh construct was to be introduced. Due to the animal's wider dimensions and anatomic particularities, the visualization of the EF was particularly difficult during this intervention. After several visualization tries, the EF was properly assessed and no adhesions were observed at the level of the EF, indicating it had not spontaneously closed. The applicator tube (containing a blunt trocar) was then directed in the direction of the EF and the trocar was replaced by the mesh implant, that was folded before being introduced in the applicator tube. With laparoscopic guidance, the mesh was passed through the omental vestibule until it was almost entirely inside the structure; the applicator tube was then removed from the omental vestibule, leaving the implant slightly protruding into the abdominal cavity, through the EF. After laparoscopically confirming the mesh construct was secured in the intended place, the instruments were removed from the animal's abdomen and the portals were closed in two layers – subcutis with simple continuous suture and skin with simple interrupted knots. The procedure was similar to the ones described in the publications by Bergen et al. (Bergen et al., 2016; Bergen & Martens, 2019; Bergen et al., 2021).

The animal was given prophylactic antibiotics and anti-inflammatory for three days: benzylpenicillin procaine (15mg/kg bwt IM s.i.d.) and flunixin meglumine (1,1mg/kg bwt, PO s.i.d.). On the end of the third day post-surgery, the animal was discharged without any complications.

One and a half months after the final intervention, the horse had suffered from a new colic syndrome episode, that was diagnosed as a nephrosplenic entrapment, that was successfully treated with medical management and exercise (similarly to what has been described in section 2.2.2.1). This event's occurrence was attributed to the stereotypical behaviour of windsucking still observed in the animal.

3. Monography: Sacroiliac Dysfunction – anatomical structures involved, diagnostic approach and treatment options

3.1. Anatomic revision

Alongside a brief anatomical revision of the pelvic region constituents, a more detailed description of the important ligaments and musculature that surround and support the sacroiliac joints, as well as the closely related lumbosacral joint and the sacroiliac joint itself, is presented.

3.1.1. Pelvic gridle

The pelvic gridle (Figure 11) is a term often used to refer to the anatomical region of the *os coxae* (ilium, ischium, pubis), the sacrum, and the first coccygeal vertebrae (Pilliner et al., 2002). These osseous structures, together with the lumbar vertebrae and the main soft tissue structures present in this region, can be perceived as the source of most complaints attributable to sacroiliac dysfunction, as they are all anatomically and biomechanically closely related (McGowan et al., 2010; Dyson, 2011; Stack et al., 2016; Jeffcott, 2018; Jeffcott et al., 2018; Tallaj et al., 2019). Therefore, "sacroiliac dysfunction" can refer, from this point onwards, to any abnormality found in any or several of these anatomical structures leading to sacroiliac dysfunction suspicion and diagnosis, in similarity to what has been determined in Ellis et al., 2021.

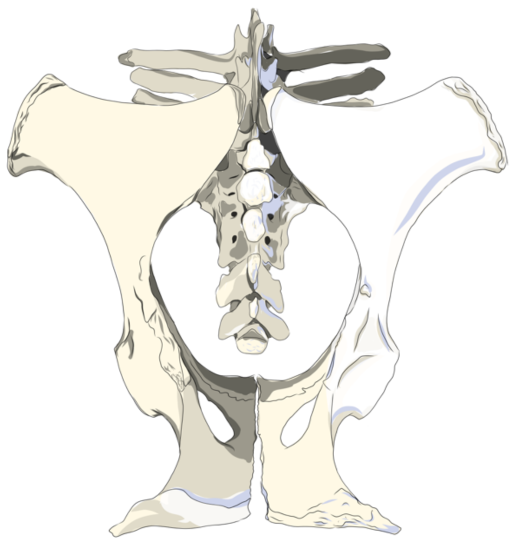


Figure 11: Schematic representation of the pelvic gridle (dorsal view).

The *os coxae* the result of the fusion of three separate bones – the ilium, the ischium and the pubis – that connect with each other to form the acetabulum; the os coxae exists as a pair connected through the pubic symphysis (between the two pubic bones) (Pilliner et al., 2002; Budras et al., 2011; Dyson, 2011; Jeffcott et al., 2018).

The ilium is a flat bone divided in Ilium wing (articulates with the sacrum on its pelvic surface – also where the interosseous sacroiliac ligament inserts; the gluteal surface of the wing is where the deep and middle gluteal muscles attach), *tuber coxae* (also known as point of the hip); Ilium crest and neck; Psoas minor tubercle, Ilium body and *tuber sacrale* (recognised as the highest point of the croup; where the dorsal sacroiliac ligament attaches) (Pilliner et al., 2002; Budras et al., 2011; Jeffcott et al., 2018; Denoix, 2019).

The ischium has a body, a lateral (acetabular) and a medial ramus, the ischium table and the tuber ischiadicum (Pilliner et al., 2002; Budras et al., 2011; Jeffcott et al., 2018; Denoix, 2019).

The pubis is the most ventral bone, and connected by the pubic symphysis, the two pubic bones create the pelvic floor. The pubis has a body and two ramus, a cranial ramus that connects with the ilium and ischium to form the acetabulum, at the pubis pecten, and a caudal ramus, that connects to the contralateral pubis through its symphysial face (Pilliner et al., 2002; Budras et al., 2011; Jeffcott et al., 2018; Denoix, 2019).

The sacrum is a triangular-shaped bone, result of the fusion of the five sacral vertebrae by the time the animal reaches the age of five years (Pilliner et al., 2002; Budras et al., 2011; Jeffcott et al., 2018; Denoix, 2019; Fails, 2020). It has dorsal and ventral pairs of sacral foramina, through which the spinal nerves exit the vertebral canal. The inclination of the sacral dorsal spinous processes (DSPs), or median sacral crest, is opposite to the inclination of the lumbar DSPs, creating a wide space between the sixth lumbar and first sacral DSPs, that justifies for the greater movements of flexion and extension registered in the lumbosacral joint, when compared to those of the sacroiliac joints (Budras et al., 2011; Dyson, 2011; Jeffcott et al., 2018; Denoix, 2019; Fails, 2020). The first sacral vertebra (S1) has two cranial articular processes, also known as the sacral wings, with which the sacrum articulates with both the last lumbar vertebra (L6) transverse processes – forming two of the five lumbosacral joints (Budras et al., 2011; Dyson, 2011; Denoix, 2019) – and the ilium – forming the sacroiliac joint (Budras et al., 2011; Denoix, 2019; Fails, 2020).

3.1.2. Lumbosacral junction

The first sacral vertebra, as mentioned above, has five points of articulation with the last lumbar vertebra. Besides the intertransverse lumbosacral joints, it also articulates with the L6 by means of the central intervertebral joint (same as the rest of the vertebrae), formed between the vertebral body of the L6 and the cranial extremity of the S1 body which are separated by an intervertebral disc, and via the two intervertebral joints formed by the articular processes of the two vertebrae (L6 and S1) (Dyson, 2011; Jeffcott et al., 2018; Denoix, 2019; Fails, 2020) Fusion of the fifth and sixth lumbar vertebrae is a common anatomic variation finding, as well as the sacralization of the sixth lumbar vertebra (ankylosis lumbosacral) (Budras et al., 2011; Dyson, 2011; Denoix, 2019).

3.1.3. Sacroiliac joints and ligaments

The sacroiliacs joints (SIJ) are unusual bilateral synovial articulations composed of two flat surfaces – one hyaline cartilage surface (articular surface of the sacral wing) and one fibrocartilaginous surface (articular surface of the iliac wing). (Erichsen et al., 2002 b; Goff et al., 2008; Budras et al., 2011; Barstow & Dyson, 2015; Stack et al., 2016; Jeffcott et al., 2018; Tallaj et al., 2019; Fails, 2020) These joints constitute the connection between the axial skeleton and the hindlimbs, transmitting the energy from the respective hindlimb to the vertebrae and the rest of the body during locomotion, thus being constantly under biomechanical stress. (Erichsen et al., 2002 b; Goff et al., 2008; Budras et al., 2011; Barstow & Dyson, 2015; Jeffcott, 2018; Jeffcott et al., 2018; Tallaj et al., 2019; Fails, 2020) The SIJ is mostly described as a C to L-shaped joint, varying from flat to convex in caudoventral direction. (Erichsen et al., 2002 b; Goff et al., 2008; Tallaj et al., 2019) Even though the joint is encased by a fibrous capsule, it is mainly through the three pairs of sacroiliac ligaments (ventral sacroiliac, interosseous sacroiliac and dorsal sacroiliac ligaments) (Figure 12) that the joints' integrity and stability are achieved, since they allow only for the sacrum's nutation and counternutation motions that are associated with the joint's shock-absorbing function and occur parallel the greater flexion and extension movements of the lumbosacral joint (Goff et al., 2008; Budras et al., 2011; Barstow & Dyson, 2015; Jeffcott, 2018; Jeffcott et al., 2018; Tallaj et al., 2019; Fails, 2020).

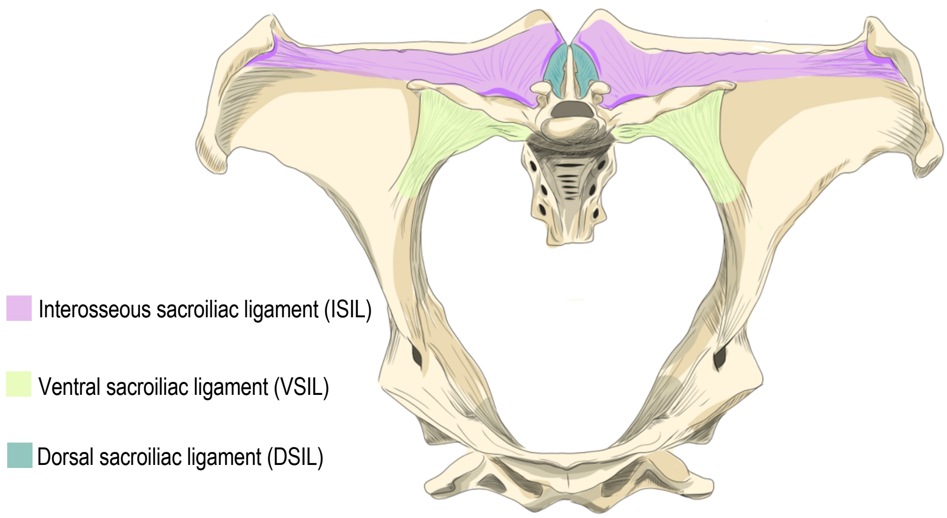


Figure 12: Schematic drawing of the cranial view of the sacroiliac joints and the sacroiliac ligaments.

The ventral sacroiliac ligaments (VSIL) run along the ventral articular borders of the ilium and sacrum articular surfaces, extending from medial to lateral direction to insert on the *tuber sacrale* and the iliac wing, surrounding the SIJs (Goff et al., 2008; Kersten & Edinger, 2010; Budras et al., 2011; Jeffcott et al., 2018; Tallaj et al., 2019; Fails, 2020). These ligaments "reduce rotational and sliding movements" within the joint (Jeffcott et al., 2018).

The interosseous sacroiliac ligaments (ISIL) are constituted by several vertical fibres intertwined with fatty tissue. They connect each dorsal surface of the sacrum wing with the ipsilateral cranioventral surface of the iliac wing, ensuring the suspended position of the sacrum in the pelvic gridle; these ligaments are not observable with the ultrasound due to their location and direction (Goff et al., 2008; Kersten & Edinger, 2010; Budras et al., 2011; Barstow & Dyson, 2015; Tallaj et al., 2019; Fails, 2020).

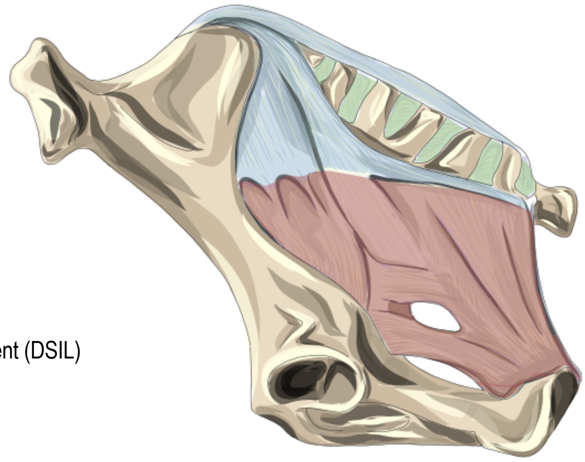


Figure 8: Schematic drawing of the ligamentous structures on lateral view of the pelvic gridle.

The dorsal sacroiliac ligaments (DSIL) do not have a direct connection to the SIJs and have two distinct components: the short dorsal part, or funicular, which spreads cranially to insert on the *tuber sacrale* originating from the median sacral crest and is overlaid by the tendon of the longissimus dorsi muscle (which connects to the contralateral one by an aponeurosis on top of the median sacral crest), and the long ventral part, or membranous, that is also referred to as the lateral dorsal sacroiliac ligament by some (Goff et al., 2008; Jeffcott et al., 2018), which originates from the *tuber sacrale* and the iliac wing projecting ventrally to insert on the lateral sacral crest and merge with the sacrosciatic or broad sacrotuberous ligament (Goff et al., 2008; Kersten & Edinger, 2010; Budras et al., 2011; Jeffcott et al., 2018; Tallaj et al., 2019; Fails, 2020). This sacrosciatic or sacrotuberous ligament (bilateral) also contributes to the stabilization of the sacroiliac region. It consists of a sheet-like extension of the lumbar intertransverse ligament that runs in a caudal direction to insert on the first coccygeal vertebrae and on the tuber ischium and ischial crest, therefore strengthening the connection between pelvis and axial skeleton (Goff et al., 2008; Budras et al., 2011; Jeffcott et al., 2018; Fails, 2020). It is further believed that this structure appeared as an evolutive adaptation to rearing movement (Jeffcott et al., 2018). These two ligaments (Figure 13) are the main structures responsible for the transference of energy from the hindlimbs to the vertebral spine, together with the fasciae and muscles to them attached (Goff et al., 2008).

3.1.4. Musculature of the sacroiliac region

Along with the mentioned ligaments, the various groups of muscles existent in the sacroiliac region, particularly the gluteal muscles, the hypaxial lumbar muscles and part of the epaxial muscles, are major contributors to the stability not only of the SIJ, but of the whole region and the back (Fails, 2020; Goff et al., 2008; Tallaj et al., 2019).

The gluteal muscles consist of a group of muscles that originate from diverse places of the pelvic bones to insert on the femur and are responsible for the protraction and abduction of the hindlimbs and flexion and extension of the hip joint, transmitting the power generated in movement to the sacroiliac region and, consequently, to the rest of the body (Budras et al., 2011). The gluteus superficialis originates from the *tuber coxae* and gluteal fascia and inserts on the third trochanter of the femur, the gluteus medius is the largest of the three gluteal muscles, originating from the aponeurosis of the longissimus lumborum, as well as the gluteal surfaces of the sacrum and ilium, particularly from the sacroiliac and sacrosciatic ligaments, and inserting on the trochanter major of the femur; the gluteus profundus originates from the ischiatic spine of the ischium and also inserts on the trochanter major (Budras et al., 2011; Denoix, 2019).

The hypaxial lumbar muscles are located ventrally to the transverse processes of the vertebrae in the trunk of the animal and they act together with the abdominal muscles to induce flexion of the vertebral axis during locomotion, especially during canter and gallop This group of muscles is made by the psoas major muscles (that merges with the iliacus muscle to form the iliopsoas muscle; origin – lumbar transverse processes (psoas major m.)/ilium and wing of sacrum (iliacus m.); insertion –trochanter minor of femur), the psoas minor muscles (origin – last thoracal and first lumbar vertebrae; insertion – psoas minor tubercle of ilium) and the quadratus lumborum muscles (origin – last ribs and lumbar transverse processes; insertion – ventral surface of sacral wing, close to VSIL) (Pilliner et al., 2002; Budras et al., 2011; Denoix, 2019; Fails, 2020).

The epaxial muscles stand dorsally to the transverse processes of the vertebrae and control the movements of the equine's back, working together to extend the vertebral column and acting opposed to the hypaxial muscles during locomotion. The extensor muscles related to the lumbosacral region belong to different groups: the iliocostalis group (iliocostalis thoracis portion originating from the lumbar transverse processes), the longissimus group (longissimus lumborum, that originates from the spinous processes of the sacrum and lumbar vertebrae and merges with the rest of the longissimus muscles to form the longissimus dorsi) and the multifidi group (multifidus lumborum muscle, that originates from the articular processes of each lumbar and sacral vertebrae to insert on the spinous process of the preceding vertebra) (Pilliner et al., 2002; Budras et al., 2011; Fails, 2020) The gluteus medius can be considered a part of the epaxial muscles group, since it originates from the aponeurosis of the longissimus lumborum and help stimulate the back's movement, especially during rearing (Pilliner et al., 2002; Budras et al., 2011; Barstow & Dyson, 2015; Denoix, 2019).

3.1.5. Other important structures

Furthermore, there are three important anatomical structures topographically close to the ventral sacroiliac ligament, running ventrally to the SIJ: the cranial gluteal artery and vein, that will originate the iliolumbar artery and vein, and some of the spinal nerves of the lumbosacral plexus (namely the roots of the sixth lumbar and first sacral intervertebral nerves), which will divide into the gluteal nerves and the sciatic nerve (Goff et al., 2008; Kersten & Edinger, 2010; Budras et al., 2011; Barstow & Dyson, 2015; Fintl, 2018; Jeffcott et al., 2018; Denoix, 2019; Tallaj et al., 2019).

3.2. Diagnostic approach to Sacroiliac Dysfunction

3.2.1. SID signalment and presentation

Sacroiliac dysfunction (SID) has for long been identified as source of back pain, associated with poor performance, gait abnormalities, lack of impulsion and non-overt lameness. (Dyson et al., 2003; Dyson & Murray, 2003; Gorgas et al., 2007, 2009; Goff et al., 2008; Dyson, 2011; Barstow & Dyson, 2015; Jeffcott, 2018; Nagy et al., 2020; Ellis et al., 2021). A definite diagnosis of SID still remains challenging due to the non-pathognomonic clinical signs and the location of the SIJ, whereas presumptive sacroiliac dysfunction diagnosis has been recurrently made whenever no other explanatory conditions for the complaints were found, and a combination of back stiffness, worsening of the clinical signs at canter and when ridden and distinctive bucking while in movement was exhibited. (Dyson et al., 2003; Dyson & Murray, 2003; Gorgas et al., 2007, 2009; Goff et al., 2008; Dyson, 2011; Barstow & Dyson, 2015; Jeffcott, 2018; Munroe, 2018; Nagy et al., 2020; Ellis et al., 2021).

SID is more frequently observed in athletic horses, of bigger stature, particularly those practicing high-level dressage and showjumping, when compared to the rest of the population. Breed predisposition also seems to be present, with warmbloods seemingly more prone to the development of the condition. (Dyson & Murray, 2003; Goff et al., 2008; Dyson, 2011; Jeffcott, 2018; Nagy et al., 2020)

Because of the association of SID with mild and chronic manifestations and also because of the similarity of presentation with cases suffering from thoracolumbar and lumbosacral problems, its diagnosis is widely obtained by exclusion of other conditions causing similar clinical signs, and it should be taken into consideration that the occurrence of SID is frequently concurrent with other musculoskeletal conditions or even be secondary to these other primary injuries (Goff et al., 2008; S. J. Dyson, 2011; Barstow & Dyson, 2015; Munroe, 2018; Nagy et al., 2020; Ellis et al., 2021).

Recent studies (Barstow & Dyson, 2015; Nagy et al., 2020) have demonstrated that only a small percentage of the studied animals presented with SI regional pain alone (14,5% and 17,9% of the studied populations, respectively). Several conditions have been diagnosed concurrently with SID, such as synovitis of the cervical articular processes, impingement of the thoracolumbar spinous processes ('kissing spines'), ankylosis and/or spondylosis of lumbar transverse processes, lumbosacral pathology, osteoarthritis (OA) of the coxofemoral joints and hind proximal suspensory desmitis/enthesopathy (in the latter, the findings associated with SID tend to be mild); moreover, some cases of SID can lead to a rapid atrophy of the back and croup muscles, increasing the sensitivity of the back to manipulation and its stiffness (Dyson, 2011; Barstow & Dyson, 2015; Munroe, 2018).

The main differential diagnosis for poor performance and hind gait abnormalities are thoracolumbar pathologies, lower and upper hindlimb lameness, particularly proximal suspensory desmitis, aorta thrombosis, ataxia and cauda equina syndrome, and recurrent exertional rhabdomyolysis (RER) (Goff et al., 2008; Munroe, 2018). Multiple sources of pain and painful response to stimuli may further complicate the clinical diagnosis and even neck/cervical problems can not only be mistaken for back issues, but also aggravate the clinical presentation when simultaneously existent (Barstow & Dyson, 2015; Munroe, 2018).

SID development has been recurrently considered the result of various pathological changes around the SI region, i.e. OA of the SIJ, desmitis of the SI ligaments and general instability of the SIJ, OA of the lumbosacral joint, ankylosis of the intertransverse lumbar joints, desmopathy of the longissimus lumborum and pelvic fractures (stress fractures and fracture of the ilium) (Gorgas et al., 2007, 2009; Kersten & Edinger, 2010). Findings at the SIJ region previously described include osteophyte formation, lipping and cortical buttressing and, sometimes, cartilage erosion. Occasionally, 'kissing spines', ankylosis and/or spondylosis of the lumbar transverse processes and OA of the articular facets of thoracolumbar vertebrae have also been found in association with the changes in the SIJ (Dyson, 2011; Jeffcott, 2018), with Dyson (2011) implying that there is a positive correlation between the severity of these changes with those identified on the SIJs, and Jeffcott (2018) pointing to the possibility of the thoracolumbar alterations being compensatory to the SID or the other way around.

3.2.2. Clinical Examination

Because of this complex and equivocal presentation, and the difficulty to reach a definite diagnosis of SID, every case should be approached systematically, with a thorough clinical examination, followed by an as extensive imaging study (radiography, ultrasonography, scintigraphy, computerized tomography) as possible, in order to assess the clinical relevance of each of the findings and treat the primary cause leading up to the initial complaint.

The clinical signs associated with SID, although ambiguous, include pain at SI region and poor performance, gait abnormalities with or without asymmetrical muscular mass, back pain and sensitivity on palpation and stiffness (loss of suppleness) on the hand and/or ridden, difficulty to move in short circles, disunited gaits (particularly at canter), 'bunny hopping', refusal to canter or breaking to trot, poor hindlimb impulsion, indistinctive uni/bilateral hindlimb lameness, hindlimb plaiting and/or toe-dragging and bucking and/kicking intermittently at canter; these signs are often worse after periods of rest and can progress to total unwillingness to work under saddle (Goff et al., 2008; Dyson, 2011; Barstow & Dyson, 2015; Jeffcott, 2018; Nagy et al., 2020).

When performing a clinical examination, the horse should be observed both at hand, at the lunge and, ideally, ridden, to allow for the manifestation of the clinical signs above mentioned. Furthermore, flexion tests should also be performed in order to detect primary hindlimb lameness, but these tests are usually negative when a back-only problem is observed (Goff et al., 2008; Dyson, 2011; Munroe, 2018). When a flexion test triggers lameness in the contralateral limb or the animal is reluctant to pick up the hindlimbs or endure for the duration of the flexion test, this may be the first indicator SID (Munroe, 2018). The lateroflexion (or suppleness) of the back is assessed by making the horse turn on tight circles in both directions, resorting to the trailing of imaginary figure eights on a hard surface by hand, for example, as well as at the lunge and ridden – horses with back pain and SI region pain associated with stiffness of the back usually have difficulty in turning on the forehand, although the reluctance is not exclusive to this condition. Rearing the horse is also useful to determine the origin of the back pain, as is doing so in inclined surfaces, to increase the biomechanical stress on the SIJs and exacerbate the signs (Goff et al., 2008; Dyson, 2011; Jeffcott, 2018; Munroe, 2018). The manual tests or pain provocation tests are not always indicative of SID, but palpation of the areas correspondent to the location of the structures related to the SI region and the osseous prominences of the back and pelvic region may be useful in detecting cases of chronic pain associated with SID (Dyson & Murray, 2003; Goff et al., 2008; Dyson, 2011; Barstow & Dyson, 2015; Jeffcott, 2018; Munroe, 2018)

3.2.3. Diagnostic Imaging

A number of imaging techniques are currently available as means to evaluate the equine back and SI region and reach a definite diagnosis, such as radiography, computerized tomography, nuclear scintigraphy and ultrasonography. These techniques are best used in association with one another and, more importantly, their results interpreted considering the clinical examination's findings, in order to obtain a more detailed list of the detected abnormalities and assess their clinical relevance for each individual case (Dyson et al., 2003; Dyson & Murray, 2003; Tomlinson et al., 2003; Kersten & Edinger, 2010; Budras et al., 2011; Dyson, 2011; Barstow & Dyson, 2015; Henson, 2018; Jeffcott, 2018; Powell, 2018; Whitcomb et al., 2018; Tallaj et al., 2019; Nagy et al., 2020; Ellis et al., 2021).

3.2.3.1. Radiography

Radiographic studies are very useful for the diagnosis or exclusion of other neck and back pathologies that are associated with the clinical signs attributable to SID. The pathologies identifiable by this modality include cervical OA, overriding spinous processes or 'kissing spines', pelvic fractures and remodelling/OA at the stifle joints. (Dyson, 2011; Henson, 2018; Ellis et al., 2021) It is highly difficult to obtain and interpret SI region images with this technique and, although it is technically possible, it is not of common practice (Dyson, 2011; Henson, 2018; Ellis et al., 2021). An example of radiological images used to evaluate some osseous changes in the vertebral column of the horse is represented on Figure 14.

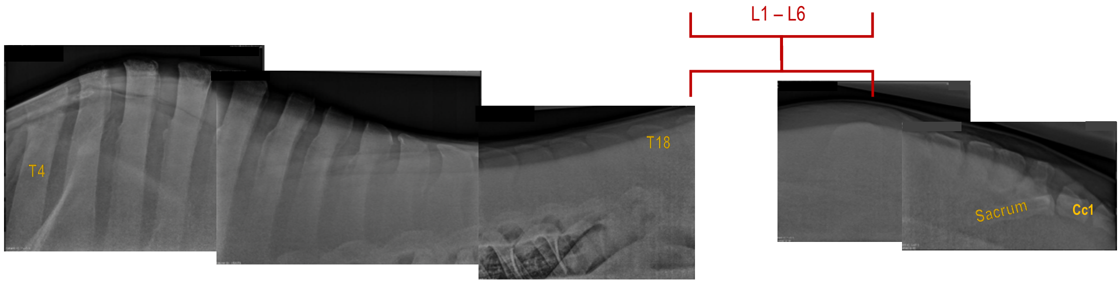


Figure 14: radiographic images of the spinous processes from the fourth thoracal vertebra (T4) to the first coccygeal vertebra (Cc1)(cranial is to the left); the radiographic image of the lumbar portion column is not easily obtained (correspondent to the region marked in red). *Images from a radiographical study of a case followed at De Lingehoeve.*

3.2.3.2. Nuclear Scintigraphy and Computerized Tomography (CT)

Nuclear scintigraphy creates images based on the physiological characteristics of the different tissues, using the radionuclide uptake (RU) patterns observed. This RU reflects the activity of the osteoblasts, the blood supply to each tissue and the bone metabolism (turnover), being somewhat indicative of pathological conditions in areas of increased radionuclide uptake (IRU), referred to as 'hot spots' (Dyson et al., 2003; Dyson, 2011; Powell, 2018). This technique allows the identification of bone remodelling areas and OA, fractures, sacroiliac dysfunction, blood supply to the imaged areas, and may point to a diagnosis of rhabdomyolysis (Dyson, 2011). Given the SIJ's location and the relative position of the other SI region components, nuclear scintigraphy can be considered the 'gold standard' imaging technique for this region (Powell, 2018). Nuclear scintigraphy has, however, a high occurrence of false positive results, especially considering the age-dependent abnormalities detected in SIJs of otherwise 'sound' horses (Dyson, 2011;

Ellis et al., 2021), with some authors (Dyson et al., 2003) reinforcing the importance of combining the findings in this exam with an extensive clinical evaluation before reaching a definite diagnosis.

Computerized Tomography (CT) is a relatively new technique in equine diagnosis and is becoming progressively more available to veterinary practitioners around the world. CT uses the same principles of radiography (the absorption and reflexion of x-rays by the different densities of the tissues), but takes it a step further by creating cross-sectional images of the imaged areas and even allows for computerized 3-D reconstructions of said areas (Powell, 2018). Besides the need for the animal to be under general anaesthesia in order to obtain artefact-free images, the dimensions of the more available machines are not compatible with the pelvic region diameter of fully-grown horses of bigger breeds, turning this technique in a rarely sought out resource. Images from the SI region obtained by CT are shown in Figure 15.

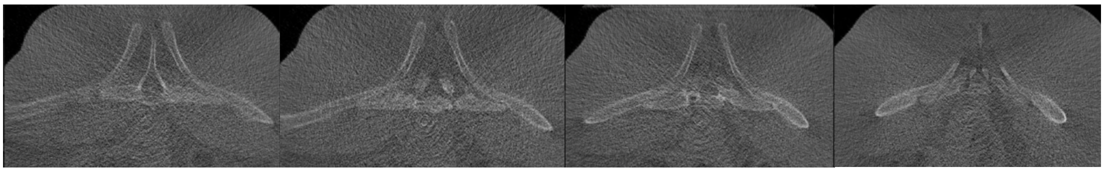


Figure 9: transverse sections of the sacroiliac region obtain with computerized tomography (CT); cranial to caudal planes displayed left to right. *Images of a CT scan performed in one of the sacroiliac dysfunction (SID) cases.*

3.2.3.3. Ultrasonography

Ultrasonography is the most frequently chosen modality when evaluating musculoskeletal abnormalities, both in ambulatory as in hospital environment. It is highly reliable, relatively easy to use and the images obtained usually have diagnostic validity (Whitcomb et al., 2018). Ultrasonographic evaluation of the SI region is very helpful and can be performed transcutaneously to visualize the DSILs and the musculature adjacent to the SIJ and lumbosacral region (Figure 16), being otherwise less useful for diagnosis of SID (this approach used mostly for diagnostic analgesia and treatment purposes of SID), the intertransverse lumbar processes and the supraspinous ligament; and transrectally, allowing for assessment of the VSILs, the ventral aspect of the SIJ, as well as the LS joints and intervertebral disc, the caudal aorta and iliolumbar arteries, the roots of the L6, S1 and S2 nerves' roots and the intertransverse joints of the LS joint (Kersten & Edinger, 2010; Jeffcott, 2018; Whitcomb et al., 2018; Tallaj et al., 2019; Ellis et al., 2021). According to some authors (Ellis et al., 2021; Tomlinson et al., 2003), the ultrasonography can be more sensitive than other imaging techniques in the premature diagnosis of SID development, since it allows for early detection of periarticular reaction and osteophyte formation.

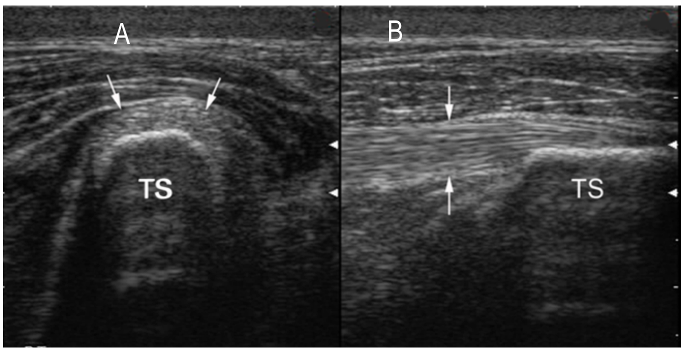


Figure 10: normal appearance of the short portion of the right dorsal sacroiliac ligament (DSIL) (arrows) at the level of its insertion on the *tuber sacrale* in (A) transverse and (B) longitudinal images*. Images adapted from Whitcomb et al. (2018)*

3.2.3.3.1. Transrectal ultrasound technique

The technique used for diagnostic imaging was similar to that described by several authors (Kersten & Edinger, 2010; Whitcomb et al., 2018; Tallaj et al., 2019). All rectal scans start dorsally at the lumbosacral junction (lumbosacral intervertebral disc identification), using the promontorium as a guiding landmark, in the median longitudinal scan. The transducer is then moved laterally to a parasagittal plane, in order to identify the L6 nerve root. Moving caudally, an image of the S1 nerve root is produced and one of the S2 nerve, when moving the transducer slightly in caudal direction. If the transducer is moved laterally at the L6 region, the intertransverse lumbosacral joint becomes visible. After the identification of these structures, the transducer is positioned back in the sagittal plane, at the level of L6 and S1 nerve roots. Sliding the transducer laterally, the caudoventral portion of the sacroiliac joint comes into view, moving first under the ventromedial part and then more laterally to the ventrolateral border of the sacral wing – the joint should appear tight and with smooth borders; it is also possible to observe transverse or longitudinal images of the iliolumbar artery at this point, depending on the position of the transducer. Tilting the transducer more oblique to the parasagittal plane, the SIJ will appear as a triangular shape formed by the margins of the sacrum and ilium that is filled with the VSIL. This process should be repeated on the contralateral side as well, with mirroring movements of the transducer. A schematic representation of the transducer's positioning and the images produces can be seen in Figure 17.

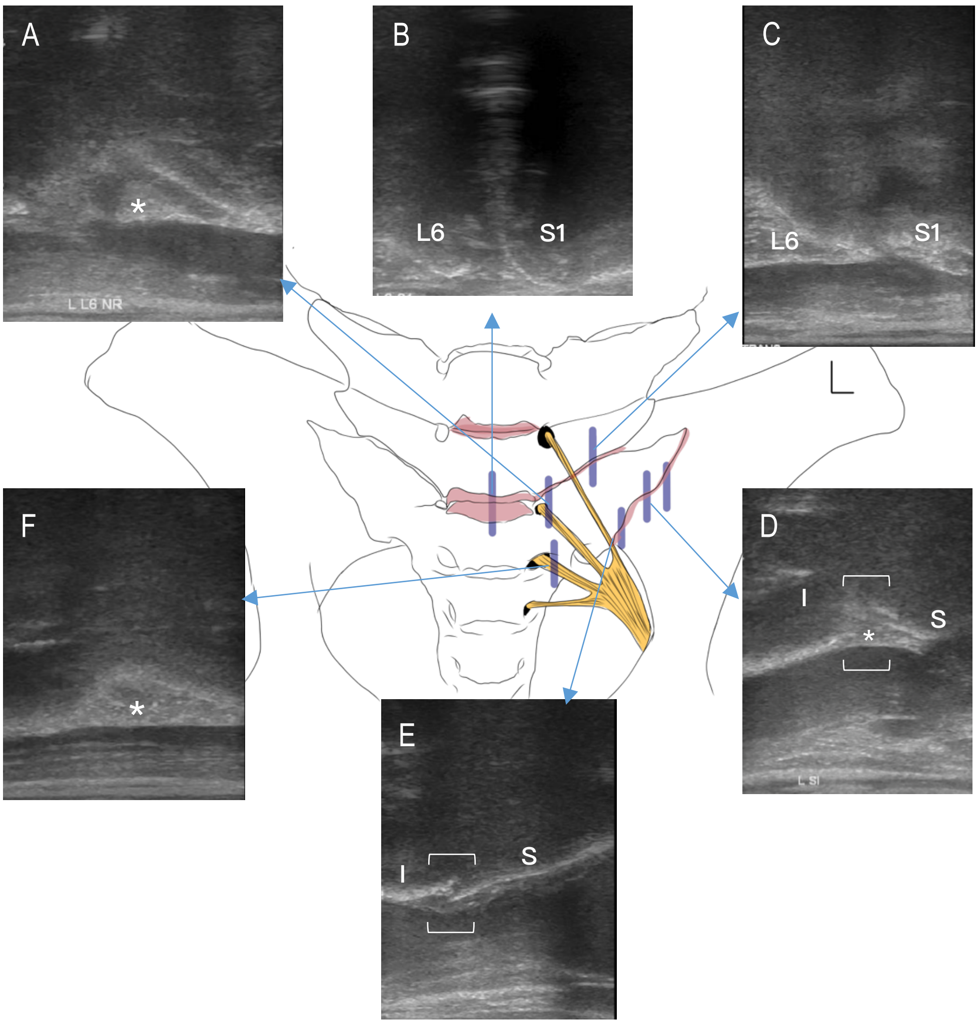


Figure 11: Representation of transducer's placement in the various observable structures and obtained ultrasound images. From top left. clockwise: (A): L6 nerve root (marked with *, transversal cut); (B): lumbosacral (LS) joint longitudinal (L6 to the left); (C): intertransverse lumbosacral joint (cranial to the left); (D) and (E): SIJ marked with [ ], (D) is obtained with the transducer slightly oblique, making visible the ventral sacroiliac ligament (VSIL) filling the joint space (marked with *), (E) shows the ventromedial border of SIJ, (I – ilium; S – sacrum); (F) S1 nerve root (marked with *, transversal cut). *The ultrasound images were retrieved during the examination of some of the animals of this study.*

3.2.4. Diagnostic Analgesia

The diagnosis of SIJ pain can also be obtained with resource to diagnostic analgesia performed in the SI region. Although true intraarticular injection of the SIJ is not possible, a regional infiltration of the SIJ region is normally achieved instead, but variable degrees of distribution to other close structures such as the LS joint region, the local nerve roots and even the muscles and ligaments overlaying all the structures mentioned before have been registered, thus it cannot be considered highly specific (Dyson & Murray, 2003; Goff et al., 2008; Budras et al., 2011; Dyson, 2011; Barstow & Dyson, 2015; Jeffcott, 2018; Nagy et al., 2020; Ellis et al., 2021). The ultrasound-guided techniques are considerably safer than blind approaches, since technical errors, such as trauma to adjacent structures or injection of anaesthetic components into the vertebral canal or inadvertent blocking of the sciatic nerve, are less likely to occur (Denoix & Jacquet, 2008).

There are several techniques described for diagnostic analgesia of the SI region (Cousty et al., 2008; Denoix & Jacquet, 2008), also used as therapeutical approaches for local injection of corticosteroids and others, with one (the caudal approach) not being recommended for diagnostic purposes (Denoix & Jacquet, 2008; Nagy et al., 2020); the most often used techniques are the cranial approach and the craniomedial approach. Despite the mentioned diffusion of the injected materials to other adjacent regions, these injections are still regarded as intraarticular injections, making the asepsis of the area where the needle is inserted particularly important; the transducer is also encased with a sterile glove in order to maintain the materials in contact with the injection area surface clean.

For the cranial approach (Figure 18), a square-to-rectangle area is clipped between the *tuber sacrale* and the *tuber coxae.* After the skin is aseptically prepared and the transducer covered with a gel-filled sterile glove, good contact between the transducer and the surface of the skin is achieved by saturation of the area with alcohol (Denoix & Jacquet, 2008). The transducer is placed in the prepped surface and moved in the parasagittal plane to allow for visualization of the transverse process of the fifth lumbar vertebra cranially, the iliac crest in the middle and the iliac wing caudally (normally corresponds to the right side of the screen). A long spinal needle (18 – 25 cm) is inserted cranial to the transducer and therefore cranial to the iliac wing, using an imaginary line uniting both *tuber coxae* to insert the needle transversally to this line, through the *gluteus medius* muscle (Cousty et al., 2008; Denoix & Jacquet, 2008; Stack et al., 2016). The needle is then imaged in the screen and re-directed in caudoventral direction of the SIJ, running along the caudal margin of the iliac wing, that will conceal the needle from this point. The needle is advanced until contact with bone is felt (sacral wing), and the solution is injected (Cousty et al., 2008; Denoix & Jacquet, 2008; Stack et al., 2016). This technique is associated with a moderate risk of temporary paresis of the hindlimb, due to the proximity to the L6 and S1 nerves that make the sciatic nerve, although it is not often manifested (Dyson & Murray, 2003; Denoix & Jacquet, 2008; Budras et al., 2011; Dyson, 2011; Stack et al., 2016; Jeffcott, 2018)

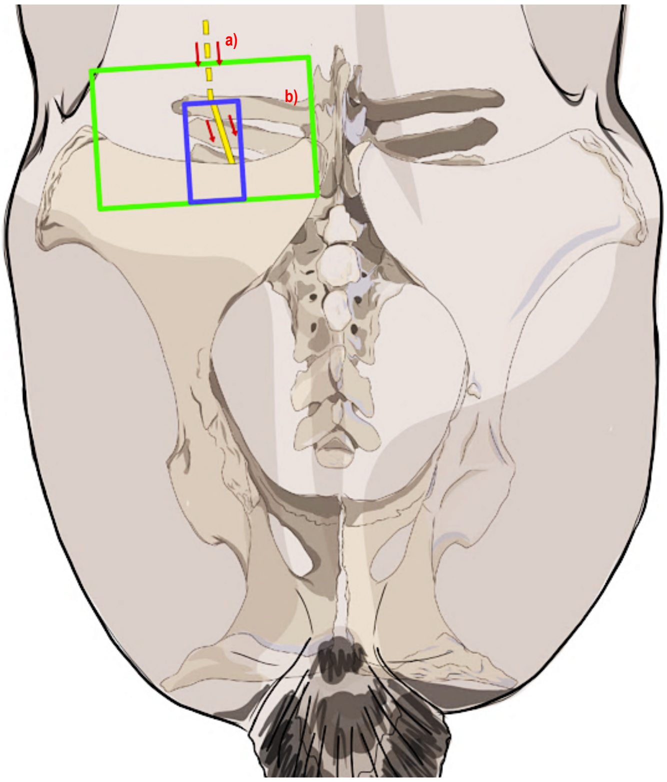


Figure 12: schematic representation of the cranial approach to the SIJ injection (dorsal view). The green rectangle represents the sterile area, and the blue rectangle represents the transducer placement. Note the change in direction of the needle (yellow interrupted and continuous lines), signalled by the red arrows, from a) transversal to the iliac wing to b) caudoventral once it is inserted cranially to the transducer.

For the craniomedial approach (Figure 19), a rectangular area is clipped over and between the two sacral tubers and the DSP of L6. The transducer is placed over the *tuber sacrale* ipsilateral to the SIJ intended for injection at an approximately 45º craniomedial – caudolateral angle to allow for simultaneous visualization of the DSP of the sixth lumbar vertebra (L6) and the *tuber sacrale.* A 9 to 15 cm spinal needle is then inserted between the DSP of the L6 and the cranial margin of the *tuber sacrale,* progressing in a caudolateral direction until contact with bone occurs, and the solution is injected (Cousty et al., 2008; Stack et al., 2016). Some authors (Dyson & Murray, 2003; Budras et al., 2011) have described a modified craniomedial approach, where the needle is inserted axial to the *tuber sacrale* contralateral to the SIJ intended to treat. The needle insertion is oblique in a caudal direction, and it is progressed to the location of the caudomedial border of the SIJ (inserted close to left *tuber sacrale* to inject right SIJ, for example). When performing a craniomedial approach, it is important to consider the risk of damage to the dorsal branches of the sacral nerves, the inadvertent injection of the solution into the blood vessels surrounding the SIJ and the incidental infiltration of the LS joint.

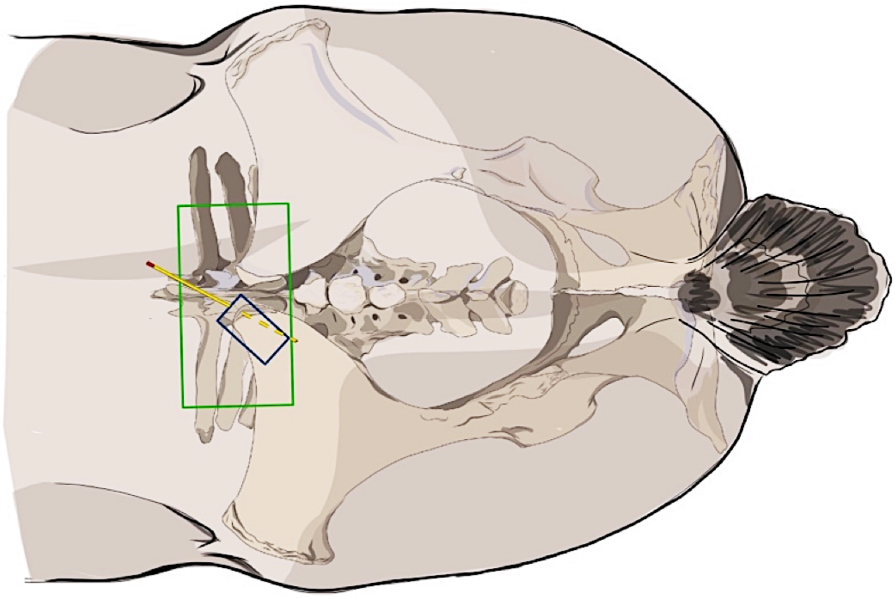


Figure 13: schematic representation of the craniomedial approach to the SIJ injection (dorsal view). The green rectangle represents the sterile area, and the blue rectangle represents the transducer placement. The needle is represented by the yellow line.

For the medial approach, a similar area as to the craniomedial approach is aseptically prepared. The transducer is positioned perpendicular to the axial plane, over the two *tubers sacrale (TS)* and moved caudally to allow for visualization of the caudal margins of both TS. Then, the transducer is slightly moved laterally, and a 9 to 15 cm spinal needle is introduced medially to the transducer and directed to the ipsilateral SIJ, running under the medial margin of the *tuber sacrale* (Cousty et al., 2008). This transducer positioning can also be used for a medial approach to the contralateral SIJ, as described by Budras et al. (2011) and Jeffcott et al. (2018). In this case, the transducer is positioned in the lumbosacral space then moved laterally to one of the sacral tubers; an 18 to 25 cm spinal needle is inserted axial to the tuber sacral (and cranial to the transducer) and directed caudomedially, towards the contralateral SIJ, by progressing between the DSPs of the L6 and the first sacral vertebra. The process can be repeated for the contralateral SIJ, by repeating the positioning of the transducer in the other *tuber sacrale*. The medial approach has its disadvantages and can result in diffusion of the injected solution to the ISILs, the dorsal branches of the sacral nerves and the *longissimus dorsi* muscle, and in transitory paresis of the sciatic nerve (Budras et al., 2011).

For the caudal approach, the position of some anatomical structures such as the cranial gluteal artery and veins and the sciatic nerve has to be taken in consideration, since their proximity to the injection site can result in catastrophic consequences (Cousty et al., 2008; Denoix & Jacquet, 2008). A rectangular area extending in a caudolateral direction from the *tuber sacrale* is aseptically prepared. The transducer is positioned caudally to the TS slightly oblique to the axial plane and perpendicular to the direction of the clipped rectangle (craniolateral to caudomedial). The dorsal SIJ space is visualized on ultrasound between the iliac and sacral wings. A 9 to 15 cm spinal needle is inserted between the transducer and the DSPs of the sacrum in caudodorsal to cranioventral direction, appearing on the right (caudal) side of the ultrasound image, and redirected to the imaged SIJ (Denoix & Jacquet, 2008). As mentioned, this approach is not recommended for diagnostic purposes and/or treatment due to the high risk of hindlimb paresis and, although considered safer than blind techniques, technical errors still occur, like injection of the solution into the vertebral canal and damage to the neurovascular components (Denoix & Jacquet, 2008; Nagy et al., 2020). Furthermore, Cousty et al. (2008) have reported injection of a solution in the retroperitoneal space of the pelvic cavity in a study of ultrasonographic-guided approaches to the SIJ, making this approach highly unsafe when compared to other techniques. Therefore, these authors (Cousty et al., 2008) have suggested an alternative caudal approach (Figure 20) intended to avoid retroperitoneal injection – positioning of the transducer longitudinally and parallel to the axial plane in order to simultaneously visualize the triangular shape formed between the lateral crest of the sacrum and the iliac wing and then moving it laterally until the lateral crest disappear and the nerves and vessels present are avoided. The needle is inserted caudally to the transducer and directed under the caudal margin of the iliac wing. Further advance of the needle is performed with caution and should be stopped after the needle end becomes concealed by the bone.

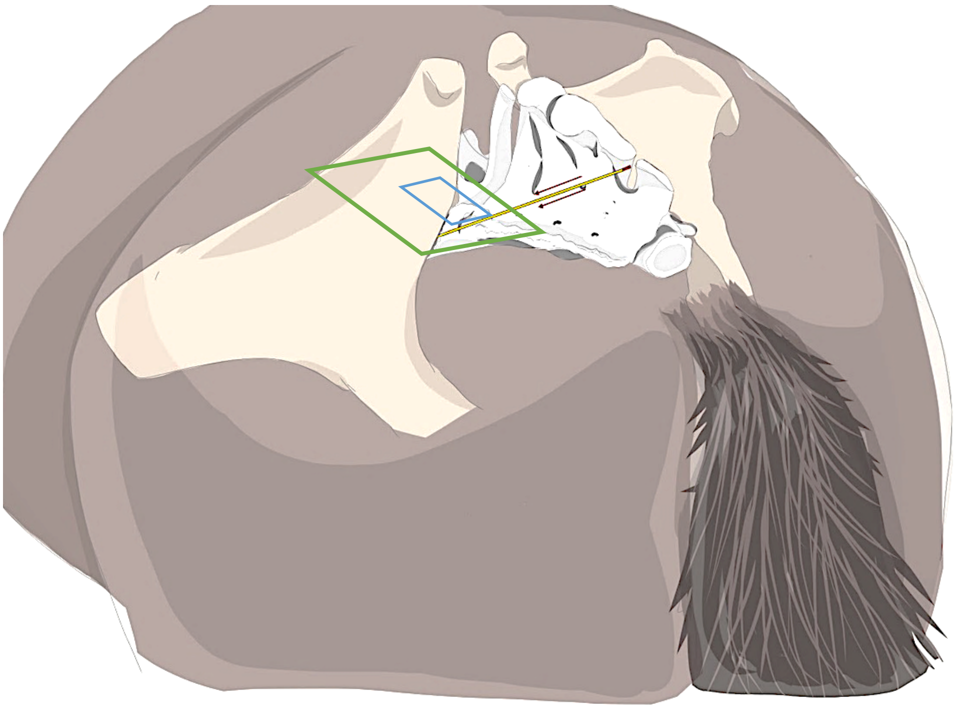


Figure 20: schematic representation of needle placement for the modified caudal approach to the SIJ (isometric view). The green rectangle represents the sterile area, and the blue rectangle represents the approximate position of the transducer. The needle is represented in yellow; the red arrows represent the direction of the needle's progression.

3.3. Treatment and prognosis

The management of SID is complex and revolves around pain-management and structural reinforcement, since the condition involves irreversible degenerative processes. A wide variety of treatment options is available, from pharmaceutical management (local injection of anti-inflammatories, systemic administration of NSAIDs, mesotherapy) to manual and complementary therapies (osteopathy, acupuncture, physiotherapy, shockwave) and rehabilitation exercises. (Dyson & Murray, 2003; Goff et al., 2008; Dyson, 2011; Jeffcott, 2018; Nagy et al., 2020; Ellis et al., 2021).

Local infiltration of corticosteroids, such as methylprednisolone acetate or triamcinolone, is the most common approach for pain management of SID, in combination or not with pitcher plant extract (Sarapin), unless the clinical signs and the imaging findings indicate acute injury, in which case rest along with systemic oral NSAIDs administration and revaluation of the animal after the end of the initial inflammatory response are advised. The techniques used for this local infiltration are the same as the described for diagnostic analgesia purposes, except the caudal approach. Oral administration of NSAIDs is also used as an adjuvant fore some cases of SID where the adjacent muscles and ligaments may benefit from the pain relief in order to allow for core musculature strengthening and development, essential in the rehabilitation exercises of the animals suffering from SID. (Dyson & Murray, 2003; Goff et al., 2008; Dyson, 2011; Jeffcott, 2018; Nagy et al., 2020; Ellis et al., 2021)

Despite prompt and adequate management of the condition, there is still a low chance of return to full athletic level by horses diagnosed with SID, with Nagy et al. (2020) determining that 16,7% of the studied animals temporarily returned to the same level of work, but only 13,1% maintained this work level for a period longer than a year (n = 84). Findings in the literature suggest that the prognosis for these animals has an inverse correlation with the severity of the clinical signs observed at the moment of diagnosis, as well as with the degree of SIJ degeneration and its contribution to the complaints – according to Nagy et al. (2020), horses with SIJ problems alone had more severe changes and did not return to full work, whereas horses where SID was determined secondary to other problems had higher chances of doing so (Dyson, 2011; Nagy et al., 2020).

4. Sacroiliac Dysfunction – Diagnosis and Treatment approaches: a clinical study

4.1. Introduction

Sacroiliac Dysfunction (SID) has been long established as a source of sacroiliac and back pain, causing loss of performance, gait abnormalities and inconsistent proximal hindlimb lameness in athletic horses (Dyson et al., 2003; Dyson & Murray, 2003; Gorgas et al., 2007, 2009; Goff et al., 2008; Dyson, 2011; Barstow & Dyson, 2015; Jeffcott, 2018; Nagy et al., 2020; Ellis et al., 2021).

To this day, diagnosis of SID relies not only on the clinical examination, but in its combination with a thorough imaging study, given the lack of specific clinical signs to this condition. Nevertheless, poor performance, lack of hindlimb impulsion, back pain/loss of suppleness and gait abnormalities without overt lameness have been consistently attributed to SID (Dyson et al., 2003; Dyson & Murray, 2003; Gorgas et al., 2007, 2009; Goff et al., 2008; Dyson, 2011; Barstow & Dyson, 2015; Jeffcott, 2018; Munroe, 2018; Nagy et al., 2020; Ellis et al., 2021).

The incidence of this condition can be somewhat underrated, given the fact that clinical signs may be misinterpreted as behavioural or riding issues, and, in the initial onset of the clinical signs, they can be mild to almost undetectable to a more unexperienced observer (Barstow & Dyson, 2015; Nagy et al., 2020). SID is more frequently observed in athletic horses, of bigger stature, particularly those practicing high-level dressage and showjumping, when compared to the rest of the population. Breed predisposition also seems to be present, with warmbloods seemingly more prone to the development of the condition. (Dyson & Murray, 2003; Goff et al., 2008; Dyson, 2011; Jeffcott, 2018; Nagy et al., 2020)

A small percentage of the studied animals presents with sacroiliac (SI) pain alone (Barstow & Dyson, 2015; Nagy et al., 2020). It is most common for the animals to present with concomitant conditions, such as cervical synovitis, 'kissing spines', lumbosacral pathology and hind proximal suspensory desmitis (Dyson, 2011; Barstow & Dyson, 2015; Munroe, 2018).

Many authors have described in detail the pathological changes found within the sacroiliac joints (SIJs) to which the clinical signs of pain and gait abnormalities have been attributed (Dyson, 2011; Gorgas et al., 2007, 2009; Jeffcott, 2018; Kersten & Edinger, 2010).

A variety of imaging modalities have been successfully used as means to evaluate the equine back and SI region and reach a definite diagnosis, such as radiography, computerized tomography, nuclear scintigraphy and ultrasonography. The results are best interpreted in association with the clinical findings, in order to assess the clinical relevance of the discoveries (Dyson et al., 2003; Dyson & Murray, 2003; Tomlinson et al., 2003; Kersten & Edinger, 2010; Budras et al., 2011; Dyson, 2011; Barstow & Dyson, 2015; Henson, 2018; Jeffcott, 2018; Powell, 2018; Whitcomb et al., 2018; Tallaj et al., 2019; Nagy et al., 2020; Ellis et al., 2021)

Ultrasonographic evaluation allows for a more complete analysis of the SI region. Furthermore, it has been proven to be more sensitive in cases of early onset of the pathological changes (Ellis et al., 2021).

Treatment of SID requires a dedicated and continuous approach; a successful management of SID depends on pain-management and structural reinforcement, given the condition's degenerative character. Treatment options include pharmaceutical management (local injection of anti-inflammatories, systemic administration of NSAIDs, mesotherapy), manual and adjuvant therapies (osteopathy, acupuncture, physiotherapy, shockwave) and rehabilitation exercises (Dyson & Murray, 2003; Goff et al., 2008; Dyson, 2011; Jeffcott, 2018; Nagy et al., 2020; Ellis et al., 2021). Local injection of anti-inflammatories is the most common methodology for pain management in SID, and the technique's description is widely available in the literature (Kersten & Edinger, 2010; Budras et al., 2011; Jeffcott, 2018; Whitcomb et al., 2018; Tallaj et al., 2019; Ellis et al., 2021).

The objectives of this study are to: 1) describe the clinical presentation of horses with suspected SIJ pain and/or SID, with and without concurrent locomotor pathologies; 2) describe and discuss the imaging findings acquired by the available modalities; 3) detail the treatment choices, considering primary and secondary pathologies, and report the outcome of the analysed cases.

4.2. Materials and Methods

4.2.1. Data Collection

32 horses from the Lingehoeve Diergeneeskunde informatic system's database were selected for this study. The inclusion criteria consisted of horses that were presented to the clinic, either for first consult or for follow-up consult, during the externship's period (29th November 2020 to 30th January 2021) and fulfilled one or more of the following premises: having a previous diagnosis of SID or clinical signs that led to the suspicion of SI region pain or SID, imaging findings compatible with SID, treatment of the SI region. The signs considered suggestive of SI pain or SID included: poor performance, difficulty in canter/bucking in canter, reluctance to work when ridden, back pain, sensitivity on palpation of lumbosacral area, *tuber sacrale* and *tuber coxae* and gluteal muscles, discomfort in proximal hindlimb flexion (i.e., pick up feet, flexion tests), and exaggerated response to stress tests of the SI region. Horses with concurrent lameness of the fore- or hindlimbs were also included whenever the flexion tests were negative for the lower limbs and/or diagnostic analgesia of the distal limbs was negative or, when positive for the lameness, didn't resolve the rest of the clinical signs. The data collected for the purposes of this study involved the signalment of the horses (sex, age, breed), the motive for consult, the relevant clinical findings, the imaging findings in radiographic, scintigraphic, tomographic and ultrasonographic studies (when performed), the treatments instated in the SI region and in other concurrent pathological locations, and the evolution of the case, whenever related by the treating veterinarian or reported by the client and transcribed to the patient's file.

4.2.2. Clinical Evaluation

The clinical examination producing a diagnosis was always performed by one of the two ISELP-certified orthopaedic veterinarians working at De Lingehoeve. All horses were examined: at rest in a flat surface, where manipulation and stress tests were also performed; in hand on a hard surface - in straight lines and turning on tight figure eights; on the lunge on both hard and soft surfaces. Whenever necessary and possible, a ridden lameness evaluation was also performed.

4.2.3. Imaging Evaluation

Radiographic images of the thoracolumbar region were captured whenever clinical signs of back pain and stiffness were shown, for the possibility of concurrent primary or secondary thoracolumbar pathology.

Ultrasonographic evaluation was performed in the 32 horses included in this study. The regions evaluated included not only the SI region, but the cervical, the thoracolumbar and the coxofemoral joints, and, whenever lower hindlimb lameness was suspected, these areas were also scanned. This evaluation was performed transcutaneous to assess the cervical, thoracolumbar, lumbosacral, coxofemoral and distal limbs regions, and transrectally, to assess the LS disc and joint, the nerve roots of L6, S1 and S2, the VSILs, the ventral part of the SIJs, the intertransverse joints and the aorta and iliolumbar arteries. Pathological findings in the SIJ were categorized on a three-point scale: mild, moderate and severe.

Nuclear scintigraphy was performed whenever the findings on the radiographic and ultrasonographic studies were inconclusive or didn't explain the clinical signs. The grading of the images was performed by the ISELP certified veterinarians on a four-point scale: no significant uptake (-); mild IRU, possibly not clinically relevant (+); moderate IRU, possibly related to the clinical signs (++); marked IRU, probably related to the clinical signs (+++).

Computerized Tomography (CT) of the pelvic region was performed on three horses; the findings are detailed further on section 4.3.2.2. and on table 21.

4.2.4. Treatment

All the local treatments to the SI and LS region were performed under ultrasonographic guidance; the SI infiltration was performed with the craniomedial approach (described in section 3.2.4.) to the SI region. Other treatments included systemic oral administration of NSAIDs, mesotherapy, rest, physiotherapy, osteopathy and rehabilitation exercises, in accordance to the literature (Dyson & Murray, 2003; Goff et al., 2008; Dyson, 2011; Jeffcott, 2018; Nagy et al., 2020; Ellis et al., 2021). Whenever other pathologies were present and treatments were warranted, these were also registered and accounted for when evaluating the evolution of the case and return to performance.

4.2.5. Statistical analysis

All data analysis was performed using Microsoft Excel (2021).

4.3. Results

4.3.1. Signalment

The mean age of the 32 horses diagnosed with SI pain or SID was 10,3 ± 4,7 years (range 4 – 22; median = 10), and the complete signalment can be observed on Table 18.

Table 18: signalment of the 32 horses with sacroiliac dysfunction.

		SI	SI + other pathologies	All
Age	*Mean age + s.d. (years)*	8,6 +- 3,3	10,8 +- 4,8	10,3 +- 4,7
	Median age (years)	8	11	10
	Range (years)	5 to 14	4 to 22	4 to 22
Sex	*Gelding*	4	15	19
	Mare	5	6	11
	Stallion	1	1	2
Breed	*Warmblood*	8	15	23
	Other	2	7	9
Fi (Fr %)		10 (31,3)	22 (68,7)	32 (100)

4.3.2. Clinical and Imaging Findings

4.3.2.1. *Clinical findings*

Table 19: List of complaints reported by the owners prior to clinical examination.

Complaint	Fi
Stiff movement of the back	13
Problem in canter	7
Impossibility to ride	2
'Wobbler'	1
Drops the hindquarters	1
Breaks to trot in canter	1
Poor performance	16
Hindlimb lameness	5
Feels different	1
Previous diagnosis SI	2
Hindlimb rigidity	1
Painful/sensitive back	3
Bunny hopping	1
Headshaking	1
Forelimb lameness	1
Lack of impulsion	2
Total	46

Table 20: List of clinical signs observed during clinical examination.

Clinical examination	Fi
Fore and hindlimb(s) lameness	2
Little flexibility neck	3
Refusal to canter	3
No flexion/extension epaxial muscles	5
Plaited gait hindlimb(s)	6
Reduced lateroflexion	9
Shortened canter	4
No lumbar/lumbosacral flexibility	4
Painful/sensitive manipulation back	7
Painful/sensitive manipulation LS/SI	8
Stiff canter	4
Hindlimb(s) lameness	5
Wide hindlimbs in gait	1
Difficulty to turn on its length	2
Hard to pick up hindlimb(s)	4
'Bunny hopping'	2
Cross-gait canter	1

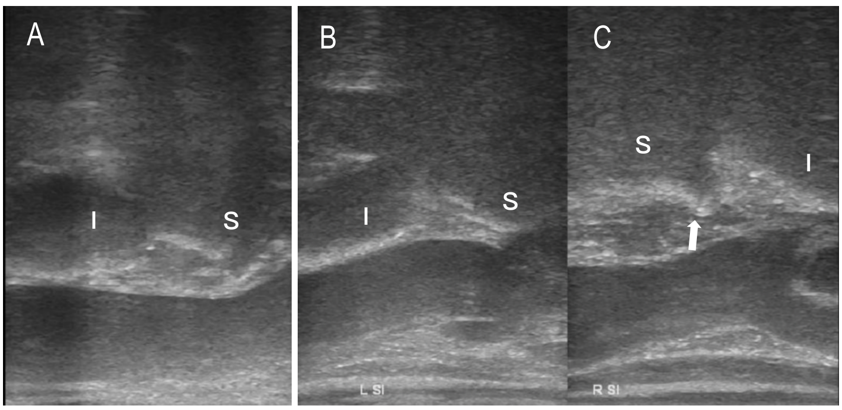
Hindlimb dragging	**4**
Overall stiffness	5
Lack of impulsion hindlimbs	5
Forelimb(s) lameness	1
Refusal to rear	2
Ataxic	2
Bucking in canter	1
Asymmetrical *tuber sacrale/coxae*	2
Shortened walk	1
Total	93

A summarized list of the initial complaints and motive for consulted is presented on Table 19, along with a list of the clinical signs observed by the veterinarians during the clinical examination of the 32 horses (Table 20). The majority of the horses had concurrent pathologies along with SID and, along with those who were presented with only SID symptoms/diagnosis, horses presented with multiple complaints and clinical signs, explaining the disparity between the number of horses (32) and the large number of reported complaints (46) and clinical findings (93).

4.3.2.2. *Imaging findings*

All of the horses included in this analysis underwent ultrasonographic evaluation, 46,9% (15 of 32) were subjected to radiographic evaluation, 9,4% (3) did a nuclear scintigraphy exam and computerized tomography was performed on 9,4% (3) of the horses.

Ultrasonographic abnormalities within the lumbosacral region were detected in 34,4% (11 of 32) of the horses. All 32 horses (100%) presented some degree of SI abnormalities that ranges from mild to severe, either uni- or bilateral. Examples of SI findings are illustrated on *Figure 21*. Abnormalities not related to SID included cervical synovitis in 25% (8 of 32) of the horses, scapulohumeral joint arthritis and bicipital enthesopathy in one horse, and proximal suspensory desmopathy in a forelimb of one horse. Abnormalities detected in coxofemoral joint – 12,5% (4) of the horses – and in the femorotibial joint (FTJ) – 12,5% (4) of the horses – were considered primary injuries that led to SID development in these horses, along with the proximal suspensory desmopathy detected in the hindlimbs in 12,5% (4) of the horses.



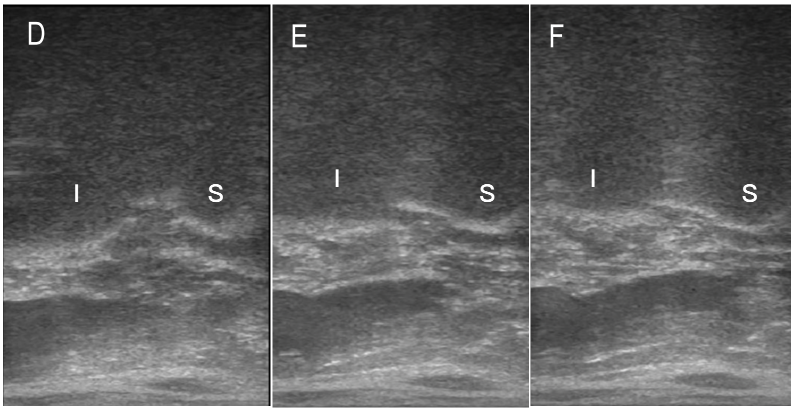


Figure 21: transrectally obtained ultrasound images of the SIJ, displaying different degrees of remodelling. **(A)** shows mild remodelling of a left SIJ, with some echogenic spots on the ventral border of the iliac wing (I); **(B)** and **(C)** show the left and right SIJs of a horse, left SIJ is normal in appearance and right SIJ shows moderate to severe signs of remodelling, with several hyperechogenic spots on the ventral border of the iliac wing (I) and a small hook formation (white arrow) on the caudoventral border of the sacrum wing (S); **(D)**, **(E)** and **(F)** show the left SIJ of a same horse, with severe changes in shape and appearance – note the heterogenicity of the SIJ space and the irregular margins of both sacrum and ilium wings.

Of the radiographic changes detected on the 15 horses subjected to this modality, 20% (3) had overriding spinous processes ('kissing spines'), one horse had osteophyte formation in the lumbar vertebrae, one horse had osteoarthritis (OA) of both metacarpophalangeal (MCP) joints, one horse presented OA of the tarsometatarsal and distal metatarsal joints ('spavin'), one horse showed changes compatible with OA of the metatarsophalangeal (MTP) joint and 2 horses had changes compatible with cervical arthritis.

Of the horses subjected to nuclear scintigraphy, clinically relevant IRU (++) was present in only two (2) cases, with one of them presenting concurrent IRU in thoracolumbar region, and the other concurrent hip region IRU. The third horse subjected to nuclear scintigraphy only revealed a bilateral IRU (++) in the stifles.

Regarding the three (3) horses that underwent computerized tomography (CT) examination, one horse concurrently presented ankylosis in the intervertebral joints of L2L3 and L3L4, subluxation of the lumbosacral joint, prolapse of the L6 disc, lateral spondylosis on the L4L5 and moderate remodelling of the right SIJ (Figure 22, B), another horse had severe left coxofemoral joint OA with an acetabular slap fracture, severe OA of both SIJs and mild remodelling of the right coxofemoral joint; the third horse had OA on the left acetabular surface and mild OA of both SIJs, considered to be secondary to coxofemoral OA.

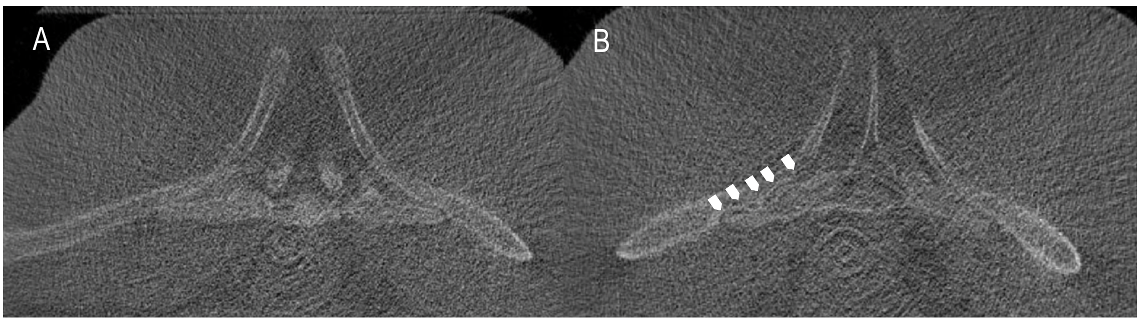


Figure 22: computerized tomography (CT) transversal scans of a horse with (A) normal left SIJ and (B) moderate OA of the right SIJ (white arrow heads)

The complete list of abnormalities detected in each modality were registered and are displayed on Table 21.

Table 21: Abnormalities detected on imaging examination of suspected problematic areas, including the SI region.

Abnormalities		**Fi**
Ultrasound		
SI changes	*Mild*	13
	Moderate	8
	Severe	11
Ventral sacroiliac ligament desmopathy		3
Lumbosacral OA		6
L6 disc protrusion/prolapse		2
Abnormal nerve roots		2
Lumbosacral intertransverse ankylosis		3
Lumbar spondylosis		4
Supraspinous ligament desmopathy		2
Cervical synovitis/OA		8
Remodelling coxofemoral joint		4
Acetabulum slap fracture		1
Shoulder distention/capsulitis		2
Enthesophytes bicipital tendon attachment		1
Knee distention/remodelling		5
Proximal suspensory desmopathy		5
Radiography		
Kissing spines		3
Lumbar osteophytes		1
MCP OA		1
MTP OA		1
Spavin OA		1
Cervical arthrosis		2
Scintigraphy		
Knee IRU (++)		1
SI IRU (++)		2
Thoracolumbar IRU (++)		1
Hip IRU (++)		1
CT		
Remodelling SI		2
Lumbar OA/ankylosis		1
Subluxation LS joint		1
Prolapse L6 disc		1
Lateral spondylosis L4L5		1
Coxofemoral remodelling/fracture		2
Knee distention/remodelling		1
Total		103*

**Note: when interpreting the results, that the majority of the horses presented more than one abnormal finding on the imaging exams, hence the disparity between the number of abnormalities (103) and the number of horses examined (32).*

4.3.2.3. *Concomitant pathologies*

Based on the clinical and imaging findings, a list of concurrent pathologies was elaborated and can be consulted on Table 22. As mentioned before (*Table 18*), several horses presented with at least one concomitant pathology at the moment of evaluation, representing 68,7% (22 of 32) of the animals in this analysis.

Table 22: List of concomitant pathologies found in the 32 horses

Concomitant pathologies	Fi (Fr %; n=32)
Shoulder pathology	2 (6,3)
Cervical synovitis/remodeling	8 (25)
Thoracal/Lumbar/lumbosacral	11 (34,4)
Proximal suspensory desmopathy	4 (12,5)
Knee injury/remodeling	4 (12,5)
Hip joint injury/pathology	4 (12,5)
RER	2 (6,3)
Enthesopathy SL forelimbs	1 (3,1)
Osteaoarthrosis distal forelimbs	2 (6,3)
Total	38

4.3.3. Treatment

The treatment decision for each animal depended on the concurrent diagnosis of other pathologies, the severity of the clinical signs, the economical limitations of the owners and the prognosis for each individual. The therapeutical decision included ‘no treatment’, injection of the SIJ, injection of the LS joint, systemic oral administration of NSAIDs, mesotherapy, rest, physiotherapy, osteopathy and rehabilitation exercises. It was also decided, considering the probability of the SID being the primary or a secondary condition, if other diagnosed conditions should be treated first or concurrently with the SI region. More than one treatment modality was applied to the majority of the horses. The distribution of these decisions can be consulted on table 23.

Table 23: distribution of the therapeutical decisions and modalities for the 32 cases studied

Treatment	Fi	Fr % (n =32)
Inject SI (Triamcinolone/ Triamcinolone + Dexamethasone)	21	65,7
Inject LS (Triamcinolone)	3	9,4
NSAIDs (oral)	10	31,3
Mesotherapy (Dexamethasone + Sarapin + Lidocaine)	16	50
Rest	6	18,8

Physiotherapy/osteopathy/exercise	5	15,7
Treat other conditions first	*7*	*21,9*
Treat multiple conditions at the same time	*14*	*43,8*
Treat only SID	*8*	*25*
No treatment	*3*	*9,4*

All SI and LS regions infiltrations, as well as cervical intraarticular injections, were performed with ultrasound guidance.

Three animals (9,4%) didn't receive any type of treatment, with two of them subjected to euthanasia due to the severity of the changes detected; the other animal's treatment was not allowed by the owner due to economic reasons. A quarter of the horses (8 of 32) were treated only for SID and the treatment consisted in local infiltration of corticosteroids + mesotherapy in 75% (6 of 8) of the horses, with 25% (2) receiving only regional infiltration of the SI region; two of the eight horses were also administered oral NSAIDs. Seven horses (21,9%) were treated first for the primary causes believed to be at the origin of the clinical signs, delaying the treatment of the SI region to future evaluation and possible intervention. The remaining 43,8% of the horses were concurrently treated for SID and concomitant injuries after analysing the importance of the SI changes and the severity of the other pathologies.

4.3.4. Return to performance

Based on the available data, the animals' return to performance was divided in 'Euthanasia', 'Retired', 'Lower level', 'Same level' and 'Higher level'. The distribution of the animals' return to performance is available on Table 24.

Three (9,4%) horses were euthanized, two at the moment of diagnosis, due to the severity of the imaging and clinical changes observed, and one was treated for SHJ pathology at the first consult, but the clinical signs worsened, and the owner opted for euthanasia one month later. These horses had severe osteoarthritic changes in one or both SIJs, along with other chronic conditions, including OA of the shoulder joint (1), 'kissing spines' (1), enthesopathy of the left hind suspensory ligament (1), severe synovitis on caudal cervical joints (2) and severe osteoarthritic changes of the coxofemoral joints with acetabulum slap fracture (1). Two horses (6,3%) were retired; one had SID in association with ankylosis of the L2-L4 transverse processes, lateral spondylosis of the L4L5, subluxation of the lumbosacral and prolapse of the L6 (lumbosacral) intervertebral disc. These animals were mares and due to the found changes they were retired for breeding. 28,1% of the horses (9 horses) were working on a lower level of performance at the time of this analysis, with one horse diagnosed with SID alone and two horses with lumbar/lumbosacral pathology. Almost half (43,8%) of the horses returned to the same level of work as before the clinical signs arose, with 22,2% of these horses (4 of 14) suffering from SID without other concurrent pathologies and 22,2% (4 of 14) suffering from concomitant lumbosacral pathology. Two of the horses that returned to the same level of performance had a diagnosis of recurrent exertional rhabdomyolysis (RER), which was determined as being the causing condition of the clinical signs (back stiffness, sensitivity on palpation of back and gluteal muscles, inability to change gaits).Only four horses (12,5%; n=32) were performing at a higher level of performance after treatment, at the time of this analysis, with only one of these four horses diagnosed with SID alone.

Table 24: Distribution of the horses by the level of performance after initial diagnosis

Return to performance	Fi	Fr %
Euthanasia	3	9,4 (n=32)
Treated (Fr for n =3)	*1*	*33,3(3)*
Not treated (Fr for n =3)	*2*	*66,6(6)*
Retired	2	6,3 (n=32)
SI pathology alone (Fr for n=2)	1	50
>1 pathologies other than SI-related (Fr for n=2)	1	50
Lower level	9	28,1 (n=32)
Concomitant Knee injury/remodelling (Fr for n =9)	*2*	*22,2(2)*
Concomitant Hindlimb SL enthesopathy (Fr for n =9)	*1*	*11,1(1)*
SI pathology (Fr for n =9)	*1 (not treated)*	*11,1(1)*
Concomitant Lumbar/lumbosacral pathology (Fr for n =9)	*2*	*22,2(2)*
Concomitant Hip remodelling (Fr for n =9)	*1*	*11,1(1)*
>1 pathologies other than SI-related (Fr for n =9)	*2*	*22,2(2)*
Same level	14	43,8 (n=32)
>1 pathologies other than SI-related (Fr for n =14)	*3*	*21,4*
RER (Fr for n =14)	*2*	*14,3*
SI pathology (Fr for n =14)	*4*	*28,6*
Concomitant Knee injury/remodelling (Fr for n =14)	*1*	*7,1*
Concomitant Lumbar/lumbosacral pathology (Fr for n =14)	*4*	*28,6*
Higher level	4	12,5 (n=32)
Concomitant Cervical synovitis/arthrosis (Fr for n =4)	*1*	*25*
>1 pathologies other than SI-related (Fr for n =4)	*1*	*25*
Concomitant Hindlimb SL enthesopathy (Fr for n =4)	*1*	*25*
Only SI pathology (Fr for n =4)	*1*	*25*

4.4. Discussion

According to the analysis of the data collected, 31,3% (10 of 32) of the selected cases presented SID without any other diagnosed pathologies, meaning the majority of the horses (68,7%; n = 32) had concurrent pathologies besides SID or SI region pain, being in accordance to the approximately 75% of concomitant pathologies that has been described by some (Ellis et al., 2021), but in opposition to the 14,5% to 17,9% that has been reported by others (Barstow & Dyson, 2015; Nagy et al., 2020). Of the 32 horses, 34,4% were concurrently diagnosed with back (thoracolumbar, lumbar and lumbosacral) pathologies. Moreover, 25% of the animals in this study presented concomitant cervical pathology. Other pathologies, such as coxofemoral OA, FTJ OA and proximal suspensory desmopathy were also present in 12,5% of the analysed cases. These findings align with those described by other authors (Dyson, 2011; Barstow & Dyson, 2015; Munroe, 2018), that SID often presents with concomitant pathologies of the musculoskeletal system.

The mean age of all the 32 horses diagnosed with SI pain or SID was 10,3 $\pm$ 4,7 years, which in agreement to what has been reported by others (Dyson & Murray, 2003; Ellis et al., 2021).

Poor performance and stiffness of the back were the most commonly reported complaints (50% and 40,6%, respectively, but a variety of gait abnormalities and hindlimb lameness were reported, consistent with previous the existing literature (Dyson et al., 2003; Dyson & Murray, 2003; Gorgas et al., 2007, 2009; Goff et al., 2008; Dyson, 2011; Barstow & Dyson, 2015; Jeffcott, 2018; Nagy et al., 2020; Ellis et al., 2021).

Clinical signs most often observed were related to gait abnormalities on the hindlimbs, that worsened at canter, in line to what has been reported (Dyson, 2011; Goff et al., 2008; Gorgas et al., 2007, 2009; Jeffcott, 2018; Kersten & Edinger, 2010).

The imaging findings included ultrasonographic abnormalities of the lumbosacral region in 34,4% and of the SI region in 100% of the cases. Abnormalities not related to SID were detected in 31,3% (10 of 32) horses, with the abnormalities detected in the coxofemoral (12,5%) and in the FTJ (12,5%) being considered primary injuries that led to SID development, with or without association with hindlimb proximal suspensory desmopathy detected in 12,5% of the cases (Goff et al., 2008; Dyson, 2011; Barstow & Dyson, 2015; Nagy et al., 2020; Ellis et al., 2021). The number of scintigraphic and tomographic exams is limited, especially due to economic restrictions, but it can be concluded that, when in association with clinical signs, ultrasonographic evaluation can be sufficient to produce a definite diagnosis, following the same conclusions of some authors (Tomlinson et al., 2003; Barstow & Dyson, 2015; Ellis et al., 2021).

Treatment approaches to the cases depended mainly on whether SID was considered the primary pathology or a consequence of other limb and back pathologies, reflected by the low percentage (25%) of horses only treated for SID, when compared to the 65,7% of cases where other conditions were treated first than SI-related changes (21,9%) or simultaneously (43,8%). The remaining horses (9,4%) that did not receive treatment were either euthanized (2 of 3) or the treatment was refused by the owner.

To the present moment, 18 of the 32 horses (56,3%) returned to same (43,8%) or higher level (12,5%) of performance, according to what was reported by the owners by telephone or at follow-up consults, all of which received treatment to the existing condition(s). The three horses subjected to euthanasia had severe osteoarthritic changes at time of diagnosis and their prognosis was very guarded. The two retired horses presented also with severe SI osteoarthritis. The retirement decision was made by the owners, considering the several abnormalities detected, the horses' age (the one with multiple conditions was 16 years-old and the other with SID alone was five years-old) and the fact that both were mares with good pedigree and ability to breed. The horses that returned to a lower level of performance (28,1%) had, except for one, concomitant pathologies that were treated and the outcome of the cases was also influenced by the evolution of these other conditions.

The findings in this analysis may not be representative of the equine world population, not only because of the relatively small number of participating individuals (32), but because the signalment of this group of animals is related to the signalment of the client database of De Lingehoeve, which in itself is not representative of the general Dutch population of horses presented at veterinary facilities for orthopaedic consult. Future studies with a wider database, built with sample groups from various facilities form several countries, would provide results more representative of the global incidence of this condition and allow the analysis of predisposing factors to the development of SID, such as environmental factors and training habits.

In conclusion, SID is an important cause for poor performance in horses, and the vague clinical signs with it associated and the common occurrence of concomitant injuries, make this condition a diagnostic challenge that is likely to remain somewhat underdiagnosed (Barstow & Dyson, 2015; Ellis et al., 2021; Nagy et al., 2020). Nonetheless, recent developments in imaging modalities have rendered the diagnosis of SID more likely to occur, and further education of veterinarian practitioners may contribute to a more common presence of this condition in the list of differential diagnosis in cases of upper hindlimb lameness and gait abnormalities (Erichsen et al., 2002 a; Dyson et al., 2003; Tomlinson et al., 2003; Gorgas et al., 2007, 2009; Kersten & Edinger, 2010; Dyson, 2011; Barstow & Dyson, 2015; Nagy et al., 2020). Furthermore, an extensive comprehension of the equine biomechanics and the anatomical structures involved in the development of SID is essential for the correct diagnosis of the condition and the determination of the clinical relevance of the findings encountered when performing an orthopaedic evaluation (Goff et al., 2008).

5. Final Conclusions

The completion of an externship at the end of the academic education of the student of veterinary medicine is essential in demonstrating the clinical and practical application of the concepts and techniques taught throughout the years. In the externship, the student is finally able to consolidate and verify the importance of all the accumulated knowledge and, more importantly, contact with the veterinarian-client relationship on a daily basis and learn to associate the medical approach to the barriers and unexpected situations that rise in the clinical context.

The opportunity to complete the externship in a foreign country (the Netherlands) brought to light the differences between our two countries, not only in the scientific perspective, but also in the client's relation with the veterinarian and their willingness to pursue an evidence-supported diagnosis and treat the animals in accordance. The fact that it is common practice in the Netherlands for the owners to go to the clinical facility with their horses for thorough investigation, whether the case requires constant monitoring or supplementary exams, as is the case for orthopaedic consults, including pre-purchase examinations, and most cases attributed to internal medicine causes, contrasts with the general Portuguese reality. Gynaecological consults, prophylactic procedures including routine dentistry procedures and simple wounds are exceptions to this conduct, as are some non-strangulating colic cases, but the latter will be referred to the hospital if the colic symptoms do not resolve after two interventions in a 12-hour window. The fact that there are so many diagnostic and treatment modalities, and that it is common practice for veterinarians to refer their clients to specialized veterinarians/institutions with access to these techniques, make up for the wide variety of cases observed by the extern during this relatively short period.

This externship report intends to describe the amount and diversity of the caseload followed, highlighting one or more cases related to each medical field of expertise, in order to portray the medical and/or chirurgical approach to each of these cases by the veterinarians of the institutions where the externship was carried.

The selection of the subject for the monography was a result of the frequent observation of orthopaedic cases showing signs of this condition, as well as of the fact that the two orthopaedic specialists working at the Lingehoeve Diergeneeskunde were certified by the International Society of Equine Locomotor Pathology, that encourages its members to resort to several imaging techniques for the establishment of a definite diagnosis, with special emphasis on the conditions not easily and commonly diagnosed by general and ambulatory practitioners. The data for the study was collected considering the animals followed during the externship period, in order to ensure that the procedures reported were observed at some degree by the extern. The main objective of this descriptive analysis of the cases was to highlight the importance of a good knowledge of biomechanical and anatomical features particular to the sacroiliac region, the variety of pathologies that are direct and indirectly related to this region and the effect of the progression of the condition in the equine's athletic performance.

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