Chiari-like malformation and syringomyelia

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Syringomyelia is an increasingly common diagnosis in veterinary medicine, most commonly caused by Chiari-like malformation in dogs, as is outlined in this comprehensive FECAVA award-winning paper

INTRODUCTION

Syringomyelia is a condition characterised by fluid filled cavities (syrinxes or syringes) within the central spinal cord, and the resulting damage produces clinical signs of pain and neurological deficits. Since the increase in availability of magnetic resonance imaging (MRI), syringomyelia is an increasingly common diagnosis in veterinary medicine.[1,2]
The most common cause of syringomyelia in the dog is Chiari-like malformation (Figure 1), a condition analogous to Chiari type I and 0 malformation in humans.[3,4]

PATHOPHYSIOLOGY OF SYRINGOMYELIA

A satisfactory explanation of how syringomyelia develops has yet to be elucidated. There is not even a consensus as to whether syrinx fluid is derived from extracellular or cerebrospinal fluid (CSF).[5-8] Syringomyelia is a disorder of CSF; therefore, understanding the pathogenesis of this enigmatic disorder is dependent on understanding CSF flow dynamics, biochemistry and factors that influence its absorption and production.
The majority of CSF is produced by the four choroid plexuses (one in each ventricle of the brain), which circulates through the ventricular system and the subarachnoid spaces of the brain and spinal cord.[9,10] Drainage of CSF is partly into the blood through arachnoid granulations and villi, and partly along lymphatic drainage pathways, mostly associated with the cribriform plate of the ethmoid bone.[11] It has also been suggested that the spinal central canal may play a part in drainage of CSF and/or excess extracellular fluid as there is functional communication between the central canal and the subarachnoid space at the terminal ventricle.[12,13]
One of the major functions of CSF is as a mechanical buffer, however it does not just provide a physical cushion and reduce tension on nerve roots but also accommodates the pressure of the systolic pulse and reduces the weight of this heavy organ. Without the CSF, a human could not stand upright and within the CSF, a 1,500g brain weighs only 50g.[14]
According to the Munro-Kellie doctrine, the central nervous system and its accompanying fluids are enclosed in a rigid container whose total volume remains constant. Therefore, when the heart beats and there is increase in volume of intracranial blood, CSF is displaced from the cranial to the spinal subarachnoid space through the foramen magnum thus avoiding a deleterious increase in intracranial pressure. The spinal dural sac is distensible, further increasing the compliance of the system and minimising rises in central nervous system pressure.[15] Disturbance of the normal free flow of CSF through the foramen magnum appears to be a major factor responsible for the formation of a syrinx in the cervical spinal cord.[2,16,17] However, there may be other possible factors influencing the pathogenesis of a syringomyelia such as failure of absorption or drainage of extracellular fluid,[18] intracranial hypertension,[19-21] imbalance in the production and absorption of CSF,[22] disruptions of the blood-spinal cord barrier or alterations of aquaporin expression.[23]
The currently most accepted theory of pathogenesis of syringomyelia is that obstruction to CSF flow in the subarachnoid space results in a mismatch in timing between the arterial pulse peak pressure and CSF pulse peak pressure. Earlier arrival of peak CSF pressure compared to peak spinal arterial pressure encourages flow of CSF into the perivascular space. The perivascular space changes in size during the cardiac cycle and is widest when spinal arteriole pressure is low. If, at that time, peak CSF pressure is high then the perivascular space could act as a 'leaky' one-way valve.[8,24-27] From the perivascular space, fluid flows into the central canal, ultimately resulting in a syrinx.[28-30] However, this theory also leaves many unanswered questions and further study is required.
In the dog, syringomyelia is associated with a number of different pathologies with a common theme of CSF flow obstruction. The most common cause is Chiari-like malformation, which is a complex abnormality characterised by overcrowding of the craniocervical junction and obstruction of CSF flow through the foramen magnum. It is unclear why some dogs with Chiari-like malformation develop syringomyelia and some do not.[31,32] Numerous studies, mostly in Cavalier King Charles spaniels (CKCS) and Griffon Bruxellois, have identified many 'pieces of the jigsaw', however key parts are still missing.
No study has identified a single anatomical feature that consistently predicts syrinx development and it is likely that the pathogenesis of syringomyelia is a multifactorial process.

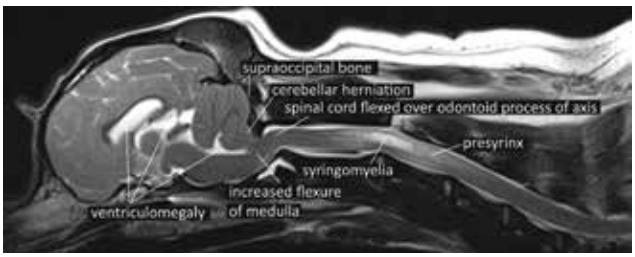

Figure 1: Midline sagittal T2-weighted MRI image of the brain and cervical spinal cord from one-year-old female CKCS with Chiari malformation and syringomyelia and presenting with pain.

PREVALENCE AND INCIDENCE

CHIARI MALFORMATION

Brachycephalicism and miniaturisation are risk factors for Chiari-like malformation.[33] The condition is most commonly reported in toy breed dogs, in particular CKCS, King Charles spaniels, Griffon Bruxellois, Affenpinschers, Yorkshire terriers, Maltese terriers, Chihuahuas, Pomeranians, Boston terriers and Papillons.[34] Chiari-like malformation has also been recognised in cross-breed dogs, particularly CKCS crosses. Partly because of its popularity as a pet, the CKCS is over-represented and Chiari malformation is considered ubiquitous in this breed.[1,31,35] Up to 65 per cent of the Griffon Bruxellois breed has Chiari-like malformation;[21,36] data for other breeds are not available. Chiari-like malformation may also be seen in cats and is again more common in brachycephalic varieties, such as the Persian. The incidence of symptomatic Chiari-like malformation is not known and is difficult to determine because the most common clinical sign is pain. Pain is a complex amalgamation of sensation, emotions and (in humans) thoughts, and manifests itself as pain behaviour[37] which, in a dog, may not be recognised by owners or their veterinarians. In addition, pain associated with Chiari-like malformation is rarely constant or focal. In humans, the key features of Chiari-related headaches are their relationship to any Valsalva-like manoeuvre, their brief duration – often lasting only seconds – and their posterior, suboccipital location.[38] In a dog, this might manifest as a yelp on a rapid change of position, for example being picked up. It is difficult to attribute non-specific and brief signs to a specific aetiology, especially when a condition is common in a breed and can be asymptomatic. The reported number of human patients with asymptomatic Chiari malformation type 1 varies between a third and a half of those diagnosed with the condition by MRI.[39-42]

SYRINGOMYELIA

Due to the relationship with Chiari-like malformation, prevalence of syringomyelia is also high in brachycephalic toy-breeds.[34] Again, not all animals with syringomyelia are symptomatic and, like Chiari-like malformation, it is difficult to obtain reliable incidence data. In humans, the reported frequency of syringomyelia in people who have Chiari malformation type 1 ranges from 65 to 80 per cent[44] and the frequency of asymptomatic syringomyelia has been reported as being 23 per cent.[45] Syringomyelia has a varying age of onset. There is 46 per cent prevalence in

Figure 2: It is common for dogs with Chiari-like malformation to have exotropia or outward deviation of the eye (in this case, the right eye) when gazing to the ipsilateral side.

(allegedly) asymptomatic breeding CKCS but prevalence (symptomatic and asymptomatic) increases with age and may be as high as 70 per cent in dogs over six years of age.[1] In the Griffon Bruxellois, 42-52 per cent of dogs have syringomyelia and this is not always in association with a classical Chiari-like malformation.[21,46]

CLINICAL SIGNS

CHIARI–LIKE MALFORMATION

It is recognised increasingly that Chiari-like malformation alone can cause significant morbidity and reduced quality of life.[47] As with humans with Chiari type I malformation, the most important clinical sign in affected dogs is behavioural signs of pain. It is common for dogs with Chiari-malformation to have exotropia (outward deviation of the eye) – typically a ventrolateral strabismus when gazing to the ipsilateral side (Figure 2). It is unclear whether this is oculomotor nerve/muscle palsy or related to orbit confirmation. Some human craniosynostosis syndromes (premature fusion or abnormal development of one or more cranial sutures) with a high prevalence of Chiari malformation (for example, Apert's and Crouzon's syndrome)[22] also have a high prevalence of strabismus.[48] In some instances of neurological dysfunction, it is difficult to be convinced of a true association with Chiari-like malformation. For example, there is a high incidence of epilepsy in dogs with Chiari-like malformation, especially in CKCS. In one report, 32 per cent of the study population had seizures[35] and, in a long-term study of 48 CKCS with syringomyelia-associated neuropathic pain and where dogs with a history of seizures had been excluded from the original cohort, 12.5 per cent of the study population developed epilepsy in the follow-up period.[47] Consequently, it has been suggested that there may be an association between Chiari-like malformation and epilepsy in the dog. An association has also been suggested in humans but, again, it is unclear whether the association is coincidental.[49] A recent study compared ventricle size and caudal cranial fossa overcrowding in CKCS with and without seizures and found no significant differences.[50] Electroencephalogram

evaluation performed in three epileptic CKCS suggested paroxysmal abnormalities were mainly located over the frontal and temporal regions.[50] Similar changes have been reported in humans with seizures and Chiari type I malformation.[51] Further study is required to investigate if there is a connection between Chiari malformation and epilepsy. Vestibular dysfunction, facial nerve paralysis and deafness may also be seen but, as with epilepsy, no direct relationship has been proven and this association may also be circumstantial.

SYRINGOMYELIA

Enlarging syrinxes cause progressive neurological damage through a combination of direct pressure on neural tissue, and ischaemia. The location of functional impairment depends on the site of neuronal damage and may include scoliosis (Figure 3), gait abnormalities and other signs. However, the most important and consistent clinical sign of syringomyelia is neuropathic pain. Pain is positively correlated with syrinx transverse width and symmetry on the vertical axis, ie. dogs with a wider asymmetrical syrinx are more likely to experience discomfort, and dogs with a narrow symmetrical syrinx may be asymptomatic. Pain is particularly associated with asymmetrical dorsal horn involvement, especially when there is extension into the superficial lamina I and II which receive primary afferents for nociception[52] and itch.[53] Axons from projection neurons with cell bodies in lamina I cross the midline and ascend in the contralateral white matter (for example, the spinothalamic tracts) to brain stem and thalamic targets. Different types of excitatory and inhibitory interneurons selectively innervate these projection neurons. They are also influenced by descending serotoninergic axons originating from the raphe nuclei.[52] It is hypothesised that disruption to the complex synaptic circuitry in the dorsal horn is primarily responsible for the development of neuropathic pain in syringomyelia.[54,55]

The pathogenesis of the phantom scratching is not well understood. It has been presumed it is a response to allodynia (discomfort or pain from a non-noxious stimulus) and/or dysaesthesia (a spontaneous or evoked unpleasant sensation) and part of the neuropathic pain that these dogs appear to experience.[54,55] However, it is possible that damage to inhibitory neuron circuits has permitted overexpression of a hyperactive reflex. This may explain why mutilation is not a feature of the disease and why a minority of dogs with phantom scratching do not appear to suffer pain. The lack of purposeful contact with the skin and the rhythmic action is reminiscent of the 'scratch reflex' described by Sherrington in 1906.[56] He induced this in dogs that had undergone complete transection of the caudal cervical spinal cord. After approximately three months, stimulation of the skin in the scapular region induced a scratching action in the ipsilateral pelvic limb. The rhythmic action had a frequency of four to eight times per second with the limb scratching towards, but not making contact with, the skin. Like dogs with syringomyelia, there was a receptive field where stimulation of the skin induced ipsilateral pelvic limb action. Sherrington hypothesised that there was a spinal cord central pattern generator for scratching and that this had evolved as a protective response against clinging parasites and other irritants.[56] It is now well established that there are spinal cord central pattern generators for scratching.[57] Similar scratching action can be elicited in cats by the application of tubocurarine to the dorsal surface of the cervical cord at C1 (and to a lesser extent C2), with the scratch being elicited by rubbing the pinna and the skin behind the ear.[58] Tubocurarine blocks Renshaw cells, inhibitory interneurons found in the spinal cord ventral horn[59] that are rhythmically active during activity such as locomotion and scratching,[60] innervate motor neurons and receive inhibitory and excitatory synaptic inputs from commissural interneurons and from ipsilateral locomotor networks.[61] Hypothetically, a syrinx, particularly in the C1/C2 region, could lead to damage to these intricate networks resulting in a scratch reflex when the appropriate dermatome is tactilely stimulated.

Figure 3: A two-year-old female CKCS with cervicothoracic scoliosis and torticollis as a consequence of syringomyelia. The torticollis may be confused with a head tilt associated with vestibular dysfunction. This error of neurological localisation may result in a poor choice of diagnostic tests, for example performing MRI of the brain and ears rather than the cervicothoracic spinal cord. It is thought that the abnormal posture is due to asymmetrical grey matter destruction by the expanding syrinx resulting in an imbalance of afferent proprioceptive information from the cervical neuromuscular spindles.[54,130]

DIAGNOSIS

MRI is essential for diagnosis and determining the cause and extent of syringomyelia (Figure 1). Chiari-like malformation is a complex disorder and, although there is less phenotypic variation than with humans, there can be differences between breeds and individuals within the same breed. In particular, the conformation of the craniocervical junction varies. A consistent feature is hindbrain, and sometimes forebrain, overcrowding with narrowing or obstruction of the CSF channels. The caudal fossa is small and has a more horizontally orientated tentorium cerebelli.[62,63] The medulla often has a kinked appearance.[63] The supraoccipital bone indents the cerebellum, which loses its normal rounded shape.[62,63] Dilatation of the entire ventricular system secondary to cerebrospinal fluid obstruction is common.[63] In classical Chiari-like malformation, the cerebellum and medulla extend into or through the foramen magnum, which is occluded with little or no CSF around the neural structures. However, in some individuals, the size of cerebellar herniation may be minimal.[21] A flexed head position increases the size of

cerebellar herniation and is useful to determine the extent of disease.[64] However, care is essential when obtaining these dynamic views in case there is concomitant atlanto-axial subluxation and/or airway obstruction. The most important craniovertebral junction abnormality associated with Chiari-like malformation is atlanto-occipital overlapping, which has been reported as similar to basilar invagination in humans.[34,65] Both conditions are characterised by increased proximity of the cranial cervical spine to the base of the skull;[66] however, a defining characteristic of basilar invagination is displacement of the odontoid process of the axis through the foramen magnum with compression of the medulla by the dens.[66] In the dogs, there may be flexure of the cranial cervical spinal cord over the odontoid process, but this is more subtle than the human condition[31,34,62,67] (Figure 1). Other less common canine craniovertebral junction anomalies include atlantoaxial subluxation[68,69] and dorsal angulation of the dens.[67] Occipital dysplasia (ie. widened foramen magnum) also may be seen;[70] however, this is probably an acquired condition due to overcrowding of the caudal cranial fossa, mechanical pressure from the cerebellum and supraoccipital bone resorption.[71] It is also common to see dorsal impingement of the subarachnoid space and/or spinal cord at C1-C2 due to fibrosis and proliferation of the ligamentum flavum and dura.[31,34,62] Brachycephalic dogs are also predisposed to quadrigeminal cysts.[72] By occupying space within an already crowded caudal cranial fossa, this may aggravate the obstruction at the foramen magnum and increase the likelihood of syringomyelia developing, although most quadrigeminal cysts are incidental findings. Syringomyelia is indicated by fluid-containing cavities within the cervical spinal cord. When evaluating the patient with syringomyelia then the spinal cord from C1-L4 should be imaged otherwise the extent of disease may be underestimated.[73] The cranial cervical and cranial thoracic segments are typically most severely affected. Maximum syrinx transverse width is the strongest predictor of pain, scratching behaviour and scoliosis.[54]

DIFFERENTIAL DIAGNOSIS

The most important differential diagnoses are other causes of pain and spinal cord dysfunction such as intervertebral disc disease, central nervous system inflammatory diseases such as granulomatous meningoencephalomyelitis, vertebral abnormalities such as atlantoaxial subluxation, neoplasia; and discospondylitis. Intervertebral disc disease would be an unlikely cause of pain in a brachycephalic toy breed aged less than four years old. When scratching or facial/ear rubbing is the predominant clinical sign, ear and skin disease should be ruled out. The classic scratching behaviour for syringomyelia is to one distinct area. It is a common incidental finding for CKCS to have a mucoid material in one or both tympanic bullae and in the majority of cases this is not associated with clinical signs of pain although it may cause hearing loss.[35,74] Some cases with scoliosis appear to have a head tilt which could be confused with vestibular dysfunction[75] (Figure 3). CSF analysis may be abnormal in dogs with syringomyelia, possibly due to syrinx-induced cell damage and an inflammatory response in these dogs. A comparative study of CSF in CKCS with syringomyelia showed a higher protein and cell content, as compared to those with a Chiari-like malformation and no syrinx.[76]

TREATMENT

SURGICAL MANAGEMENT

Medical and surgical treatment options exist for dogs with Chiari-like malformation with syringomyelia. The main treatment objective is pain relief. There are no clear guidelines as to when surgery is indicated over medical management because robust outcome studies have not been performed. Some authors have suggested that early surgical intervention may improve prognosis but this hypothesis has not been vigorously tested.[77] The author is most likely to recommend surgery for painful dogs with Chiari-like malformation but without marked syringomyelia and/or dogs with syringomyelia where medical management does not give adequate pain relief. The reason why surgery has not been recommended universally is that no technique reported thus far has resulted in long-term syrinx resolution.[77-81] In addition, surgery does not necessarily improve long-term prognosis as 25-47 per cent of the operated dogs have recurrence or deterioration of the clinical signs within 0.2-3 years of surgery.[77-79] However, it should be remembered that it is probable that previous reports of surgically managed cases include dogs with more severe clinical signs so a valid comparison between medical and surgical management cannot be made at this time. The most common surgical management is craniocervical decompression, establishing a CSF pathway via the removal of part of the supraoccipital bone and dorsal arch of C1.[79,80] Depending on the surgeon, this may be combined with a durotomy, with or without patching with a suitable graft material and with or without a cranioplasty, using titanium mesh or other prosthesis.[77,78] Craniocervical decompression surgery is successful in reducing pain and improving neurological deficits in approximately 80 per cent of cases, and approximately 45 per cent of cases may have a satisfactory quality of life two years post-operatively. The clinical improvement is probably attributable to improvement in CSF flow through the foramen magnum. A syringosubarachnoid shunting procedure using a 5 French equine ocular lavage catheter has also been described. Clinical improvement in approximately 80 per cent of cases was reported but, like other reported surgeries, there was no evidence of long-term syrinx resolution on post-operative MRI and dogs still expressed signs of neuropathic pain post-operatively.[81]

MEDICAL MANAGEMENT

Due to the persistence of syringomyelia and/or spinal cord dorsal horn damage, it is likely that the post-operative patient will require continuing medical management for pain relief. Also, in the majority of canine patients, medical management alone may be chosen for financial reasons or owner preference. There are three main type of drugs used

for treatment of Chiari-like malformation with syringomyelia: drugs that reduce CSF production (acetazolamide, cimetidine, omeprazole or furosemide); analgesics (non-steroidal anti-inflammatory drugs and anti-epileptic drugs that have analgesic properties); and corticosteroids. As yet, there are no scientific studies to prove the efficacy of these drugs in the management of neuropathic pain in dogs, and recommended management is based on anecdotal evidence only.

DRUGS REDUCING CEREBROSPINAL FLUID PRODUCTION

The process of CSF production by the choroid plexus epithelial cells involves the enzymes carbonic anhydrase C, sodium and potassium ATPases, and aquaporin-1, and results in the net transport of water, sodium chloride, potassium and bicarbonate ions from the blood into the ventricles.[82] Acetazolamide reduces CSF production by inhibiting carbonic anhydrase C and by reducing the amount of aquaporin-1 through an alteration in protein transcription.[83] The use of acetazolamide for management of Chiari-like malformation and syringomyelia has been described[55,63] and is also used in management of benign intracranial hypertension in humans.[84] However, long-term use of acetazolamide is often limited by adverse effects including lethargy, abdominal pain and bone marrow suppression.[63]

Omeprazole is a specific inhibitor of H(+)-K(+)-activated ATPase; however, it is not clear if this is the mechanism by which it reduces CSF production.[85] In experimental models using a ventriculocisternal perfusion technique, omeprazole reduces canine CSF production by 26 per cent.[86] Histamine (H2)-receptor antagonists, such as cimetidine and ranitidine, are proposed to reduce CSF production by competitive inhibition of H2 receptors located on the choroid plexus epithelial cell or by a direct effect on the capillaries of the choroid plexus.[87] However, there is also evidence that histamine may act physiologically by increasing the electrical activity of vasopressin-secreting neurons.[88] Vasopressin reduces blood flow to the choroid plexus, thereby decreasing CSF production.[89] Cimetidine has been shown to be superior to ranitidine in reducing CSF production in an experimental cat model.[87] The usefulness of omeprazole or cimetidine for Chiari-like malformation, with or without syringomyelia, is unclear. They are often prescribed in the hope that this may limit disease progression, a variable that is difficult to assess in a scientific study of clinical cases. Some owners report a significant improvement in clinical signs of pain. Adverse effects from these drugs are infrequently reported. Cimetidine retards P450 oxidative hepatic metabolism, so caution is advised if using this preparation concurrently with other drugs metabolised by the liver and with both cimetidine and omeprazole, periodic monitoring of haematology and serum biochemistry is advised. Absorption of gabapentin may be reduced with concurrent cimetidine administration however the effect is thought to be clinically insignificant.[90] It has been suggested that chronic hypergastrinaemia, caused by omeprazole, may increase the risk of gastric carcinomas, at least in laboratory rodent models, but this has not been reported in any other species.[91,92]

Use of the diuretic furosemide for management of Chiari-like malformation and syringomyelia has also been described[55,63] and is also used in management of benign intracranial hypertension in humans.[84] Furosemide may not be ideal in toy breed dogs that also have a high likelihood of mitral valve disease[93] and where the most common cause of death is congestive heart failure.[94] Furosemide can result in significant increase in plasma aldosterone concentration and renin activity in healthy dogs.[95] This early activation of the renin-angiotensin-aldosterone system might be deleterious in an animal predisposed to heart disease.[96] Moreover, long-term use of diuretics can lead to a diuretic-resistant state which necessitates the use of higher doses, further activating the renin-angiotensin-aldosterone system.[97]

ANALGESICS

NSAIDs are inhibitors of cyclooxygenase-1 and/or cyclooxygenase-2 and suppress inflammatory pain by reducing generation of prostanoids, in particular prostaglandin E2. Prostaglandin E2 also contributes to the genesis of neuropathic pain.[98]

Anecdotally, NSAIDS, eg. meloxicam, carprofen, firocoxib, mavacoxib, can be useful in management of Chiari-like malformation and syringomyelia. However, monotherapy with NSAIDs is unlikely to provide sufficient analgesia if there are signs of neuropathic pain. Therefore, in these situations, the addition of drugs with an anti-allodynic effect is recommended.[55] All primary afferents in the spinal cord dorsal horn use glutamate as their main fast excitatory neurotransmitter. Nociceptive afferents are divided in two groups: those that contain neuropeptide (for example substance P and calcitonin gene related peptide) and those that do not.[52] Substance P-containing primary afferents play an important part in nociception and neuropathic pain and have a high density in laminae I and II of the spinal cord dorsal horn.[52] Therefore, drugs that affect the firing of these neurons are useful in the management of neuropathic pain. Gabapentin and pregabalin modulate voltage-gated calcium channels, resulting in a reduction of glutamate and substance P.[99] Anecdotally, pregabalin is most efficacious for treating Chiari-like malformation and syringomyelia in dogs but gabapentin can also be useful and is more economic. In severe cases, that still have clinical signs despite polypharmacy, the addition of opioids, tramadol or amantadine can be useful. It should be borne in mind that, with the exception of NSAIDs, there are no licensed oral analgesics in veterinary medicine.

CORTICOSTEROIDS

Corticosteroids are believed to provide long-term pain relief because of their ability to inhibit the production of phospholipase-A-2[100] and to inhibit the expression of multiple inflammatory genes coding for cytokines, enzymes, receptors and adhesion molecules.[101] Corticosteroids are

also reported to reduce sympathetically mediated pain[102] and decrease substance P expression.[103] Anecdotally, oral drugs such as methylprednisolone and prednisolone provide relief for some dogs with syringomyelia and can also be useful where there are significant neurological deficits but adverse effects limit their usefulness for long-term therapy.[63]

PROGRESSION AND PROGNOSIS

The clinical signs of Chiari-like malformation and syringomyelia are often progressive. A long-term study over a mean of 39±14.3 months, found that approximately three-quarters of CKCS with Chiari-like malformation and syringomyelia-associated neuropathic pain will deteriorate when managed medically, whereas one-quarter remain static or improved.[47] However, despite this progression, all the owners of the alive dogs in this study reported that their dog's quality of life was not severely compromised.[47] Fifteen per cent of dogs were euthanased because of severe neuropathic pain. Morphometric values (volume of the caudal cranial fossa, parenchyma within the caudal cranial fossa, and the sizes of the ventricles and syrinxes) were not correlated with prognosis. Dogs with higher neuropathic pain scores are more likely to have fear-related behaviour, which can have a negative impact on the owner-perceived quality of life of a dog.[104] Obesity is also positively correlated with a reduced quality of life but not greater neuropathic pain.[104] In humans, there is also a known association between increasing body mass index and CSF disorders such as idiopathic intracranial hypertension[105] and syringomyelia secondary to Chiari type 1 malformation.[106] It has not been established if obesity is the cause or effect of disease; however, in humans, reducing weight can reduce syrinx size after unsuccessful surgical decompression and reduction in body weight is recommended for all overweight and obese patients.[106]

GENETIC FACTORS AND BREEDING ADVICE

The high prevalence, within closely related populations, suggests that syringomyelia is inherited in the dog, and studies in the CKCS have shown it to be a complex trait with a moderately high heritability (h2 = 0.37 ± 0.15 standard error).[107] Since the early 2000s it has been recommended that dogs of breeds predisposed to Chiari-like malformation and/or syringomyelia be MRI screened at least twice in their lifetime. Breeding recommendations based on syringomyelia status and ages were formulated in 2006. These guidelines concentrated on removing dogs with early-onset syringomyelia from the breeding pool while maintaining genetic diversity.[3] Early results from this breeding programme indicated that offspring without syringomyelia were more common when the parents were both clear of syringomyelia (offspring syringomyelia free; CKCS 70 per cent, Griffon Bruxellois 73 per cent). Conversely, offspring with syringomyelia were more likely when both parents had syringomyelia (offspring syringomyelia affected: CKCS, 92 per cent; Griffon Bruxellois, 100 per cent). A mating of one syringomyelia-free parent with an syringomyelia-affected parent was risky for syringomyelia affectedness with 77 per cent of CKCS and 46 per cent of Griffon Bruxellois offspring being syringomyelia affected.[108]

In the UK, there is a British Veterinary Association/Kennel Club canine health scheme to MRI screen potential breeding stock for Chiari-like malformation and/or syringomyelia.[109] MRI images are assessed by two scrutineers and graded for severity for both Chiari-like malformation and syringomyelia and, as syringomyelia is a late-onset condition, the age of onset. Results are submitted to a central database, in order to generate estimated breeding values for the UK Kennel Club Mate Select Computer program.[110] As an accurate estimated breeding value database may take some time to compile, the recommended breeding guidelines have been revised.[111] European heath schemes for Chiari-like malformation and syringomyelia also exist.[112]

CONCLUSION

Chiari-like malformation and syringomyelia is an inherited disorder with a high morbidity in many brachycephalic toy breeds. It is characterised by overcrowding of the craniocervical junction, obstruction of CSF flow through the foramen magnum and development of fluid filled cavities in the central spinal cord. Although some cases are asymptomatic, dogs with Chiari-like malformation and syringomyelia can present with neurological signs of which the most important is pain. Surgical and medical treatment options are available but these have limited success and, from a welfare point of view, it would be better to implement a breeding programme limiting the occurrence of this disabling disease.

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ORIGINAL PAPER

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REFERENCES AVAILABLE ON REQUEST