CHIARI-LIKE MALFORMATION AND SYRINGOMYELIA

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Syringomyelia (SM) is characterised by fluid filled cavities within the spinal cord. SM occurs secondary to obstruction of cerebrospinal fluid (CSF) especially if that obstruction is at the foremen magnum. The most common predisposing cause in the dog is Chiari-like malformation (CM) (Fig 1). The primary clinical sign of CMSM is pain, either due to obstruction of the CSF pulse pressure and/or a neuropathic pain syndrome due to damage to the spinal cord.

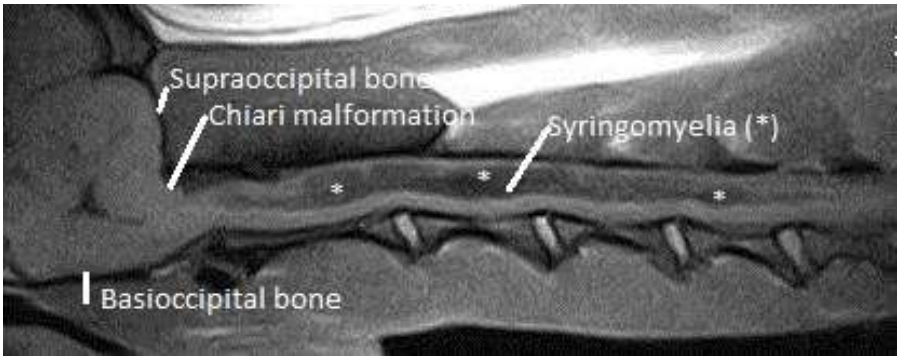


Figure 1 T1W mid-sagittal MRI scan from a Cavalier King Charles spaniel (CKCS) with CMSM (fluid = dark grey).

Chiari-like malformation (CM) is a condition characterised by disparity in volume between the cerebellum (too big) and the caudal cranial fossa (too small) such that the cerebellum and brain stem are herniated into or through the foramen magnum (Fig 2).

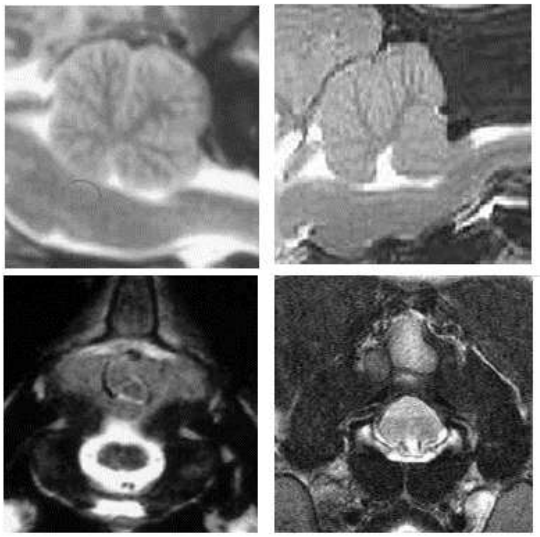


Figure 2 Comparison between the caudal cranial fossa and foramen magnum in a Staffordshire bull terrier (left) and a CKCS (right). The images on the top are mid-sagittal T2W images of the caudal cranial fossa and C1 (fluid=white). The Staffordshire bull terrier has a well-defined cisterna magnum and unobstructed foramen magnum. In the CKCS the foramen magnum is obstructed by herniated cerebellar vermis. The images on the bottom are transverse T1W images at the level of craniocervical junction. In the Staffordshire bull terrier an unobstructed subarachnoid space around the spinal cord can be appreciated. In the CKCS the CSF space cannot be appreciated and the neural tissue sectioned is the medulla and vermis – structures which are normally within the skull.

PATHOGENESIS

The pathogenesis of canine CM/SM is not fully understood. An important contributory factor is thought to be the mismatch in size between the brain and skull volume and obstruction of CSF flow through the foramen magnum. Overcrowding in the caudal part of the caudal cranial fossa (i.e. back of the skull) is particularly important. The precise mechanism of development of syringomyelia is also much debated. A popular theory is that obstruction of

CSF flow results in pressure changes in an around the spinal cord which forces fluid into spinal cord either from the cerebrospinal fluid and/or from the blood vessels. Initial changes include dilatation of the central canal and accumulation of tissue fluid which eventually coalesces into cavities

PREVALENCE

Brachycephalicism and miniaturization are risk factors for CM. The condition is most commonly reported in CKCS, King Charles spaniels, Griffon Bruxellois. Affenpinschers, Yorkshire terriers, Maltese, Chihuahuas, Pomeranians, and Papillons. Partly because of its popularity as a pet, the CKCS is overwhelmingly overrepresented. Studies into the inheritance of SM associated with CM in CKCS have shown it to be a complex trait with a moderately high heritability ($h^2 = 0.37 \pm 0.15$ standard error). It has a varying age of onset – there is 46% prevalence in asymptomatic breeding CKCS but prevalence (symptomatic and asymptomatic) increases with age and may be as high as 70% in dogs over six years of age. The prevalence of dogs with clinical signs is difficult to determine because of difficulty and expense in diagnoses and accurate reporting. One study has suggested a prevalence of 15% of 5 year old CKCS.

CLINICAL SIGNS

The most important and consistent clinical sign of CM/SM is pain however this may be difficult to localise. Owners may describe postural pain; for example pain on jumping or being picked up. Sleeping with the head in unusual positions may be reported. Pain is positively correlated with syrinx width and symmetry i.e. dogs with a wider asymmetrical syrinx are more likely to experience discomfort, and dogs with a narrow symmetrical syrinx may be asymptomatic (Fig 3). Syrinxes can progressively expand and a dog which is asymptomatic in early life may eventually become painful. Dogs with a wide syrinx may also scratch, typically on one side only, while the dog is walking and often without making skin contact, such behaviour is often referred to as an "air guitar" or "phantom" scratching. Dogs with a wide syrinx are also more likely to have scoliosis. SM may result in other neurological deficits such as thoracic limb weakness and muscle atrophy (due to ventral horn cell damage) and pelvic limb ataxia and weakness (due to white matter damage or involvement of the lumbar spinal cord by the syrinx). Seizures, vestibular dysfunction, facial nerve paralysis and deafness may also be seen; however, no direct relationship has been proven and this association may be circumstantial.

CM alone (i.e. without SM) causes significant head and spinal pain in some dogs

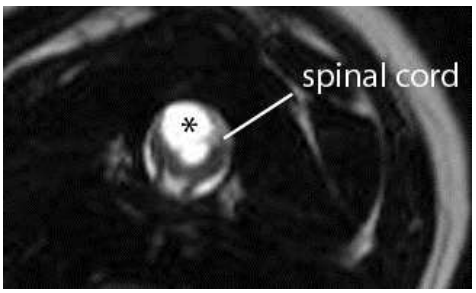


Figure 3. T2W transverse image through a wide syrinx (asterisk) demonstrating the asymmetrical involvement of the right spinal cord dorsal horn (fluid=white).

DIAGNOSIS

Magnetic resonance imaging (MRI) is essential for diagnosis and determining the cause and extent of SM. In the instance of CM/SM the cerebellum and medulla extend into or through the foramen magnum which is occluded with little or no CSF around the neural structures. The size of the cerebellar herniation is not correlated with severity. There is typically ventricular dilatation. SM is indicated by fluid-containing cavities within the spinal cord. The upper cervical and upper thoracic segments are typically most severely affected. Maximum syrinx width is the strongest predictor of pain, scratching behaviour and scoliosis.

DIFFERENTIAL DIAGNOSIS

The most important differential diagnoses are other causes of pain and spinal cord dysfunction such as intervertebral disc disease (IVD); CNS inflammatory diseases such as granulomatous meningoencephalomyelitis; vertebral abnormities such as atlantoaxial subluxation; neoplasia; and discospondylitis. IVD would be an unlikely cause of pain in a CKCS aged less than 4 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 SM 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 deafness. Some cases with scoliosis appear to have a head tilt which could be confused with vestibular dysfunction.

TREATMENT

A possible approach to management of CMSM is illustrated in Figure 4. The main treatment objective is pain relief. The most common surgical management is cranial/cervical decompression (also described as foramen magnum or suboccipital decompression) establishing a CSF pathway via the removal of part of the supraoccipital bone and dorsal arch of C1. This may be combined with a durotomy (incision of the dura with/without incision of subarachnoid meninges) with or without patching with a suitable graft material. Cranial/cervical decompression surgery is successful in reducing pain and improving neurological deficits in approximately 80% of cases and approximately 45% of cases may still have a satisfactory quality of life two years postoperatively. However surgery may not adequately address the factors leading to SM and the syrinx appears persistent in many cases. The clinical improvement is probably attributable to improvement in CSF flow through the foramen magnum. In some cases scaring and fibrous tissue adhesions over the foramen magnum seem to result in re-obstruction and 25% to as many as 50% of cases can eventually deteriorate. This can be as early as 2 months postoperatively.

Due to the persistence of SM and/or spinal cord dorsal horn damage it is likely that the post-operative patient will also require continuing medical management for pain relief and in some patients medical management alone is chosen because of financial reasons or owner preference. There are three main drugs used for treatment of CM/SM: drugs that reduce CSF production e.g. cimetidine or omeprazole or possibly diuretics such as furosemide; analgesics; and corticosteroids (Figure 4). Simple actions, for example raising the food bowl and removing neck collars, can also help. The clinical signs of CMSM are often progressive – a recent study found that approximately three-quarters of CKCS with CMSM associated neuropathic pain will deteriorate on conservative treatment only

BREEDING RECOMMENDATIONS.

It is recommended that breeders of dogs predisposed to CMSM screen their stock. Current breeding recommendations for CKCS and Griffon Bruxellois (GB) concentrate on removal of dogs with early onset SM from the breeding pool (for more information see http://www.veterinary-neurologist.co.uk/sm_screening_breeders.htm). Early results from this breeding program indicated that offspring without SM were more common when the parents were both clear of SM (SM free; CKCS 70%, GB 73%). Conversely offspring with SM were more likely when both parents had SM (SM affected; CKCS 92%, GB 100%). A mating of one SM-free parent with an SM-affected parent was risky for SM affectedness with 77% of CKCS and 46% of GB offspring being SM affected. It is recommended that all breeding dogs from breeds susceptible to SM be MRI screened; that the SM status at 5 years old is established; and all results submitted to a central database that can be used by dog breeders to better enable mate selection based on estimated breeding values. A British Veterinary Association (BVA) / Kennel Club (KC) CMSM Scheme launched in early 2012. Results of KC registered dogs are sent to the Animal Health Trust for inclusion in the Estimated Breeding Value (EBV) calculations for a Mate Select Computer program. To participate in

the scheme, owners will need to have their dog MRI scanned and submit the DICOM images on a CD accompanied by the appropriate paper work to the BVA. The MRI scans will be reviewed by two scrutineers from a BVA-appointed panel of neurologists and radiologists and graded for severity for both CM and SM (as below). Results for dogs registered with the Kennel Club will be sent to the club for publication on its online Health Test Results Finder and to the Animal Health Trust to be included in Estimated Breeding Value (EBV) calculations for a Mate Select Computer program.

Dogs are graded as follows
Grading is according to the severity of the CM and SM changes. The age of the dog at the time of scanning is also shown in the grading.

Chiari-like malformation (CM):
Grade 0 - No Chiari malformation
Grade 1 - Cerebellum indented (not rounded)
Grade 2 - Cerebellum impacted into, or herniated through, the foramen magnum.

Syringomyelia is defined as a fluid-filled cavity that includes or is distinct from the central canal of the spinal cord and is graded according to its maximum internal diameter in a transverse plane. **Pre-syrinx** is defined as spinal cord oedema, and may be a transitional state prior to development of syringomyelia. Pre-syrinx has the appearance of high signal intensity on T2W images consistent with marked increased fluid content within the spinal cord substance but not of free fluid. On T1W images the spinal cord is either normal or has a slightly hypointense signal

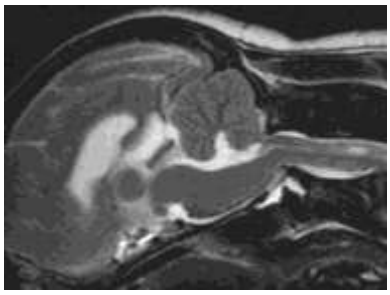
Syringomyelia (SM)
Grade 0 - Normal (no central canal dilation, no presyrinx, no syrinx)
Grade 1 - Central canal dilation or a separate syrinx which has an internal diameter of less than 2mm.
Grade 2 - Syringomyelia (central canal dilation or a syrinx which has an internal diameter of 2mm or greater), separate syrinx, or pre-syrinx with or without central canal dilation

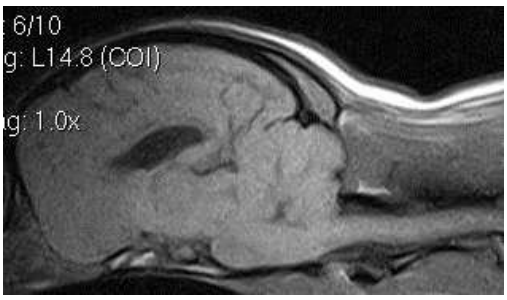
The grade is qualified with a letter indicating the age group at the time of scanning as follows: **a = more than five years of age; b = three to five years of age; c = one to three years of age.** The grade is not valid without the qualifying letter.

EXAMPLES OF GRADINGS

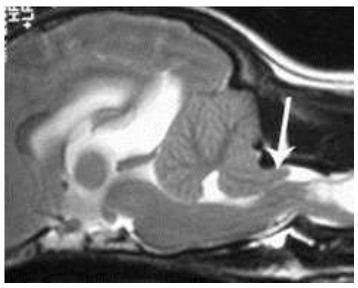
Chiari-like malformation (CM) grading

Grade 0 CM. *The cerebellum has a rounded shape with signal consistent with cerebrospinal fluid (CSF) between the caudal cerebellar vermis and the foramen magnum. Grade 0 CM or equivalent was reported in 0 of 564 (0%) breeding CKCS MRI submitted in a 24 month period.*

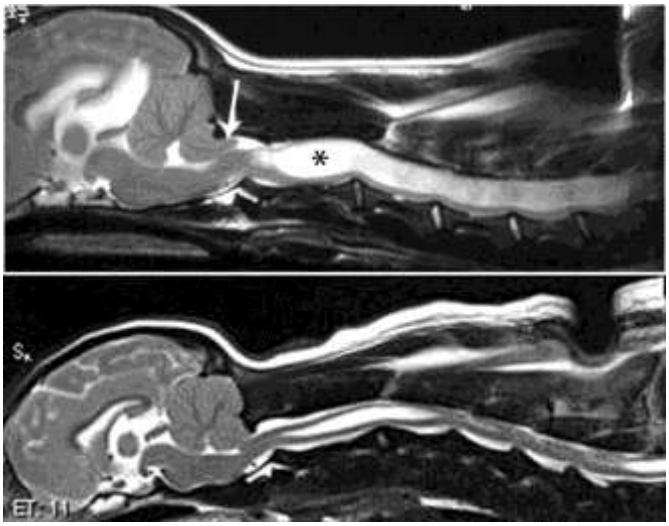




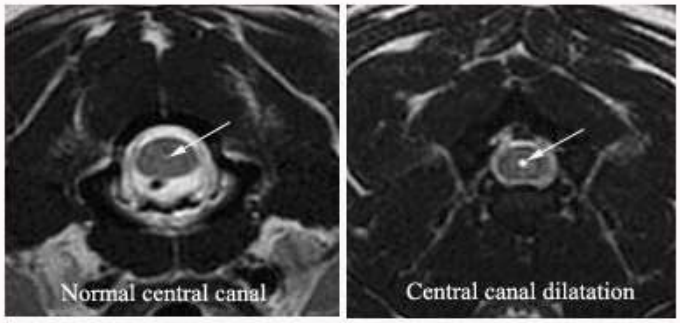
Grade 1 CM. *The cerebellum does not have a rounded shape, i.e. there is indentation by the supraoccipital bone, but there is a signal consistent with CSF between the caudal vermis and the foramen magnum. Grade 1 CM or equivalent (as "mild" CM) was reported in 6 of 564 (1.1%) breeding CKCS MRI submitted in a 24 month period.*



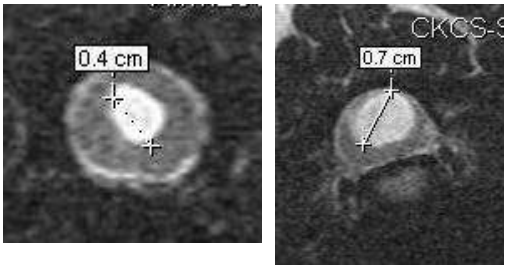
Grade 2 *CM the cerebellar vermis is impacted into or herniated through the foramen magnum. Grade 2 CM or equivalent was reported (as CM) in 558 of 564 (98.9%) breeding CKCS submitted in a 24 month period.*



Why is the size of cerebellar herniation not reported? *The size of cerebellum herniation is not graded because no correlation with genetic risk of syringomyelia has been demonstrated (yet) although dogs with larger cerebellar hernitation may have early onset of syringomyelia. The top image is from a CKCS aged 8 months and the bottom from a CKCS aged 8 years.*



Grade 1 SM - Central canal dilation or a separate syrinx which has an internal diameter of less than 2mm.



Grade 2 SM - Syringomyelia (central canal dilation or a syrinx which has an internal diameter of 2mm or greater), separate syrinx, or pre-syrinx with or without central canal dilation

Breeding guidelines (based on syringomyelia only)

			NORMAL			CCD			SM		
	AGE (years)	SM GRADE	0a	0b	0c	1a	1b	1c	2a*	2b*	2c
NORMAL	>5	0a	yes	yes	yes	yes	yes	yes	yes	yes	DO NOT BREED
	3-5	0b	yes	yes	yes	yes					
	1-3	0c	yes	yes		yes					
CCD	>5	1a	yes	yes	yes	yes	yes	yes	yes	yes	
	3-5	1b	yes			yes					
	1-3	1c	yes			yes					
SM	>5	2a*	yes			yes					
	3-5	2b*	yes			yes					
	1-3	2c	DO NOT BREED								
Dog with clinical signs CM &/or SM			DO NOT BREED								

The aim of these breeding guidelines is to remove dogs with early onset SM from the breeding programme. Please note: it is believed that due to the complex nature of inheritance of CM/SM it is still possible that affected offspring may arise from parents which are clear from or are only mildly affected by SM.

No breeding guidelines for CM are available as yet. For toy breeds other than CKCS and King Charles, breeders should aim to breed from CM1 and CM0 dogs. For breeds with almost universal CM affectedness (i.e. CKCS, King Charles and possibly other breeds such as the Griffon Bruxellois) then the above table above applies.