Prevalence of Chiari-like malformation and Syringomyelia in Cavalier King Charles Spaniels in the Netherlands between 2004 and 2012

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Introduction

Chiari-like malformation (CM), or chiari malformation, is most likely the result of a reduced volume of the caudal fossa due to an inappropriately small occipital bone.[1] This condition occurs frequently in Cavelier King Charles spaniels (CKCS). The estimated prevalence is approximately 95%.[1-3,6,7] Recent data suggest that CM in CKCS is inherited. [4,5] (fig. 3)
One hypothesis is that due to the herniation of the cerebellum (the chiari-like malformation) an abnormal cerebrospinal fluid (CSF) flow exist which in turn might cause in about 50% of the affected dogs a dilatation of the central canal and fluid-containing cavities (syrinx) within the parenchyma of the spinal cord. The latter is a condition known as syringomyelia (SM). [1] (fig. 4)
Approximately 70% of the CKCS develops SM.[6,7] It is stated that approximately 10% of dogs with CM and SM exhibit clinical signs. [1,3] The clinical symptoms consists of episodes of so called phantom scratching towards the neck and face, especially elicited by excitement. As the condition progresses, severe pain attacks and ataxia of the pelvic and thoracic limbs occur.[1]

Material & Methods

Eight hundred and fifteen scans were made of Cavalier King Charles spaniels. They were diagnosed through magnetic resonance (MR) imaging, transverse and sagittal T1 and T2 weighted images of the head and spine, between 2004 and 2012 in the Netherlands. Of every clinic in the Netherlands that had a MRI-scanner, the scans were collected as shown in table 1.

Veterinary clinic	Number of MRI's	MRI-scanner
Best	703	Esaote Vet-MR scanner 0.25T
Utrecht	51	Siemens 02T
Dordrecht	41	Esaote Vet-MR scanner 0.25T
Drachten	20	Picker Outlook Gold Performance 0.23T
Total	**815**	

Table 1. Number of MRI scans collected at the different veterinary clinics and type of MRI-scanner that has been used.

Every scan had to be reassessed according to a new assessment, specially made for this research. Image processing for volume rendering was achieved using graphical software, Osirix DICOM viewer.

The evaluation of Chiari-like malformation is devided in four degrees: no CM, an indended cerebellum, a cerebellum that is misshaped with overcrowding and indentation, or the cerebellum is impacted into, or herniated through the opening at te rear of the skull. If the cerbellum is deformed, a + is attached to the grade. (fig. 1)

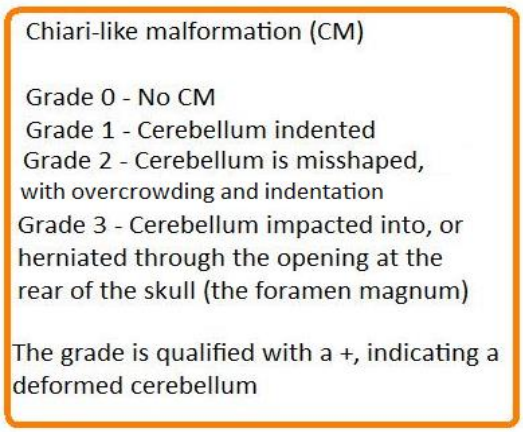


Fig. 1 Assesment schedule Chiari-like malformation

The evaluation of syringomyelia is divided in five groups. (fig. 2) It is based on the central canal dilation in millimeters and the existence of a syrinx. If the grade is

qualified with a +, this indicates a presyrinx. It is possible that the syringomyelia occurs and progresses over time, which is important for breeding projects.

Syringomyelia (SM)

Grade 0 - No abnormalities
Grade 1 - Central canal dilation (CCD) less than 1mm in diameter
Grade 2 - CCD less than 2 mm in diameter
Grade 3 - CCD more than 2 mm in diameter
Grade 4 - Syringomyelia (central canal dilation which has an internal diameter of 2mm or greater), or separate syrinx.

The grade is qualified with a +, indicating a pre-syrinx.

Fig. 2 Assessment schedule syringomyelia

These 815 scans were made from 732 different CKCS. This means that 83 scans were made from a dog that already had been scanned at least once. Of these dogs the progression over time can be evaluated. The scans are linked to a birthdate and the scan date so the age of the dog can be calculated. There are three groups: C, means an age between 0 and 3 years; B, means an age between 3 and 5 years; and A, means an age over 5 years. Of two dogs the birthdate was not known.

Results

The 815 scans are made of 732 dogs. Chiari-like malformation is shown in every dog, except for 1 (0,14%). A total of 605 out of 732 dogs had a cerebellum that was misshaped with overcrowding and indentation (82,7%). A total of 126 out of 732 dogs showed clear herniation of the caudal part of the cerebellum (17,2%). In none of the dogs were the tonsils maximally herniated.
Syringomyelia is observed in 275 dogs (37,6%) of the 732 dogs. One hundered and sixty four dogs showed a syrinx of more than 2 mm (22,4%) compared to one hundered and eleven dogs with a syrinx less than 2 mm (15,2%). SM was not detected in 457 dogs. (62,4%)
Syringomyelia was seen in approximately 37,6% of the dogs with chiari-like malformation.
If the dogs had a syrinx of more than 2 mm (164 dogs), 138 dogs had a CM with a cerebellum that was misshaped with overcrowding and indentation (84,1%) versus 26 dogs that showed clear herniation of the caudal part of the cerebellum (15,9%).
If the dogs had a syrinx of less than 2 mm (111 dogs), 86 dogs had a CM with a cerebellum that was misshaped with overcrowding and indentation (77,5%) versus 25 dogs that showed clear herniation of the caudal part of the cerebellum (22,5%).

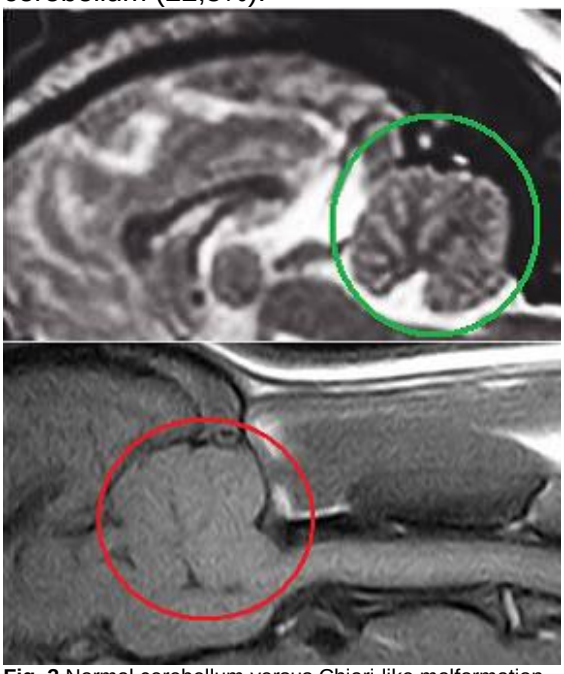


Fig. 3 Normal cerebellum versus Chiari-like malformation graded 2+ [20,21]

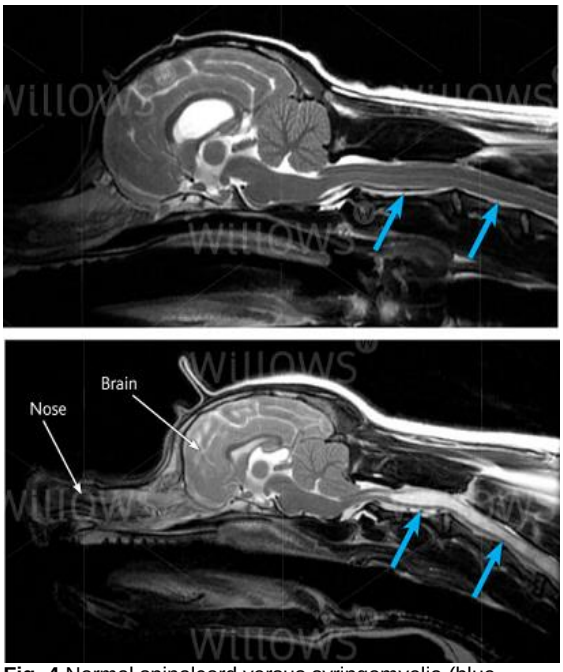


Fig. 4 Normal spinalcord versus syringomyelia (blue arrows) [22]

Age effect

Group C contains 445 CKCS. Out of the 445 dogs with CM , 115 had SM (25,8%). Sixty-one dogs had a central canal dilation with an internal diameter of 2 mm or greater, or a seperate syrinx (13,7%). Group B contains 189 dogs with CM, of which 87 had SM (46,0%). Fourty-nine dogs had a central canal dilation with an internal diameter of 2 mm or greater or a seperate syrinx (25,9%). Group A contains 126 dogs with CM of which 74 with also SM (58,7%). Fourty-eight dogs had a central canal dilation which has an internal diameter of 2 mm or greater or a seperate syrinx (38,1%). This shows a steady increase of the percentage per age group. (fig. 5)

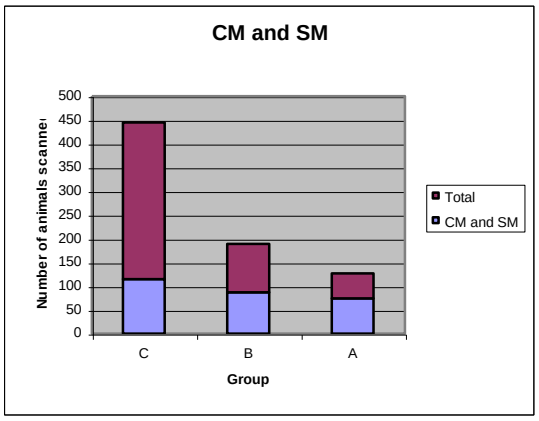


Fig. 5 Overview CM and SM incidence

Animals with multiple scans

Some dogs were followed over time. Seventy-seven animals needed multiple scans, mostly for breeding. Out of these 77 dogs, 19 dogs had CM and developed SM at some point (24,7%). Six out of the nineteen dogs already had CM and SM when the first scan was made (7,79%).(fig. 6) Thirteen out of the nineteen dogs developed SM between the first and second scan (16,9%). (fig. 7) According to these testresults, the average age of developing SM is 3,8 years (2,5-6,8). The average size of the syrinx that develops, is 1,85mm (0,9-4,8).

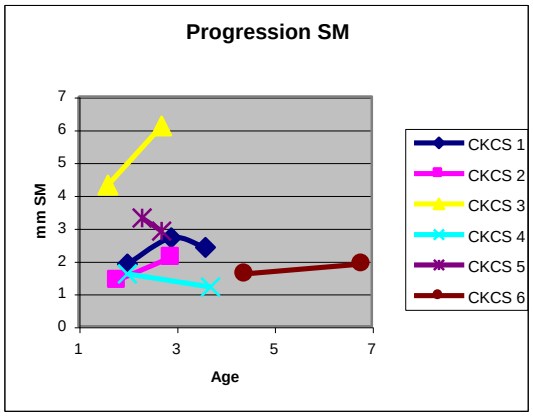


Fig. 6 Progress of SM in several cases that already had SM

Scans per year

As shown in figure 8, there is a progression in the total amount of scans made per year. In 2004 there was a small amount of scans with a high frequency of CM and SM. There was a small decrease in the amount of scans in 2005 and 2006. However, there was a major increase from 2007 until 2011. The largest amount of scans was made in 2011, 245 in total. However, the prevalence of SM appears to be lower than average (34,6%), approximately 28,2% (20,0%-83,3%). The highest percentage was shown in 2004 and 2005 (83,3% and 66,7%), but the amount of dogs was very low.

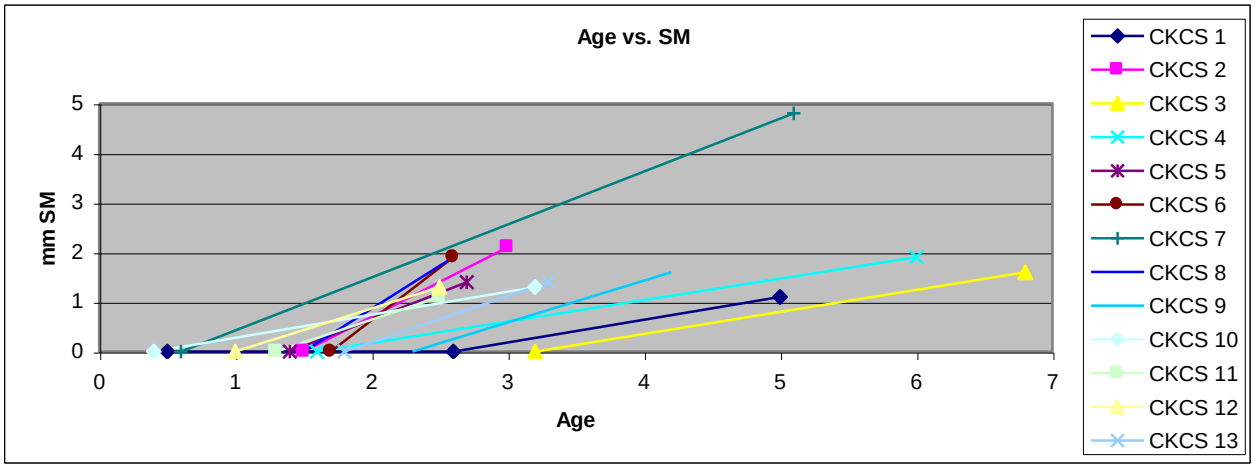
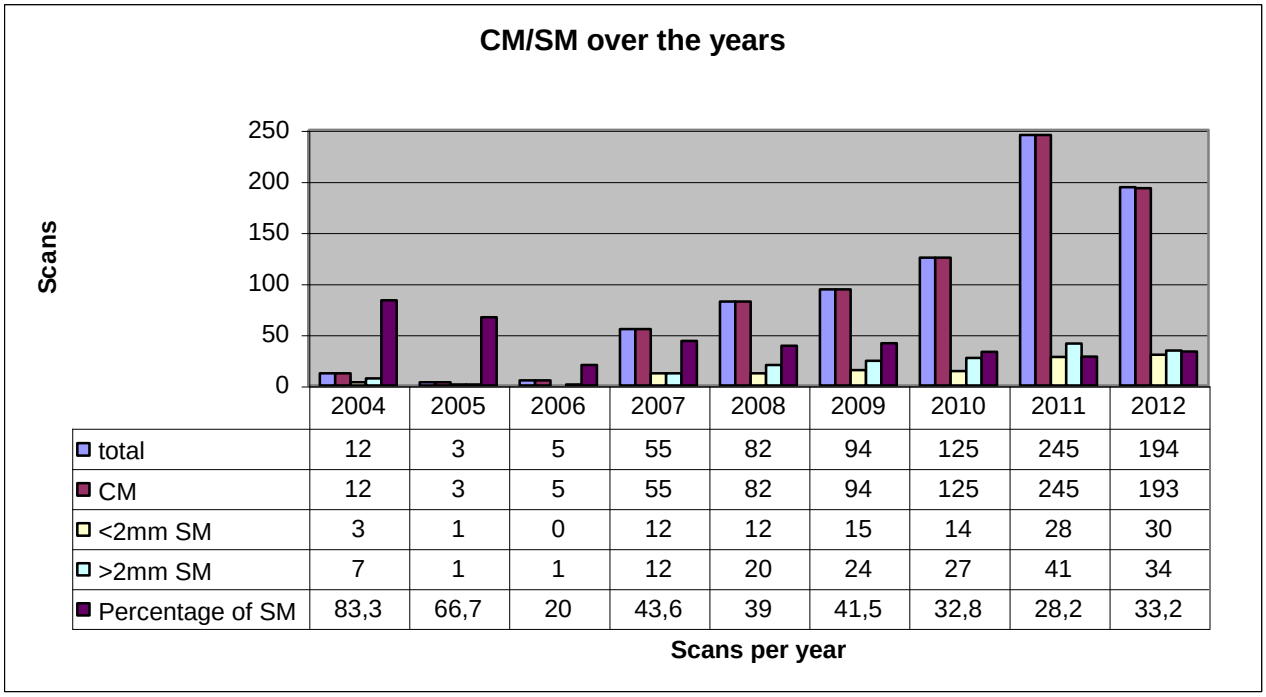


Fig. 7 Age versus developing SM



	2004	2005	2006	2007	2008	2009	2010	2011	2012
total	12	3	5	55	82	94	125	245	194
CM	12	3	5	55	82	94	125	245	193
<2mm SM	3	1	0	12	12	15	14	28	30
>2mm SM	7	1	1	12	20	24	27	41	34
Percentage of SM	83,3	66,7	20	43,6	39	41,5	32,8	28,2	33,2

Fig. 8 Progression SM over time

Hydrocephalus
23 dogs are diagnosed with a hydrocephalus (3,51%). All these dogs have CM. Out of these 23, 14 dogs had SM and all had a central canal dilation which has an internal diameter of 2 mm or greater or a seperate syrinx (2,14%).

Discussion

Only one dog out of 732 CKCS had no chiari-like malformation, nor did it show syringomyelia. It is possible that the dog developed it over time, it was only 1,2 years old at the time of the scan. All other 731 dogs had chiari-like malformation, indicating the severe impact of the disorder for this breed. In this study, approximately 37,6% of the dogs with CM developed SM. Since SM is a progressive disease in CKCS, it is possible that certain dogs with only CM may develop SM in the future.[12] CM/SM has been shown to be inherited in the Cavalier King Charles Spaniel, although the mechanism of inheritance is not yet understood.[23]

The dogs were divided into 3 age groups. There was a visible development that the prevalence of syringomyelia increased with age. [7] There is evidence from this data to suggest that the lifetime risk of developing SM may be even higher, because in CKCS of five years and older the prevalence was 58,7%.[12] Approximately 62,4% CKCS does not develop a lesion, but a progressive central canal dilatation can be a precursor of a syrinx formation. [17,18] The average age of developing SM is 3,8 years. Dogs can breed when they are 15 to 18 months old, which means that they can already breed before SM can be diagnosed. The average size of the syrinx that develops, is 1,85 mm. It has been proven that dogs with a wider asymmetrical syrinx are more likely to experience discomfort, and dogs with a narrow symmetrical syrinx may be asymptomatic. [8] As maximal syrinx width is associated with pain, this increase can be clinically relevant. [19] However, the clinical progression was not determined in this study due to its retrospective nature.

Based on the results of this study it is not possible to say anything about the relation between CM and SM as all dogs had CM except for one. According to *Lewis et al 2010*, there is a moderately high heritability. [8,16] There are different theories that suggest the development of SM. Multiple studies suggest that CM/SM is known as a disorder and it is characterised by overcrowding of the craniocervical junction. [8] This leads to a turbulent flow

and jets of cerebrospinal fluid (CSF) through the foramen magnum and the upper spinal cord and are associated with the development of SM. [8,11] This could also lead to a hydrocephalus. [11] However, this concept cannot explain the absence of SM in cases with severe herniations or the presence of SM with minimal or absent herniation. Neither the volume of the caudal fossa nor the severity of cerebellar herniation can predict the occurence of SM in CKCS. [9,10] In other literature, there is a debate as wether narrowing of the foramen magnum is the only pathogenetic factor responsible for the development of CSF pressure waves, because herniation less than 5 mm or even absent herniation can still be accompanied by classic Chiari malformation.

Another hypothesis is based on an altered venous drainage and cerebrospinal fluid flow dynamics. According to *Schmidt et al 2012*, CKCS with CM/SM have a narrowed jugular foramina in comparison with CKCS with CM only. [11] Because of the reduction of the caudal cranial fossa, the venous sinus volume is reduced in dogs with SM. This reduction can be a result of the CM. [12,14,15] This means that the ventricular volume is higher in CKCS with CM/SM and that there is a positive association between the width of the syrinx and the size of the ventricular system. [14]

Syringomyelia is a progressive syndrome and these results suggest that SM lesion width increased in CKCS with CM over time. According to *Driver et al 2012*, the height of the foramen magnum, extent of cerebellar herniation and caudal cranial fossa (CCF) volume was significantly increased with time. [12] However, There was no significant difference for CCF parenchymal volume or ventricular system volume between the first and second scans. This can suggest that there may be dynamic changes to the bones of the CCF which has implications for the possible pathogenesis of CM and SM in CKCS. [12]

Conclusion

Chiari-like malformation and syringomyelia are a serious problem in the Cavalier King Charles Spaniel. There is a correlation between the prevalence and age of the dogs. This study can not determine the original cause of SM and any influence of CM. More research is necessary to determine the development of SM.

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