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THE LOCATION OF THE MESENCEPHALIC TECTUM IN CANINE BRAIN DEFECTS: A MAGNETIC RESONANCE IMAGING STUDY

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ABSTRACT
The mesencephalic tectum is well described in man, but few studies have been performed on this structure in dogs. The aims of this study were to use magnetic resonance images (MRI) in the midline sagittal plane to 1) describe the shape, position and area of the tectum in normal and abnormal canine brains, and 2) determine the effect of head phenotype, body weight and gender on midline area and position in normal canine brains. 73 dogs representing a spectrum of breeds and head phenotypes were included this study, divided into either a normal or abnormal group according to their brain status. The normal group comprised 32 dogs of different breeds. The abnormal group had 41 dogs diagnosed with brain MRI abnormalities and comprised of 41 dogs. The tectal shape, position and area were compared on midline MR images in both groups. In the normal group the influence of head phenotype, body weight and gender on tectal area and position were defined. Tectal area was defined in relation to midline cranial cavity area, in order to normalize for size. The landmarks and shape of the mesencephalic tectum were defined in normal canine brains and this was altered in around 22% of the abnormal group. The tectum was situated within the middle and caudal fossa in the entire normal group; however, a significant rostral deviation of the tectum was evident in the abnormal group. The corrected area of the tectum was not significantly different between groups; however, the degree of brachycephalia did significantly influence the position of the tectum in normal group (P=0.0048). In conclusion the shape and position of the tectum can readily be determined on midline sagittal plane MR images and is a useful anatomical region to assess in order to increase the clinical suspicion for the presence of brain abnormalities.

KEYWORDS - Mesencephalic tectum, MRI, dog, brain, caudal fossa**.**

INTRODUCTION

The mesencephalic tectum is defined as the roof of the mesencephalon which is composed of a pair of caudal and rostral colliculi and their respective commissures (Beitz and Fletcher, 1993).While, the mesencephalon is described by others as consists of the cerebral peduncles, the tegmentum, and the tectum (Rhoton, 2000). The mesencephalic tectum had other terms namely quadrigeminal lamina/ plate (Bolgov, 1976) and the roof of the mesencephalon (Beitz and Fletcher, 1993).

The tectum was identified in canine brains using MRI technique on different planes (Leigh *et al*., 2008). The normal and abnormal tectal area was recognized in man and cats using ultrasound and MRI technique (Wolpert *et al*., 1987, Callen and Filly, 2008). The tectal abnormalities composed of about 60% of total lesions of the mesencephalon when a study has been done on man in 1994 (Fritschi *et al*., 1994). The lamina was found to be displayed when there was increasing in the intracranial pressure in dogs (Bittermann *et al*., 2012). The aims of this study were to define the normal shape and location of the mesencephalic tectum; determine the effect of head phenotype, bodyweight and age on the above parameters and find out the effect of brain abnormalities on the area and location of the tectum.

MATERIALS & METHODS

73 dogs of different breeds were included in this study. All these dogs were client-owned pets that were come to the small animal hospital in Glasgow University. These dogs had MRI as part of the examination that was made for them. Ethical approval was done as part of the hospital owner agreement form. Midline sagittal plane T2-weighted images of 1.5 Tesla MRI Unit (Siemens Magnetom Essenza, Siemens Medical Solutions, Camberley, UK) were used. Dogs were classified according to their final diagnosis which was been made by the clinicians as following:

Group-1: (Dogs that have no abnormalities within the cranial cavity): 32 dogs of the following breeds [Boxer 9, Labrador 5, Bichon fries 2, Collie 2, Retriever 2, Shih-tzu 2, and one of the each following: Cocker spaniel, German shepherd, Irish setter, Lhasa apso, Lurcher, Miniature schnauzer, Northern Inuit dog, Shetland sheepdog, Staffordshire bull terrier and Tibetan terrier].

Group-2: Dogs that have abnormalities within the brain [obstructive and non-obstructive hydrocephalus (congenital and acquired), Granulomatous meningio encephalomyelitis, tumour, brain lesion, polyneuropathy, degenerative myelopathy, brain infarction and cerebral herniation] were included in this group: This group had 41 dogs named as Yorkshire terrier 6, Chihuahua 5, CKCS 3, Boston terrier 2, Boxer 2, Cocker Spaniel 2, Cross breed 2, German shepherd 2, Lhasa apso 2, Maltese terrier 2, Pug

2, and one of the these breeds [Beagle, Border terrier, Fox terrier, Labra-doodle, Labrador, Lurcher X, Miniature poodle, Papillon, Staffordshire bull terrier, Tibetan terrier and West Highland White Terrier (WHWT)].

Measurements of the mesencephalic tectum

The images were examined using Clear Canvas software [Clear Canvas (439 University Ave Suite 1920, Toronto, Ontario M5G 1Y8, Canada)]. Each image was calibrated then measured using ImageJ software [ImageJ 1.42q is public domain open source software created by Wayne Rasband at the National Institute of Health, USA].

Description of the mesencephalic tectal both shape and location were defined. The tectal area was then measured depend on the defined shape of the tectum. For the measuring of the head phenotype, it was used the technique of measuring the angulation of the olfactory bulb (Hussein *et al*., 2012). The tectal area was corrected to the brain area to normalize the data and the caudal fossa was delineated for defining the location of the mesencephalic tectum.

Statistical analysis

GraphPad Prism 5 software (GraphPad Software Inc., La Jolla, USA) was used for data analysis. Mean, standard deviation, range, normality of the data (D'Agostino and Pearson Omnibus normality test) were examined. Then based on the results of the normality outcome, two tailed t-tests between the relative groups were evaluated.

RESULTS & DISCUSSION

Normal description of the canine mesencephalic tectum

The landmarks of the mesencephalic tectum were demarcated using MRI by the caudal commissure rostrally, the suprapineal recess antero-dorsally and the quadrigeminal cistern caudo-dorsally and by the mesencephalic aqueduct ventrally (Fig.1). These landmarks have been identified grossly for detecting the mesencephalic tectum by anatomists (Beitz and Fletcher, 1993).

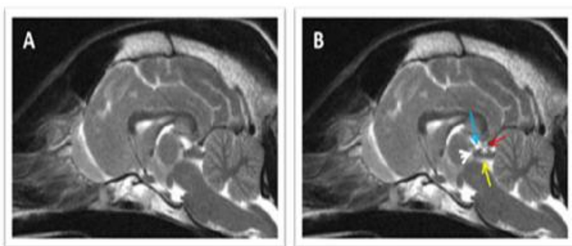

FIGURE 1: T2w MR images on midline sagittal plane shows the normal shape of the mesencephalic tectum representing the tectum (*), the structures that surround the tectum: rostrally by the caudal commissure (the white head arrow), rostro-dorsally by the suprapineal recess (the blue arrow), the caudo-dorsally by the quadrigeminal cistern (the red arrow) and the mesencephalic aqueduct ventrally (the yellow arrow).

More description of the roof included its ventral aspect which is appeared to be straight in all (Fig. 2-A) but one case. The latter case showed to have concave shape instead (Fig. 2-B). On the other hands, its dorsal aspect had roughly hill-like appearance. Leigh and his group identified the general appearance of the canine mesencephalic tectum using magnetic resonance imaging technique on T2w midline sagittal plane however; special description did not included in their study (Leigh et al, 2008).

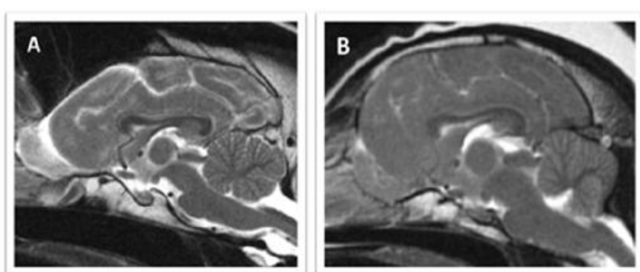

FIGURE 2: Two images of dogs' brain representing the normal shape of the mesencephalic tectum which has straight ventral and hill-like dorsal aspects (A) except of one case which showed to have slightly concave shape in its ventral aspect (B). These images were measured using T2w MRI on midline sagittal plane.

Defining the tectal area and its influence by head conformation, body weight and gender factors

After correcting the tectal area to the whole brain area at the midline sagittal plane, the corrected area ranged between 0.319 and 1.128 (Mean ±Std. Deviation =0.762 ±0.189). The corrected area appeared to be affected by the bodyweight (P=0.0149), but not the head conformation (P=0.3083) factors (Fig. 3). It is thought that the less body weight the dog has, the smaller the corrected tectal area will be. At the same time, the corrected area had no significant differences between males and females as the results represented in this study (Fig. 3). In man, the gender factor also appeared not to be correlated to the tectum measurements [Bolgov, 1976 and Sabanciogullari *et al*., 2013].

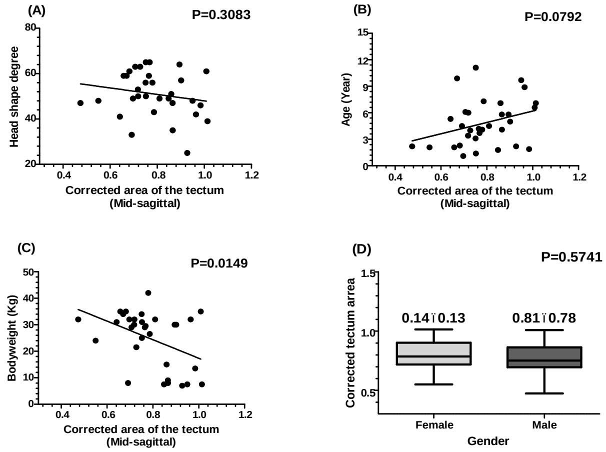

FIGURE 3: Linear regression representing the effect of head conformation (A), age (B), bodyweight (C) and gender (D) on the corrected area of the tectum when it was measured using midline sagittal plane on T2 weighted MRI.

When the location was determined according to the caudal fossa on midline sagittal plane, two third of the tectal area was situated within the caudal fossa in about 22% of total normal group while, the other 78% had only one third of the tectum within the caudal fossa (Fig. 4). When these results compared to the head shape, it is appeared that the head phenotype had only noticeable effect on them (P=0.0048) (Fig. 5). It is suggested that the more the brachycephalic head shape the animal has, the less percentage of the tectal area it will have within the caudal fossa. It is suggested that the structures of the caudal fossa may be deviated rostrally in shorter nose dogs in compare to the longer nose ones.

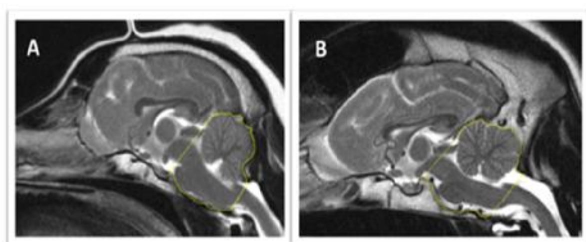

FIGURE 4: one third of the tectum appears to locate within the caudal fossa (A), while, two third of the tectum appears to locate within the caudal fossa (B) when the tectum measured using T2w MR Images on the midline sagittal plane.

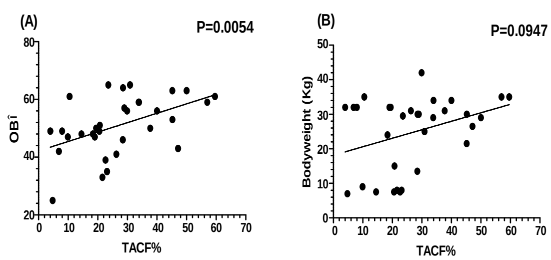

FIGURE 5: linear graphs representing (A) the effect of head conformation (OB°= olfactory bulb angle) and the bodyweight (B) on the ratio of the tectum (TACF%= the tectal area to the caudal fossa) located within the caudal fossa when it was measured using T2w MR image on midline sagittal plane.

The abnormal group

The shape deviated from the normal one that is already defined. In this group, 4 dogs showed to misplace the hill-like shape and three dogs have lost the normal straight ventral aspect of the tectum. In another three dogs, both of the dorsal and ventral aspect characters are lost. The breeds of the dogs that have these abnormalities are: Yorkshire terrier 3, Chihuahua 2, CKCS, Pug, cross breed, WHWT and Papillon. The tectum moved totally from the caudal fossa to the middle fossa in fifteen cases (36% of total group). The dorsal beaking was seen in the tectum when abnormalities were diagnosed in the human brain as studies referred ([11] Adeloye, 1976 and Tubbs *et al.*, 2014). The corrected area of the mesencephalic tectum revealed no significant differences in abnormalities comparing to the normal one (Fig. 6-A). However; obstruction of the mesencephalic aqueduct had a correlation to the size of the tectum in man ([13] Sherman *et al*., 1987). Furthermore, others had referred to possible enlargement of the tectum when there are defects within the tectum itself (Ho, 1982). This may be explained by the fact that the abnormalities in our study were within the cranial cavity generally and not specifically to the tectum itself. On the other hands, the ratio of the tectum which was located within the caudal fossa appears to be smaller in abnormal group in compare to the normal one (Fig.6-B). The mesencephalic tectum showed to be totally pushed forwards towards the middle fossa when there was elevation in the intracranial pressure in canine brains (Salam, 1977).

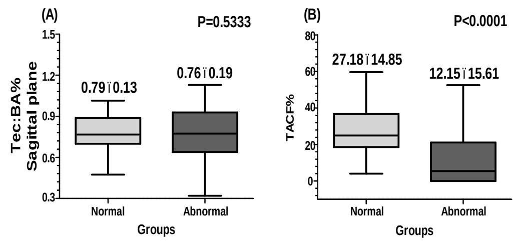

FIGURE 6: Whiskers box plot representing (A) the differences between normal and abnormal corrected area of the tectum and (B) ratio of the tectal area within the caudal fossa in normal and abnormal groups as they were measured using T2w MRI on midline sagittal plane. Note: Tect: BA%= corrected area of the tectum to the brain area on midlines sagittal plane, TACF= tectal area to the caudal fossa area on the same plane.

In our study the stenosis of the aqueduct appeared not to be correlated with the corrected area of the mesencephalic tectum. The obstruction may have correlation with enlarged tectum (Sherman *et al*., 1987), while, the aqueductal stenosis was found not to be associated with the enlargement of the tectum in man by others (Salam, 1977). In our study, the location of the tectum deviated from the caudal to middle fossa may be explained by that the smaller size of the caudal fossa associated with abnormalities may be led to push the tectum rostrally. Abnormalities like Chiari-like malformation syndrome showed to have significantly smaller caudal fossa as compare to the normal ones (Carrera *et al*., 2009 and Cerda-Gonzalez *et al*., 2009).

CONCLUSION

It is concluded that the mesencephalic tectal area on midline sagittal plane can be determined and its landmarks can be described. The location of the tectum appeared to be located between the middle and caudal fossa in normal group while, the location may deviated rostrally in abnormalities.

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