

Gross and Microscopic Anatomy of Cranial Dura Mater of Asian Elephant (*Elephas maximus*)

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ABSTRACT

Cranial dura mater of two dying male Asian elephants (*Elephas maximus*) aged 24 years and 68 years were performed for gross and microscopic studied. The cranial dura mater consisted of two layers, outer periosteal layer and inner meningeal layer. Porous appearance forming by blood vessels were seen between the two layers. Some completed foramens were found in falx cerebri sheet. Unlike most of domestic animals, there were two falx cerebelli running along two sides of vermis and also many small tubercles on the surface of inner meningeal layer. By staining with Hematoxylin & Eosin, Masson Trichrome and Weigert stains, these small tubercles were collagenous mass protrusion.

Key words: cranial dura mater, Asian elephant, tentorium cerebelli

INTRODUCTION

Since elephants possess the largest brain among land mammals, there are several reports on the development of central nervous system, the evolution of the brain, behavior, skill and intelligence of elephants (Friant, 1969; Markowitz *et al.*, 1975; Markowitz, 1982; Wright, 1984). Due to the difficulty to obtain the complete elephant's brain, very few articles reported on its anatomy. Most of the description and conclusion reported in comparative study relying on second hand data (Cozzi *et al.*, 2001) and only specific parts of the brain. Haug (1987) estimated the macroscopic size of brain and cortex. Shoshani *et al.* (1982) reported about the small hypophysis of elephant's brains. The detail of meninges has not yet been studied. The objective of this study was to

investigate on both gross and microscopic anatomy of cranial dura mater of Asian elephants (*Elephas maximus*).

MATERIALS AND METHODS

The brains of two dying male Asian elephants aged 24 and 68 years at the Elephant Conservation Center, Lumpang Province, Thailand were fixed in 10% neutral buffer formalin. Dissection of cranial dura mater was performed for gross study by making 2 parasagittal incision through dura mater from cranial end of cerebrum to the caudal end of cerebrum. Cranial end of falx cerebri, which attaches to the ethmoid crest was severed, then the falx cerebri was pulled upward and backward to expose the tentorium cerebelli and falx cerebelli. The surfaces of dura mater were

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examined under stereomicroscope. For microscopic study, the tissue samples of the cranial dura mater were processed according to histological technique for paraffin section and stained with Hematoxylin and Eosin (H&E), Masson Trichrome and Weigert staining (Luna, 1960).

RESULTS

Cranial dura mater of 2 dying male Asian elephants were studied both in gross and microscopic anatomy. The outer periosteal layer had rough surface as fibrous trabeculae. The inner meningeal layer had many small tubercles all over the surface (Figures 2, 3). There were small blood vessels draining to the thick sheet of dura mater on both outer and inner layers. By observing at the cut surface of the sheet, porous appearance forming by these blood vessels could be seen in some areas. The inner meningeal layer formed into 3 structures; 1) the septum of falx cerebri with some complete foramens (Figure 1), 2) tentorium cerebelli and 3) falx cerebelli. Unlike most of domestic animals, two falx cerebelli were found on the lateral side of vermis separating each cerebellar hemisphere.

Paraffin sections with H&E, Masson Trichrome and Weigert staining of the dura mater were examined under a compound brightfield

microscope (Olympus BX-51). Collagenous dense irregular connective tissue was the main component of the dura mater. Small blood vessels and plexus were found enormously in the outer layer but not in the inner layer. Tubercles on the inner layer were the protrusion of collagenous fibers (Figure 4). Staining with Masson Trichrome and Weigert stain, there was no elastic fibers in any area of the dura mater (Figure 5, 6). Under the highest magnification, 1000X, of the tubercle showed a lining of simple squamous epithelium on the surface. The venule blood vessels were located in the inner layer of dura mater. A few arterioles were found near the venules close to the periosteal layer. All tubercles had no any blood supply or nerve innervation.

DISCUSSION

Cranial dura mater of Asian elephant's brain had 2 layers, the outer periosteal layer and the inner meningeal layer as those of other mammals (Carpenter, 1991; Evans, 1993). Its outer surface was connected to the bony wall of cranial cavity by numerous fiber strand and blood vessels. Unlike other animals, the inner meningeal layer of elephant dura mater contained many small tubercles, the collagenous mass protrusion, instead

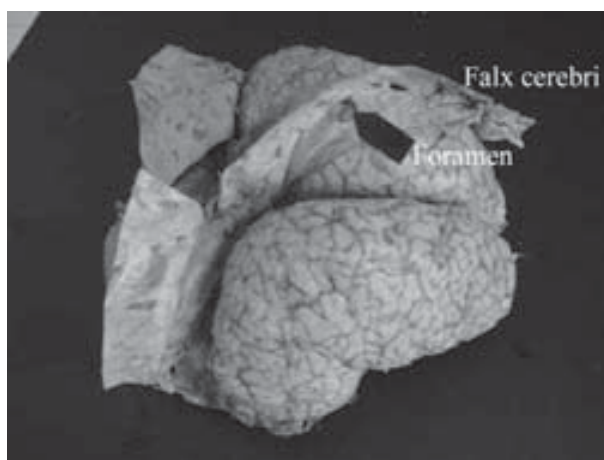


Figure 1 Asian elephant brain showing falx cerebri with foramens.

of smooth and glistening with multiple layers of flattened fibrocytes from outer cells of arachnoid membrane (Dellmann and Eurell, 1998). Since these tubercles have not been found in other mammals, the morphological function of the tubercle needs further study. The dura mater comprised of falx cerebri, tentorium cerebelli and two septum of falx cerebelli. The falx cerebri was a sickle-shaped median partition situated in the longitudinal fissure between the cerebral hemisphere and its ventral border over the corpus callosum. The tentorium cerebelli was a crescentic

fold which occupied transverse fissure between the cerebellum and the cerebral hemisphere. The two septum of falx cerebelli was a sickle-shaped fold which projected into the notch between the cerebellar hemisphere and vermis of cerebellum. Sikes (1971) stated that the cerebellum of African elephant was very similar to the cerebellum of human. However, there is only a single septum of falx cerebelli in human and is absent in other domestic animals (Carpenter, 1991; Sission, 1953; Getty, 1975).



Figure 2 Inner meningeal layer of cerebral dura mater of Asian elephant showing tubercles on the surface.

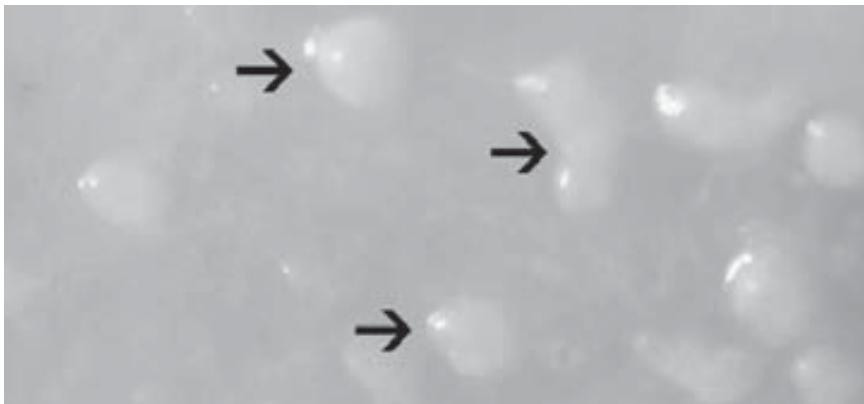


Figure 3 Magification of cranial dura mater of Asian elephant at inner meningeal layer with many tubercles. Arrows = tubercles

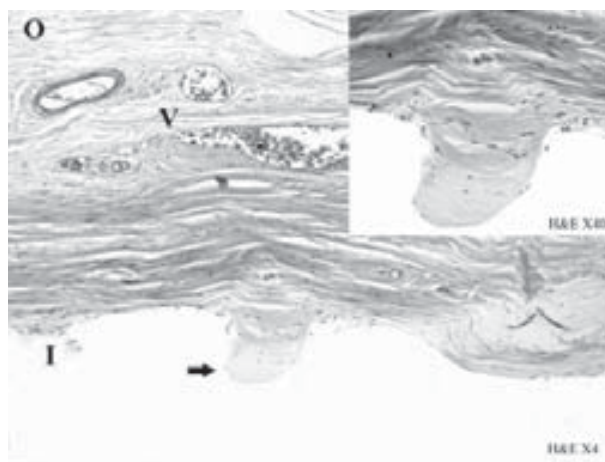


Figure 4 Microscopic structures of cranial dura mater of Asian elephant (H&E staining);
O = outer layer, I = inner layer, V = vessels, arrow = tubercle

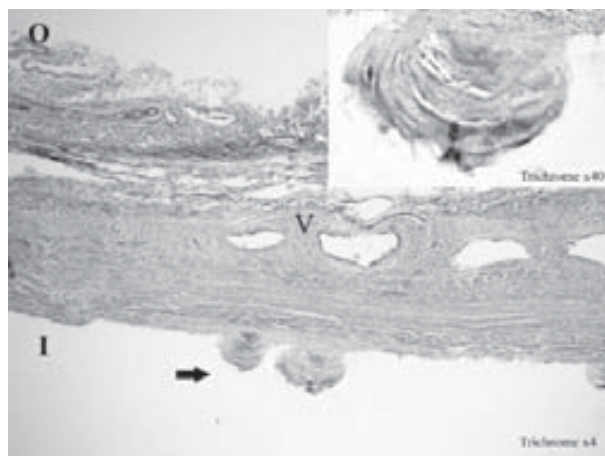


Figure 5 Microscopic structures of cranial dura mater of Asian elephant (Trichrome staining);
O = outer layer, I = inner layer, V = vessels, arrow = tubercle

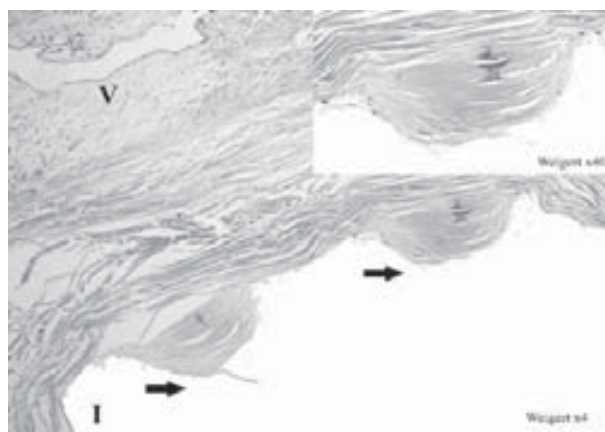


Figure 6 Microscopic structures of cranial dura mater of Asian elephant (Weigert staining);
I = inner layer, V = vessels, arrows = tubercles

CONCLUSION

Cranial dura mater of Asian elephant serves as protective sheet of brain as in other mammals but its gross and microscopic structures are different in the following aspects ; -

1. Two falx cerebelli separating each cerebellar hemisphere were found instead of one flax cerebelli.

2. Several small collagenous tubercles were found on the inner surface of meninges whereas the inner menigeal surface of dura of other mammals was smooth.

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