Magnetic resonance image and cross sectional anatomy of the normal brain of goat (*Capra hircus*)

A. Kassab*

Department of Aridland Agriculture, Faculty of Food and Agriculture, Alain 17555, United Arab Emirates University, United Arab Emirates

Abstract: Among ruminant animals, there are few studies on the brain of the goat (*Capra hircus*). Our study demonstrates the first series of magnetic resonance (MR) imaging-based anatomically labeled sectioned images of the brain of the goat. T2-weighted dorsal MR images were acquired with a 1.5-T Philips NT scanner with slice spacing of 4 mm thickness. Frozen cross-sectional slices of goat brain were photographed and compared with the MR images. The cerebral hemispheres, hippocampus, thalamus, hypothalamus, cerebellum, pons, myelencephalon and other major features of the brain are clearly defined in the images. These MR images provide an excellent soft tissue contrast and anatomic details of the brain of the goat. MR imaging provides a mean for consistent evaluation of the goat brain structures that could be useful for evaluation of diseases that affect the brain region.

Key words: Anatomy, brain, goat, magnetic resonance image

Corresponding Author, *Email*: a.kassab@uaeu.ac.ae, kassab_aa@yahoo.com

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Introduction

Magnetic resonance imaging (MRI) has known a diagnostic tool in human medicine since 1980s (Hawkes et al., 1980; Doyle et al., 1981). Furthermore, this instrument has proved to be valuable in the study of anatomy (Goncalves-Ferreira et al., 2001) and pathology (Arnold and Matthews, 2002) of the central nervous system due its superior soft-tissue contrast.

MRI can differentiate the structures of the large brains as in African elephants (Hakeem et al., 2005) and dwarf sperm whale (Marino et al., 2003) where traditional methods of sectioning, staining, mounting and microscopic examinations are not practical. Several reports in animals have been published (Kraft et al., 1989; Karkkainen et al., 1991; Hudson et al., 1995 and Chaffin et al., 1997). Few studies on the heads of ruminant animals exist specially in camels (Arencibia et al., 2005) and buffaloes (Kassab, 2007) have information on the neuroanatomy of the goat based on MRI.

The first labeled sequential description of the goat brain based on MRI within the head of the goat has been described. We are able to produce a series of slices in which the detailed brain structures can be observed with little or no distortion caused by physically sectioning of the brain. Therefore MRI has become a valuable method for examining goat brains.

Materials and Methods

Specimen

In the present study, six heads of adult goats (Capra hircus) of different ages (2-3 years) and sexes (two females and four males) were used. Goats were slaughtered in the slaughter house and the heads were sectioned at the level of atlantoaxial joint. Immediately, cooled and imaged within 12 hours to minimize post-mortem changes.

Magnetic Resonance Imaging and sectioning of the head

Contiguous T2-weighted dorsal MR images were acquired with a 1.5-T Philips NT scanner. Imaging protocol parameters were: repetition time (TR) = 4757 ms, echo time (TE) = 120 ms, matrix = 245-256 pixels, Field of view = 160mm, 4mm slice thickness with 4 mm interslice spacing. The head was scanned with the ventral side down in the human head coil.

After MRI, three heads were frozen to -20°C for 24-48 hours, and then sectioned using an electric band saw (Arencibia et al., 2005). One head was sectioned longitudinally and the other two heads were sectioned transversely. All sections were cleaned, photographed and kept for the future studies.

Anatomical labeling and nomenclature

All identifiable anatomical structures of the goat brain were labeled in the axial and sagittal plane images. The MR images were compared with the gross anatomical sections (Hillmann, 1975; Smuts and Bezuidenhout, 1987; Schaller, 1992; Arencibia et al., 2005).

Results

General morphology

The results of the present study consisted of one macroscopic image of midsagittal section, 11 dorsal MR images and 9 gross cross sections through the head of goat. This is a descriptive study of normal brain anatomy in the goat using MRI. Figure 1 shows the midsagittal section of the goat head with the clinically relevant anatomic structures.

Figure 2 (a-k) displays a dorsal-to-ventral sequence of originally acquired 4.0-mm-thick dorsal MR brain sections at 4 mm intervals. The dorsal images were oriented so that the right side of the head is to the viewer's left and the dorsal at the top. The figures include also inset images of goat brain showing the approximate orientation of each transverse section. Figure 3 (a-i) displays a rostral-to-caudal sequence of 4 mm thick transverse brain sections at 4 mm intervals.

The T2-weighted MR images provided excellent anatomical views of the anatomy of the brain and associate structures. The cerebrospinal fluid within the subarachnoid spaces and inside the ventricles had high signal intensity and appeared bright white. The other brain structures had intermediate signal intensity and appeared dark.
Figure 1. Macroscopic image of a Midsagittal section of normal goat brain. Rostral is to the right and dorsal is to the top of the image.
1, alar fold; 2, straight fold; 3, ventral nasal concha; 4, dorsal nasal concha; 5, nasal septum; 6, nasal bone; 7, corpus callosum; 8, cerebrum; 9, frontal sinus; 10, fornix; 11, Gyrus cinguli (Cingulate gyrus); 12, parietal bone; 13, thalamus and interthalamic adhesion; 14, dorsal sagittal sinus; 15, tentorium cerebella; 16, cerebellum; 17, Tegmentum of mesencephalon; 18, cerebral peduncle; 19, Fourth ventricle; 20, spinal cord; 21, Medulla oblongata; 22, pons; 23, Pituitary gland; 24, optic nerve; 25, lateral ventricle; 26, nasopharynx; 27, epiglottis; 28, soft palate; 29, tongue; 30, hard palate.

The cerebral hemispheres were narrow in the rostral part and become wider in their caudal part, as shown in the coronal slices (Figure 2). The basal ganglia structures such as the caudate nucleus can be easily visualized in Fig 3c. The internal capsule was wide and clear (Figure 2 a-h and Figure 3a-h), and carry the descending motor fibers. The hippocampus is small and in the ventral position in Figure 3e. The thalamus and hypothalamus were seen (Figure 2 g, h). The corpus callosum is thin with respect to the size of the cerebral hemispheres when compared to the human brain.

The cerebral peduncle is large and lies on the ventral surface of the midbrain (Figure 2).

Discussion
Knowledge of normal transverse anatomy of the brain of goat is essential to the evaluation of MRI. The present MR images allow for the visualization of the characteristic features of the goat brain.

The corpus callosum is relatively small structure in the goat brain with respect to the size of the cerebral hemispheres. This is in agreement with the earlier findings by Tarpley and Ridgway (1994) and Nieto et al. (1976) for cetaceans and humans and this is in contrast to the elephant brain that has an unusually large corpus callosum (Hakeem et al., 2005).

The present results show that the goat brain has small hippocampus which is found exclusively in the ventral position, similar to that observed in buffaloes (kassab, 2007). This is in contrast to the hippocampus of the elephant brain which is large and extends dorsally (Hakeem et al., 2005).

Understanding of normal brain anatomy of the goat using MRI is necessary for the diagnosis of the central nervous system diseases (Dennis, 1995).
Figure 2. (a-k) Dorsal-to-ventral sequence of anatomically labeled T2-weighted dorsal MR images through the whole goat brain.

Figure 2a. 1- Sinus frontales, 2- extension of frontal sinus into corneal process, 3- Septum sinus frontale, 4- N. opticus, 5- Hemisphérium cerebri, 6- Sinus sagittalis dorsalis, 7- Laminae intrasinuales, 8- Processus Cornalis ossis frontalis. Figure 2b. 1- Gyrus occipitalis, 2- Gyrus marginalis, 3- Gyrus preoccipitatus, 4- Gyrus ectosylvius caudalis, 5- Gyrus ectomarginalis medius, 6- Sinus frontales, 7- Septum sinus frontale, 8- Laminae intrasinuales, 9- Musculi oculi, 10- N. opticus, 11- Cornu. Figure 2c. 1- Gyrus occipitalis, 2- Gyrus marginalis, 3- Gyrus ectomarginalis medius, 4- Gyrus preoccipitatus, 5- Gyrus preoccipitatus, 6- Bulbus oculi, 7- Pars lateralis of gyrus ectomarginalis, 8- Gyrus ectosylvius caudalis, 9- Gyrus postcruciatus, 10- Sinus frontales, 11- Cornu, 12- Concha ethmoidalis. Figure 2d. 1- Lamina perpendicularis ossis, 2- Labyrinthus ethmoidalis, 3- Bulbus olfactorius, 4- Gyrus proreus, 5- Gyrus obliquus rostralis, 6- Sulcus obliquus, 7- Gyrus obliquus caudalis, 8- Fissura longitudinalis cerebri (Cerebral longitudinal fissure), 9- Sinus maxillaris, 10- Bulbus oculi, 11- Musculi oculi, 12- Capsula interna (internal capsule). Figure 2e. 1- Lamina perpendicularis ossis, 2- Labyrinthus ethmoidalis, 3- Bulbus olfactorius, 4- Bulbus oculi (Camera anterior bulbi), 5- Lens, 6- Bulbus oculi, Camera posterior bulbi, 7- Gyrus geniculi, 8- Gyrus proreus, 9- Fissura longitudinalis cerebri (Cerebral longitudinal fissure). Figure 2f. 1- Lamina perpendicularis ossis, 2- Labyrinthus ethmoidalis, 3- Lens, 4- Bulbus oculi, Camera anterior bulbi, 5- Bulbus oculi, Camera posterior bulbi, 6- Musculi oculi, 7- Bulbus olfactorius, 8- Fissura sylvia, 9- Ventriculus lateralis, 10- Capsula interna.
The use of MRI in goat is currently limited because of its expense and availability but with developing technology, it may become more readily available as the equipment become most effective.

**Conclusion**

MRI provides a mean for consistent evaluation of the goat brain structures useful for evaluation of diseases that affect the brain region.
References


