Morphological and stereotaxic studies of Iranian native goat's brain

Mohammadpour, A. A.

Department of Basic Sciences, School of Veterinary Medicine, University of Shahrekord, Shahrekord, Iran

Correspondence: A. A. Mohammadpour, Department of Basic Sciences, School of Veterinary Medicine, University of Shahrekord, Shahrekord, Iran. E-mail: a_mopour@yahoo.com

Summary

This study was conducted to find out the best outside points of skull to reach different areas of brain that are essential for neuroendocrinological studies. In this research 30 heads of Iranian native male goats aged between 2-3-year-old were collected from Shahrekord abattoir. After collecting whole heads, they were fixed in 10% formalin and then many holes were made on the dorsal surface of skull followed by median and transverse sectioning of the heads. Morphological characteristics of brain and distances from the bones of skull to different structures of brain were measured using caliper device and needle and the best points were determined. By this method the best points to reach the hypophysis and lateral ventricle with 90° angle are in distances of 45.2 ± 2.23 mm and 20.92 ± 1.02 mm at bregma point.

Key words: Stereotaxy, Goat, Brain

Introduction

Brain is the most important part of central nervous system that involves body senses and controls endocrine glands. The brain consists of a number of regions, each with specialized functions and connects the body to the external environment through sensory organs. In order to keep us alive, the brain has a set of sensory organs (eyes, ears, nose, taste and touch) to let us know what is going on in the outside world. The brains of animals have specialized sensory to challenge and threat with the ecosystems in which they evolved, for example, sharks sense blood in water, dogs hear very high-pitched sounds, bears detect scents from miles away, geese navigate thousand migrations. Their brains capacities to sense, process and act are designed to help keep them alive, to find food, to avoid threat, to procreate and keep the species going (Squire *et al*., 2002). These specifications can be important when studies are focused on different regions of brain. Stereotaxic study is a method to find out the best outside point and reaching a specific area in brain.

The stereotaxic method was first applied to study of nervous system by Horsley and Clarke (1908). Since then it has provided one of the most important techniques of investigation on the structure and function of specific regions of the brain. The availability of accurate and reliable stereotaxic coordinates has permitted experimenters to explore previously inaccessible structures deep within the brain. Stereotaxic methods have been employed in the accurate placement of experimental lesions, in electrical and chemical stimulation of the brain and in electrical and thermal recording studies (Kuhlenbeck, 1973). These techniques have found application in the laboratories of anatomists, physiologists, biochemists, psychologists and ethologists, as well as in various human clinical procedures.

Materials and Methods

Thirty heads of 2-3-year-old Iranian native male goats weighed 35-45 kg were collected from Shahrekord abattoir. For flashing the brain from blood and serum, 200 ml normal saline was injected into the left common carotid artery of each specimen and then allowed the blood and serum of brain to be removed from right common carotid artery. Subsequently, 10% formal saline was injected sufficiently by the same route for brain fixation. After removing muscles, the skulls with brains were fixed by immersion method in the same fixative for one month. Then in dorsal surface of cranium, the exact site of bregma point (suture between parietal and frontal bones) was cleared. This site was considered as the zero point. By using mechanical drill, one small hole (2 mm) was made in that point. In half a centimeter distances of zero point similar holes in rostral, caudal, left and right sides of skulls were made so that +1, +2, +3, + 4; -1, -2, -3, -4; L_1, L_2, L_3, L_4 and R_1, R_2, R_3, R_4 points were made, respectively (Fig. 1).

After preparing of 30 specimens, they sectioned as median and transverse planes equally and using needles and caliper device, different areas of brain samples were determined.

To reach the different areas of brain, for each point three factors such as: length (rostral and caudal part of zero point), width (lateral area of points) and angle of needle were determined and then depth or height (dorsoventral of points or distance between points and different areas of brain) were measured (Tables 1, 2 and 3).

Results

In this study for each landmark the mean value, standard deviation and 95% confidence interval were calculated (Tables 1, 2 and 3). Specific measurements of different areas of goat's brain are showed in Table 1. These measurements are very important for early stereotaxic studies of brain and next studies on goat's brain.

Distances between zero, rostral and caudal part of zero point and brain structures with 90º angle is showed in Tables 2 and 3. The results indicated that, the distance between zero point and top of lateral ventricle increases gradually from posterior to anterior (0 to +3). It increases from 20.92 ± 1.02 mm to 25.22 ± 1.98 mm. As can be seen in Table 3, the distance between zero point and top of anterior lobe of hypophysis increases from anterior to posterior (0 to -2). It increases from 45.2 ± 2.23 mm to 50.47 ± 0.83 mm. In transverse sections of heads, the results indicated that, distance between zero point and top of lateral ventricle decreases from medial to lateral points (0 to L_2 or R_2). It decreases from 22.05 ± 0.93 mm to 19.85 ± 1.41 mm. Also distance between zero point and top of hypophysis decreases from medial to lateral points. It decreases from 44.25 ± 0.74 mm to 41.17 ± 0.57 mm, respectively. The present study provides measurements and distances that can be used for intraventricular injections or neuroendocrinological studies, particularly in native goat. To access lateral ventricle and hypophysis, representative planes selected from the goat's brain in Figs. 2, 3 and 4.

Table 1: Morphological structures of goat's brain in median sections

Specific measurements (mm)	Mean ± SD	95% Conf. Int.
Brain length from anterior to posterior part	90.45±2.46	86.53-94.36
Brain height in zero point	46.125±2.07	46.83-49.42
Cerebral hemisphere length	65.4±3.60	59.67-71.12
Corpus callosum length	36.82±1.19	34.91-38.73
Corpus callosum height	4.07±0.68	2.99-5.15
Hypophysis length	19.22±0.9	17.78-20.66
Hypophysis height	7.8±0.96	6.26-9.33
Thalamus length	12.05±0.93	10.56-13.53
Thalamus height	8.8±0.88	5.08-14.26
Corpora quadrigemina length	10.92±0.88	9.51-12.33
Corpora quadrigemina height	6.75±1.34	4.60-8.89
Sylvian duct length	10.45±0.42	9.78-11.11
Cerebellar length	32.22±1.58	29.70-34.74
Cerebellar height	26.87±1.03	25.23-28.51
Pons length	11.62±0.43	10.93-12.31
Pons height	4.52±0.72	6.36-8.68
Fourth ventricle length	28.75±2.74	24.38-33.11
Medulla oblongata length	21.05±0.66	19.99-22.10
Medulla oblongata height	8.9±0.45	8.17-9.62
Spinal cord diameter in foramen magnum	5.62± 0.35	5.06-6.18
Epiphysis length	5.12±0.15	4.88-5.36
Epiphysis height	3.92±0.22	3.57-4.27

Discussion

The goat has been used for many years to study the endocrine control of the mammary gland and in particular, the role of pituitary hormones (Tindal *et al.*, 1968, 1987). A stereotaxic technique is essential

Table 2: Descriptive parameters of rostral points of bregma (zero point) in median sections

Specific measurements (mm)	Length (cm)	Wide (cm)	Height (mm)		
			Mean	SD	95% Conf. Int.
Bone thickness in zero point	0	0	3.77	0.74	2.59-4.95
Distance between zero point and top of anterior lobe of hypophysis	0	0	45.2	2.23	41.64-48.75
Distance between zero point and center of anterior lobe of hypophysis	0	0	46.7	1.63	44.59-49.35
Distance between zero point and bottom of anterior lobe of hypophysis	0	0	49.15	1.01	47.55-50.74
Distance between zero point and top of lateral ventricle	0	0	20.92	1.02	19.29-22.55
Distance between zero point and bottom of lateral ventricle	0	0	22.37	0.94	20.89-23.87
Cerebral height in zero point	0	0	22.8	0.60	20.83-23.76
Bone thickness in +1 point	0.5	0	3.25	0.62	2.25-4.24
Distance between +1 point and top of lateral ventricle	0.5	0	22.57	1.07	20.86-24.28
Distance between +1 point and bottom of lateral ventricle	0.5	0	24.67	0.39	24.54-25.30
Cerebral height in +1 point	0.5	0	41.07	2.40	37.24-44.90
Bone thickness in +2 point	1	0	2.92	0.22	2.57-3.27
Distance between +2 point and top of lateral ventricle	1	0	24.35	0.92	22.87-25.82
Distance between +2 point and bottom of lateral ventricle	1	0	34.55	2.22	31.01-38.08
Distance between +2 point and top of optic chiasma	1	0	40.7	1.01	39.08-42.31
Distance between +2 point and center of optic chiasma	1	0	41.95	1.5	39.56-44.33
Distance between +2 point and bottom of optic chiasma	1	0	44	2.07	40.69-47.30
Cerebral height in +2 point	1	0	40.37	1.12	38.58-42.16
Bone thickness in +3 point	1.5	0	3.9	1.04	2.24-5.55
Distance between +3 point and top of lateral ventricle	1.5	0	25.22	1.98	22.56-28.38
Distance between +3 point and bottom of lateral ventricle	1.5	0	37.65	2.33	33.93-41.36
Cerebral height in +3 point	1.5	0	36.97	0.86	35.59-38.35
Bone thickness in +4 point	2	0	5.85	1.5	3.44-8.25
Distance between +4 point and anterior part of lateral ventricle	2	0	28.5	0.89	27.58-29.91
Cerebral height in +4 point	2	0	36.82	0.96	35.28-38.36

for the accurate insertion of electrodes and cannulae bearing steroids or drugs into specific brain structures. The results of this study are more effective and helpful for the other researchers in goat's brain areas. In this study most of the morphological features of Iranian native goat's brain were determined. The brain areas, particularly ventricles and hypophysis are very important sites in neuroendocrinological studies. Comparative descriptions of the ventricular system of mammals including sheep were made by other researchers and concluded that, lateral ventricles show important variations, but the topography of their olfactory recess is constant (Kozlowski *et al*., 1973; Lignereux, *et al*., 1991). There are several methods for stereotaxic studies of brain. A new stereotaxic coordinate system has been described for the goat's brain based on cranial landmarks. In this method, osseous triangle (a-b-c) formed by three structures of point of crista galli (a), external occipital protuberance (b) and external acoustic meatus (c). By using lateral radiograph and ventriculograph a constant

Table 3: Descriptive parameters of caudal points of bregma in median sections

Specific measurements (mm)	Length (cm)	Wide (cm)	Height (mm)		
			Mean	SD	95% Conf. int
Bone thickness in -1 point	0.5	0	3.82	0.33	3.21-4.42
Distance between -1 point and top of hypophysis	0.5	0	45.8	1.26	43.48-48.11
Distance between -1 point and bottom of hypophysis	0.5	0	52.4	0.55	51.38-53.41
Cerebral height in -1 point	0.5	0	47.5	1.23	45.22-49.77
Bone thickness in -2 point	1	0	4.02	0.14	3.75-4.29
Distance between -2 point and top of epiphysis	1	0	29.5	1.93	25.94-33.05
Distance between -2 point and bottom of epiphysis	1	0	32.55	0.86	30.94-34.13
Distance between -2 point and between anterior and posterior hypophysis	1	0	50.47	0.83	48.94-52.00
Distance between -2 point and bottom of hypophysis	1	0	53.57	0.86	51.99-55.15
Distance between -2 point and top of superior colliculi	1	0	29.05	1.42	26.42-31.66
Distance between -2 point and sylvian duct	1	0	28.95	1.23	26.68-31.21
Cerebral height in -2 point	1	0	49.5	0.53	48.51-50.48
Bone thickness in -3 point	1.5	0	3.72	0.22	3.30-4.14
Distance between -3 point and top of superior colliculi	1.5	0	25.2	0.60	24.09-26.30
Distance between -3 point and sylvian duct	1.5	0	34.1	1.05	32.06-35.93
Cerebral height in -3 point	1.5	0	43.45	1.39	40.89-46.00
Bone thickness in -4 point	2	0	4.05	0.45	3.22-4.87
Distance between -4 point and anterior part of cerebellum	2	0	22.57	0.91	20.89-24.25
Distance between -4 point and top of pons	2	0	40.22	1.49	37.45-42.94
Distance between -4 point and bottom of pons	2	0	45.72	0.69	44.44-47.00
Distance between -4 point and bottom of cerebellum	2	0	36.22	1.52	34.35-38.09
Cerebral height in -4 point	2	0	40.95	1.12	38.67-43.03

mathematical relation was measured. The hypotenuse length (a-b distance) is a good predictor of the rostral nuchal position of the anterior commissure and the infundibular recess of the third ventricle (Zuccolilli and Mori, 1995). By comparing the morphological structures of goat's brain with Lori-Bakhtiari sheep (a native breed in Iran) it was observed that, the brain size and most of morphological structures of it in sheep was more. As the results, the distance between zero point and top of hypophysis in Lori-Bakhtiari sheep was 50.22 mm but in goat 45.2 mm was determined. Also the distance between zero point and top of lateral ventricle in sheep and goat was 24.3 mm and 20.9 mm, respectively (Mohammadpour and Mohammadnia, 2003). The role of catecholamines in the control of GnRH pulse generator is unclear as studies have relied on the use of peripheral or intracerebroventricular injections, with no specificity in relation to the anatomical site of action. One such area of interest in the control of GnRH is the median eminence and arcuate nucleus within the medial basal hypothalamus. (Anderson *et al*., 1997) described a method of stereotaxically targeting this area in sheep and an infusion system to deliver drugs into unrestrained conscious animals.

Based on our findings for accessing the brain regions of native goat through the frontal bone, more distances should be crossed compared to other breeds. In conclusion, these findings can be used as

Fig. 1: The holes that were made in area of zero point

Fig. 2: Distance between zero point and top of lateral ventricle (Lv)

reference values for experimental studies on goat's brain. To reach the important areas of brain, different angles should be calculated and we concluded that if a needle with 25 mm length and 75º angle from zero point inserted the apex of it, will be located in posterior part of lateral ventricle. Needle with the angle of 115º and 35 mm length will be located in anterior part of lateral ventricle. To access the third and fourth ventricles, needles with the lengths of 38.4 mm and 48.5 mm and the angles of 73º and

Fig. 3: Distance between zero point and top of adenohypophysis (Ah)

Fig. 4: Distance between -2 point and between adenohypophysis (Ah) and neurohypophysis (Nh)

130º were needed, respectively. We suggested that, although researches on other organs and systems can be generalized for many animals, central nervous system studies show considerable specification between species or in one species.

References

1- Anderson, ST; Sawangjaroen, K and Curlewis, JD (1997). A method for drug infusion into the lateral median eminence and arcuate nucleus of sheep. J. Neurosci. Meth., 2: 169-176.

2- Horsley, V and Clarke, RH (1908). The structure and functions of the cerebellum examined by a new method. Brain. 31: 44-124.

3- Kozlowski, GP; Scott, DE and Dudley, GK (1973). Scanning electron microscopy of the third ventricle of the sheep. Z. Zellforsch., 136: 169-176.

4- Kuhlenbeck, H (1973). The ontogenetic development of diencephalic centers in the bird's brain (chick) and comparison with reptilian and mammalian diencephalons. J. Comp. Neurol., 66: 23-75.

5- Lignereux, Y; Regodon, S; Marty, MH; Franco, A and Bubien, A (1991). Encephalic ventricles of the ewes (*Ovis aries Linnaeus*): conformation, relations and stereotaxic topography. Acta Anat., 141: 82-84.

6- Mohammadpour, AA and Mohammadnia, AR (2003). The stereotaxic study of central nervous system of native Iranian Lori-Bakhtiari ewe. Indian Vet. J., 80: 902-905.

7- Squire, L; Bloom, F; McConnell, S; Roberts, J; Spitzer, N and Zigmond, M (2002). *Fundamental neuroscience*. 2nd. Edn., Academic Press. PP: 16-25.

8- Tindal, JS; Knaggs, GS and Turvey, A (1968). The forebrain of the goat in stereotaxic coordinates. J. Anat., 103: 457-469.

9- Tindal, JS; Turvey, A and Blake, LA (1987). A stereotaxic atlas of the medulla oblongata of goat's brain. J. Anat., 155: 195-202.

10- Zuccolilli, G and Mori, Y (1995). Cranial and cerebral ventricular landmarks for accurate stereotaxic approach to hypothalamic nuclei in the goat brain. J. Vet. Med. Sci., 57: 453-457.