https://dergipark.org.tr/tr/pub/ataunivbd
2021; 16(2): 170-175

Research Article/Araştırma Makalesi
DOI: 10.17094/ataunivbd.870886

Atatürk Üniversitesi Veteriner Bilimleri Dergisi
Atatürk University Journal of Veterinary Sciences

Examination of the Topography and Morphometry of Hypophysis (Glandula pituitaria) by Computed Tomography in New Zealand Rabbits

Ismail DEMIRCIOGLU[1a]✉, Yasin DEMIRASLAN[2b], Iftar GURBUZ[2c], Mustafa Orhun DAYAN[3d]

1. Harran University, Faculty of Veterinary Medicine, Department of Anatomy, Şanlıurfa, TURKEY.
2. Burdur Mehmet Akif Ersoy University, Department of Anatomy, Faculty of Veterinary Medicine, Burdur, TURKEY.
3. Selcuk University, Department of Anatomy, Faculty of Veterinary Medicine, Konya, TURKEY.

ORCID: 0000-0002-0724-3019[a], 0000-0003-3612-6142[b], 0000-0001-9460-0645[c], 0000-0003-0368-4607[d]

Geliş Tarihi/Received	Kabul Tarihi/Accepted	Yayın Tarihi/Published
29.01.2021	23.03.2021	31.10.2021

Bu makaleye atıfta bulunmak için/To cite this article:
Demircioglu I, Demiraslan Y, Gurbuz I, Dayan MO: Examination of the Topography and Morphometry of Hypophysis (Glandula pituitaria) in New Zealand Rabbit by Computed Tomography. Atatürk University J. Vet. Sci., 16(2): 170-175, 2021. DOI: 10.17094/ataunivbd.870886

Abstract: The aim of this study is to determine the morphometry of hypophysis of the New Zealand rabbit by using the computed tomography images and its topography according to the anatomical structures in the cavum cranii. For this purpose, the head of 12 (6 female, 6 male) New Zealand Rabbits was scanned in a prone position by using Multi-Detector Computed Tomography. Three-dimensional modeling of the images obtained was performed. Morphometric analysis of the hypophysis, the three-dimensional modeling of which was performed, and its topographic measurements were taken according to the adjacent structures. When the data were examined, it was found that protuberantia occipitalis externa value was statistically significant in terms of sexes (P<0.05). There was no statistically significant difference between other data in terms of sexes (P>0.05). When the correlation analysis was examined, positive correlations between the gland volume and volume of cavum cranii (P<0.01) and between volume and surface area of cavum cranii were detected (P<0.05). Consequently, it is thought that the data of the study would contribute to the operative and experimental studies to be conducted on the region by determining the morphometry and topography of the hypophysis in New Zealand rabbits.

Keywords: Gl. pituitaria, Hypophysis, New Zealand rabbit, Topography.

Yeni Zelanda Tavşanlarında Hipofiz Bezi’nin (Gandula pituitaria) Topografisi ve Morfometrisinin Bilgisayarlı Tomografi ile İncelenmesi

Öz: Çalışmada, Yeni Zelanda tavşanında hipopysis’in bilgisayarlı tomografi görüntüleri kullanılarak, morfometrisinin ve cavum cranii’deki anatomik yapılara göre topografisinin belirlenmesi amaçlandı. Bu amaçla çalışmada 12 adet (6 dişi, 6 erkek) Yeni Zelanda tavşanının, cranium bölgesi, prone pozisyonda, Multi Detector Computed Tomography kullanılarak, 0,625 mm kesit kalınlığında tarandı. Elde edilen görüntülerin üç boyutlu modellemeleri yapıldı. Üç boyutlu modellemeleri yapılan hipophysis bezinin morfometrik analizi ve komşuluğu bulunan yapılara göre topografik ölçümleri alındı. Veriler incelendiğinde protuberantia occipitalis externa değerinin cinsiyetler açısından istatistiki olarak anlamlı olduğu belirlendi (P<0.05). Diğer veriler arasında cinsiyetler arasında istatistiki olarak anlamlı bir fark belirlenmedi (P>0.05). Korelasyon analizi incelendiğinde ise, bez hacmi ile cavum cranii hacmi arasında (P<0.01) ve cavum cranii hacmi ile cavum cranii yüzey alanı arasında (P<0.05) pozitif korelasyonlar tespit edildi. Sonuç olarak çalışma verilerinin, Hypophysis bezinin Yeni Zelanda tavşanlarındaki morfometresini ve topografisini belirleyerek bölge üzerinde yapılacak operatif ve deneysel çalışmalara katkı sağlayacağı düşünülmektedir.

Anahtar Kelimeler: Gl. pituitaria, Hipofiz, Topografi, Yeni Zelanda tavşanı.

✉ Ismail Demircioglu
Harran University, Faculty of Veterinary Medicine, Department of Anatomy, Şanlıurfa, TURKEY.
e-mail: idemircioglu@harran.edu.tr

INTRODUCTION

New Zealand Rabbit (*Oryctolagus cuniculus*) is a rodent belonging to the family Leparidae in the order Lagomorpha of the class Chordata (1,2). Rabbits were first started to be used in scientific studies between 1672 and 1797 and today; they are one of the most widely used experimental animals in laboratory studies (2,3). Rabbits are the frequently preferred animal models in scientific research due to the reasons such as being non-aggressive, economical care and feeding when compared to large animals, having short life circulations (pregnancy, puberty, etc.), the sustainability of the local ethics committee procedure, easy follow-up of the process before and after the experiment (4).

The hypophysis gland is localized in fossa hypophysialis on os sphenoidale within the cavum cranii (5). The dorsal of the hypophysis is covered with dura mater. Infundibulum passing through the gap in the middle of this cover connects hypothalamus and hypophysis (6). The central nervous system provides hormonal control via the hypothalamus and hypophysis. The hypothalamus controls the hormone secretion from hypophysis (7). Hypophysis consists of two partsas adenohypophysis (anterior lobe) and neurohypophysis (posterior lobe). Hormones secreted from hypophysis either show an effect in the peripheral nervous system or stimulate and control hormone secretion in the endocrine organs according to the mode of action (6,8). It is reported that computed tomography (CT) provides quite practical and accurate results in the assessment of the hypophysis (9).

Determination of detailed information about the neural, vascular, and bone anatomy of cavum cranii and the determination of the locations of such structures according to each other would minimize the damage in other vital organs in the operations to be conducted on the region and in the experimental studies (10). From this point of view, no study in which hypophysis in New Zealand rabbit, which is frequently preferred as an experimental animal model was evaluated via topographic approach was found in the literature review. Thus, the aim of the study was to determine the morphometry of hypophysis, which plays a major role in the regulation of body functions, in New Zealand rabbits by using the computed tomography images and its topography according to the anatomical structures in cavum cranii.

MATERIALS and METHODS

A total of 12 (6 female, 6 male) adult New Zealand rabbits were used in the study. The mean and standard deviation (SD) of the live weights of the rabbits were found as 2.57 ± 0.22 kg in females and 2.67 ± 0.30 kg in males. The study permissions were taken from Harran University Animal Experiments Local Ethics Committee (Decision no: 2020/006/01).

The heads of the rabbits were scanned in a prone position by using a 64-detector Multi-Detector Computed Tomography (MDCT) (TOSHIBA, Aquilion, 64 Slices) with a slice thickness of 0.625 mm under general anesthesia and MDCT images were obtained and recorded in DICOM (Digital Imaging and Communications in Medicine) format. In the scan dose and protocol, Prokop (11) and Kalra (12) were taken as a reference. MDCT images were transferred to MIMICS 20.1 (The Materialise Group, Leuven, Belgium) program which can perform the three-dimensional modeling of the images. Morphometric measurements of the hypophysis, which was modeled as three dimensional, as well as topographic measurements according to the adjacent structures were taken (Figure 1-4). Nomina Anatomica Veterinaria (4) was taken as a basis in the study terminology.

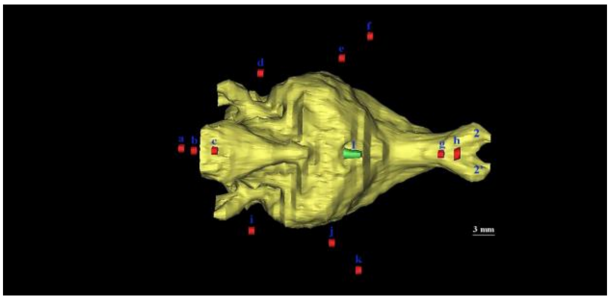

Figure 1. Basal view of landmarks.
Şekil 1. Landmark' ların bazal görünümü.
1. Hypophysis, 2., 2'. Bulbus olfactorius, a. protuberantia occipitalis externa, b. dorsal angle of foramen magnum, c. bifurcation of arteria basilaris, d. left membrana tympani, e. left temporomandibular joint, f. the most caudal level of left arcus orbitalis, g. the most ventral level of crista galli, h. the most caudoventral level of septum nasi, i. right membrana tympani, j. right temporomandibular joint k. the most caudal level of right arcus orbitalis.

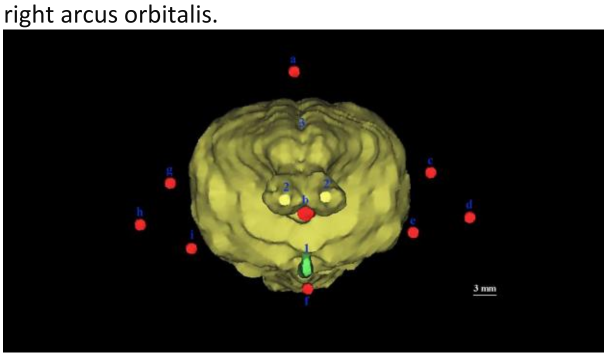

Figure 2. Rostral view of landmarks.
Şekil 2. Landmarkların rostral' den görünümü.
1. Hypophysis, 2., 2'. Bulbus olfactorius, 3. Fissura longitudinalis cerebri, a. the most dorsal level of crista sagittalis externa, b. the most ventral level of crista galli, c. left temporomandibular joint, d. the most caudal level of left arcus orbitalis, e. left membrana tympani, f. the most caudoventral level of septum nasi, g. right temporomandibular joint, h. the most caudal level of right arcus orbitalis, i. right membrana tympani.

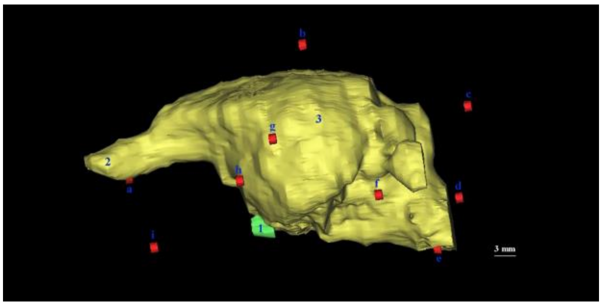

Figure 3. Left lateral view of landmarks.
Şekil 3. Landmark' ların sol lateral' den görünümü.
1. Hypophysis, 2. Bulbus olfactorius, 3. Left hemispherium cerebri, a. the most ventral level of crista galli, b. the most dorsal level of crista sagittalis externa, c. protuberantia occipitalis externa, d. dorsal angle of foramen magnum, e. bifurcation of arteria basilaris, f. left membrana tympani, g. left temporomandibular joint, h. the most caudal level of left arcus orbitalis, i. the most caudoventral level of septum nasi.

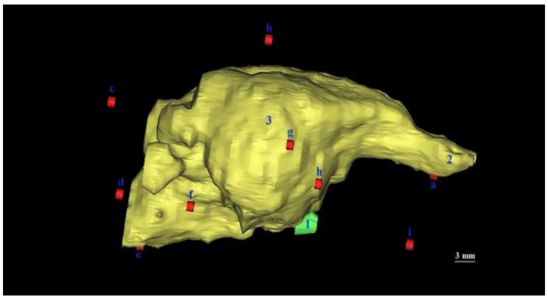

Figure 4. Right lateral view of landmarks.
Şekil 4: Landmark' ların sağ lateral görünümü.
1. Hypophysis, 2. Bulbus olfactorius, 3. Right hemispherium cerebri, a. the most ventral level of crista galli, b. the most dorsal level of crista sagittalis externa, c. protuberantia occipitalis externa, d. dorsal angle of foramen magnum, e. bifurcation of arteria basilaris, f. right membrana tympani, g. right temporomandibular joint, h. the most caudal level of right arcus orbitalis, i. the most caudoventral level of septum nasi.

Measurement points and abbreviations were taken belonging to hypophysis;

HL: Hypophysis length

HW: Hypophysis width

HSA: Hypophysis surface area

HV: Hypophysis volume

LLCC: The largest laterolateral diameter of cavum cranii

DVCC: The highest dorsoventral diamater cavum cranii

LTMJ: Level of left temporomandibular joint

RTMJ: Level of right temporomandibular joint

POE: Protuberantia occipitalis externa

DAFM: Dorsal angle of the foramen magnum

LMT: Left membrana tympani

RMT: Right membrana tympani

LCAO: The most caudal level of left arcus orbitalis

RCAO: The most caudal level of right arcus orbitalis

VCG: The most ventral level of crista galli

BAB: Bifurcation of arteria basilaris
DCSE: The most dorsal level of crista sagittalis externa
CVSN: The most caudoventral level of septum nasi
CCV: Cavum cranii volume
CCSA: Cavum cranii surface area

Statistical Analyses

Statistical analyses were conducted using SPSS 22.0 software. Compliance of data for normal distribution was assessed by the Kolmogorov-Smirnov test. The presence of the differences between the sexes or sides was examined by the independent sample t-test. All the morphologic parameters were expressed as mean ± standard deviation.

RESULTS

No statistical difference was found between the sexes in terms of the live weights (LW) of the rabbits used in the study (female: 2653.33 ± 257.52 gr; male: 2624.17 ± 229.18 gr) (P>0.05). Table 1 shows the mean values and standard deviations of the morphometric measurements taken for the hypophysis and cavum cranii for both sexes. Accordingly, it was found that the difference of POE value was statistically significant (P<0.05) in terms of sexes. There was no statistically significant difference between the other data in terms of sexes (P>0.05). Besides, no statistically significant difference was found between the right and left values of TMJ, MT, CAO data in direction analysis (P>0.05) (Table 2).

Table 1. The mean values and standard deviations (SD) of the hypophysis and cavum cranii.
Tablo 1. Cavum cranii ve hypophysis' in ortalama değerleri ve standart sapmaları (SD).

Parametreler		Descriptive			Female	Male	P
		Mean±SD	Min	Max	Mean±SD	Mean±SD	
1.	LW (gr)	2638.75±232.92	2350	3085	2653.33±257.52	2624.17±229.18	NS
2.	LLCC (mm)	26.30±0.91	24.28	27.8	26.64±0.84	25.95±0.91	NS
3.	DVCC (mm)	22.71±0.84	21.60	24.26	22.25±0.63	23.07±0.91	NS
4.	RTMJ (mm)	19.210.56	18.22	20.39	19.01±0.09	19.42±0.77	NS
5.	LTMJ (mm)	19.18±0.60	18.15	20.30	19.02±0.33	19.35±0.78	NS
6.	POE (mm)	32.37±1.18	30.11	33.81	31.69±1.28	33.04±0.55	*
7.	DAFM (mm)	26.86±0.86	24.96	27.85	26.74±1.04	26.97±0.72	NS
8.	RMT (mm)	21.63±1.05	20.00	23.08	21.38±1.14	21.88±0.98	NS
9.	LMT (mm)	21.40±0.87	19.94	22.82	21.26±0.67	21.54±1.08	NS
10.	RCAO (mm)	20.33±0.73	19.42	22.03	19.98±0.42	20.69±0.84	NS
11.	LCAO (mm)	20.34±0.54	19.14	20.99	20.27±0.60	20.40±0.52	NS
12.	VCG (mm)	20.71±2.03	18.36	24.42	20.61±2.62	20.81±1.47	NS
13.	BAB (mm)	22.42±0.93	20.72	23.60	22.49±0.92	22.36±1.02	NS
14.	DCSE (mm)	25.02±0.87	23.29	26.82	24.91±0.47	25.14±1.19	NS
15.	CVSN (mm)	13.39±0.96	11.86	14.94	13.05±0.79	13.73±1.05	NS
16.	HV (mm^3)	5.21±1.50	3.32	8.57	5.74±1.52	4.68±1.41	NS
17.	CCV (mm^3)	9030.42±858.37	7208.42	10514.73	9228.61±543.10	8832.24±1109.83	NS
18	HL (mm)	2.78±0.31	2.27	3.32	2.79±0.33	2.77±0.33	NS
19.	HW (mm)	2.13±0.23	1.89	2.58	2.20±0.29	2.06±0.16	NS
20.	HSA (mm^2)	17.62±3.59	12.97	25.11	18.73±3.74	16.51±3.38	NS
21.	CCSA (mm^2)	3306,15±231.64	3010,08	3795,45	3347.95±256.39	3264.34±219.35	NS

HL: Hypophysis length, HW: Hypophysis width, HSA: Hypophysis surface area, HV: Hypophysis volume, LLCC: The largest laterolateral diameter of cavum cranii, DVCC: The highest dorsoventral diamater cavum cranii, LTMJ: Level of left temporomandibular joint, RTMJ: Level of right temporomandibular joint, POE: Protuberantia occipitalis externa, DAFM: Dorsal angle of the foramen magnum, LMT: Left membrana tympani, RMT: Right membrana tympan, LCAO: The most caudal level of left arcus orbitalis,RCAO: The most caudal level of right arcus orbitalis, VCG: The most ventral level of crista galli, BAB: Bifurcation of arteria basilaris, DCSE: The most dorsal level of crista sagittalis externa, CVSN:The most caudoventral level of septum nasi, CCV: Cavum cranii volume, CCSA:Cavum cranii surface area. NS: No Significant, *: P<0.05.

Table 2. The values of analysis between right and left landmarks.
Tablo 2. Sağ ve sol lanmark' lar arasındaki analiz değerleri.

Parameters	Side	Mean	SD	P
TJ	Right	19.21	0.56	NS
	Left	19.18	0.60	
MT	Right	21.63	1.05	NS
	Left	21.40	0.87	
CAO	Right	20.33	0.73	NS
	Left	20.34	0.54	

TJ : Temporomandibular joint, MT: Membrana tympani, CAO: The most caudal level of arcus orbitalis. NS: No Significant.

When the correlation values of the volumetric and surface areas of the hypophysis and cavum cranii were examined (Table 3), positive correlations were detected between the volume and the surface area of the gland (P<0.001) and between the gland volume and the volume of cavum cranii (P<0.01). When Table 3 was also examined, positive correlations between the volume of cavum cranii and the surface area of the gland (P<0.05) and between the volume and surface area of cavum cranii (P<0.05) were found.

Table 3. Correlation values of volume and surface area of hypopysis and cavum cranii.
Tablo 3. Hypopysis ve cavum cranii' nin yüzey alan ve hacim değerlerinin korelasyonu.

	HV	CV	HSA	CCSA
HV	1			
CCV	0.007**	1		
HSA	0.000***	0.017*	1	
CCSA	0.332	0.005*	0.435	1

HV: Hypophysis volume, CCV: Cavum cranii volume, HSA: Hypophysis surface area CCSA:Cavum cranii surface area. *P <0.05, **P <0.01, *** P<0.001.

DISCUSSION and CONCLUSION

It is important to determine the detailed characteristics of hypophysis due to the presence of surrounding vital structures and its anatomic location. There are various studies about hypophysis via advanced imaging techniques (14-19). However, in the literature, no study was found in which the topography of the gland was detected in cavum cranii.

In the study, mean height and width values of the hypophysis of New Zealand Rabbit were found as 2.78 ± 0.31 mm and 2.13 ± 0.23 mm, respectively. In their study, Kwan et al. (14), found the height of the gland as 4.22 ± 0.57 mm and its width as 4.48 ± 0.71 mm in the measurements taken from the CT images of the rabbits, while Müllhaupt et al. (20), examined the height and width of hypophysis of New Zealand rabbit by using MRI and found them as 3.5 ± 0.26 mm and 3.5 ± 0.59 mm, respectively. It is thought that such differences between morphometric data may be caused by the variation in population sizes and the differences in the principle and modality of the imaging systems.

In the study conducted by Turamanlar et al. (15), on the change of the volume of hypophysis according to the seasons, they reported that the volume of hypophysis statistically increased in summer than winter. Han et al. (18) specified that the volume of hypophysis varied according to age and the reason for this may be related to the change of the hormonal system of the body with increasing age. Nadimi et al. (21) specified the volume of the hypophysis in cats and dogs as 26.19 ± 7.99 mm3 and 77.53 ± 51.64 mm3, respectively. In the study, the volume of hypophysis of New Zealand Rabbits was detected as 5.74 ± 1.52 mm3 in females and as 4.68 ± 1.41 mm3 in males. No statistical difference was found between females and males. A positive correlation was found between the volume of the hypophysis and the volume of cavum cranii.

Uzun et al. (17), analyzed the surgical corridors in operations by determining the morphometric analysis of the structures associated with fossa hypophysialis for surgical approaches and determining safe distances in surgical operations related to the skull base. In the present study, it was aimed to determine the topography of the hypophyseal region in cavum cranii and to figure out the regional anatomy better. It is a fact that the data obtained will guide operators during the experimental animal model operations or radiologists in the evaluation of the images.

Consequently, in the present study, the positioning of the hypophysis in New Zealand rabbits according to different anatomical points of the head was analyzed from the computed tomography images according to sex. This intervention is a preliminary study conducted in New Zealand Rabbits, which are frequently used as experimental animals. The study approach and the data obtained as a result of this approach are thought to contribute to the neurosurgical operations or the hypophysis research in the experimental models.

Conflict of interest

The authors declare that they have no conflict of interest.

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