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RESEARCH ARTICLE

Morphometric properties of larynx and trachea in the New Zealand rabbit

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Yeni Zelanda tavşanında larynx ve tracheanın morfometrik özellikleri

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Öz

Amaç: Bu çalışma Yeni Zelanda tavşanlarında larynx kıkırdakları ile trachea'nın morfometrik özelliklerini araştırarak, cinsiyetler arasındaki farklılıkları ortaya koymak amacıyla gerçekleştirildi.

Gereç ve Yöntem: Çalışmada 6 erkek, 6 dişi olmak üzere toplam 12 adet sağlıklı erişkin Yeni Zelanda tavşanı kullanıldı. Baş ve boyun bölgesinin diseksiyonu sonucunda çıkartılan larynx kıkırdakları ve trachea'dan bazı ölçümler alınarak, istatistiki analiz yapıldı. İstatistiki önem P<0.05 düzeyinde belirlendi.

Bulgular: Yapılan çalışma sonucunda Yeni Zelanda tavşanlarında trachea ve larynx'in cinsiyetler arasında istatistiki olarak farklı olmadığı, sadece cartilago thyroidea'nın bazı ölçüm değerlerinde erkek ve dişiler arasında anlamlı fark olduğu tespit edildi.

Öneri: Elde edilen bu morfometrik bilgilerin veteriner anatomi bilgi birikimine katkı sağlamasının yanısıra, oluşturulabilecek olan model ve klinikte teşhis ve tedavi noktasında da bir ışık tutabileceği öngörülmektedir.

Anahtar kelimeler: Larynx, trachea, morfometri, tavşan

Abstract

Aim: This study was conducted to investigate the morphometric features of the larynx cartilages and trachea in New Zealand rabbits and reveal the differences between sexes.

Material and Methods: In the study, the larynx cartilages belonging to a total of 12 healthy and adult New Zealand rabbits of both sexes (6 males, 6 females) were used. Some measurements were taken on the larynx cartilages and trachea, which had been taken out as a result of dissection of the head and neck, and statistical analyses were made. The statistical significance level was established at P<0.05.

Results: Although the trachea and laynx related-measurements have no statistical difference between sexes, there was a statistical significance between sexes only in some values concerning the thyroid cartilage.

Conclusion: In conclusion, it has been suggested that the results from this study will contribute to the present morphological knowledge on respiratory system and may shed light on the reconstructive anatomy and clinical procedures concerning this system.

Keywords: Larynx, trachea, morphometry, rabbit

Introduction

In laryngology, the precise anatomical information about laryngeal cartilages is essential for the process of diagnosis and treatment (Breatnach et al 1984, Jain and Dhall 2010, Joshi et al 2011). This information is especially needed in some interventions including bronchoscope and endoscopes (Echel and Sittel 1995, Kotian et al 2014). It is also important in the accurate selection of the tools to be used in surgery (Kotian et al 2014). In pediatric population, knowing the digital anatomic properties of the larynx is essential in clinical applications especially in the selection of appropriate endo-tracheal tube (Savkovic et al 2010). Moreover, the morphometric features are necessary for the formation of biomechanical models that are quite useful in studies on larynx (Hunter and Titze 2005).

Morphologically, human larynx is definitely not different from the larynx of other mammals (Saigusa 2011). Animal models are predominantly used for larynx related-lessons in medical faculties and some morphological researches. Animal experiments can make huge contributions to scientific developments as they can be controlled easily and comparisons can be made with human larynx (Carneiro and Scapini 2009).

The shape and dimensions of larynx was investigated in babies aged 1 (Savkovic et al 2010) and children from age 6 months to 13 years (Dalal et al 2009). The morphological development of fetal larynx in fetal life was investigated (Cicekcibasi et al 2008). Furthermore, morphometric properties of thyroid and cricoid cartilages were also revealed through CT images of adults (Jain and Dhall 2010). Dimensions of larynges belonging to adult men and women were measured using a digital caliper and differences between sexes were identified (Jotz et al 2014, Kotian et al 2014).

Macro-anatomic structure of the larynx and trachea of the gazelle was also revealed (Duzler et al 2005). Larynges of young and adult domestic pigs were measured and analyzed (Wysocki et al 2010). In the rabbit, the dimensions of subglottis and trachea were measured irrespective of gender in order to be able to measure the dimensions of the larynx of a normal rabbit. The values were compared with the airway in subglottic stenosis disease (Loewen and Walner 2001). Trachea plays a major role on the efficiency of respiration as it enables the passage of respiratory air. Therefore, it is extremely important to know the morphometry of trachea (Dabanoglu et al 2001). Especially, when endotracheal tube is not properly placed in trachea, affect trachea efficiency (Freitas et al 2001). Several factors affect the shape and dimensions of trachea in mammals. For example, tracheal diseases affect its efficiency by changing its shape and adaptability, which in turn results in some complications due to the changes in air flow (Byanet et al 2014).

Variations in the anatomy of trachea can be important in veterinary clinics among different animal species and between individuals (Al-Zhgoul et al 2013). Various morphometric studies on trachea were conducted on humans (Breatnach et al 1984, Chunder et al 2010, Zahedi-Nejad et al 2011), dogs (Dabanoglu et al 2001), red sokoto goats (Byanet et al 2014), horses (Freitas et al 2001), *Saimiri sciureus* (Jain and Dhall 2010), Arabian oryx (Al-Zhgoul et al 2013), giraffe (Cano and Perez 2009) and young camels (Al-Zghoul et al 2006).

In the relevant literature, no study was found where the New Zealand rabbit's larynx and trachea were investigated in detail. This study was conducted to identify all the cartilages that form the larynx of the New Zealand rabbit and the morphometric properties of its trachea and reveal the differences between the sexes.

Materials and Methods

Consent was received from Mehmet Akif Ersoy University Local Ethical Board for Animal Experiments with decision number 135 dated 26 May 2015 in order to be able to use animal material.

A total of 12 adult, healthy New Zealand rabbits, 6 males and 6 females weighing from 3-3,5 kg and 1 year old were used in the study. Head, neck and chest regions of the rabbits were dissected and larynges and trachea were removed. Muscles of the larynges were dissected and cartilaginous structures were obtained separately. A total of 14 measurements, 6 from thyroid cartilage, 3 from arytenoid cartilage, 3 from cricoid cartilage and 2 from epiglottic cartilage, were taken from the laryngeal cartilages (Figure 1-4).

Then the total length of trachea (the distance between cricoid cartilage and bifurcation of trachea) was determined, it was divided into 3 parts; each part at a rate of 1/3 (as cranial, medium and caudal). Each of the first cartilage of 3 pars were measured to vertical and transversal diameters (Figure 5). Measurements were determined on photographs using Image J program.

Statistical analysis was carried out with SPSS 20.0 windows computer packaged software. Independent- Samples T Test was performed and differences between males and females were stated by giving minimum, maximum, mean values together with standard deviation values of measurements. Statistical significance was recorded as $P<0.05$.

Nomina Anatomica Veterinaria was used as basis in anatomical terminology (NAV 2012). In this study, on the basis of literature (Dabanoglu et al 2001, Loewen and Walner 2001, Cicekcibasi et al 2008, Jain and Dhall 2010, Wysocki et al 2010, Al-Zhgoul et al 2013, Byanet et 2014, Kotian et al 2014) below measurements were taken:

The measurements taken from thyroid cartilage:
T1: The length of cranial cornu
T2: The distance between cranial and caudal cornua
T3: The distance between caudal cornua
T4: The distance between cranial cornua
T5: The width of lamina
T6: The length of lamina
The measurements taken from cricoid cartilage:
C1: The length of cricoid cartilage
C2: The vertical diameter of cricoid cartilage
C3: The transversal diameter of cricoid cartilage
The measurements taken from arytenoid cartilage:
A1: The distance between processus muscularis and apex
A2: The distance between processus vocalis and apex
A3: The distance between processus muscularis and processus vocalis
The measurements taken from epiglottic cartilage:
E1: The length of epiglottis
E2: The width of epiglottis
The measurements taken from trachea:
TV: The vertical diameter of trachea
TT: The transversal diameter of trachea

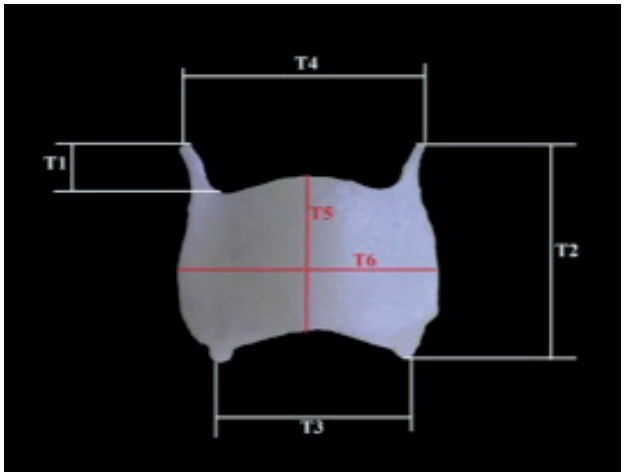

Figure 1. Locations of measurements taken from thyroid cartilage.

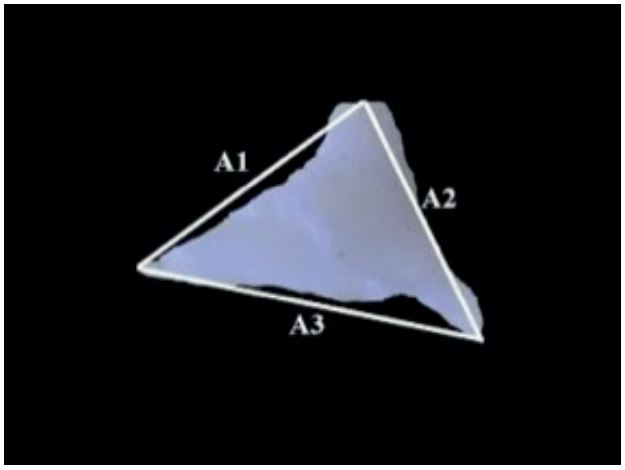

Figure 2. Locations of measurements taken from arytenoid cartilage.

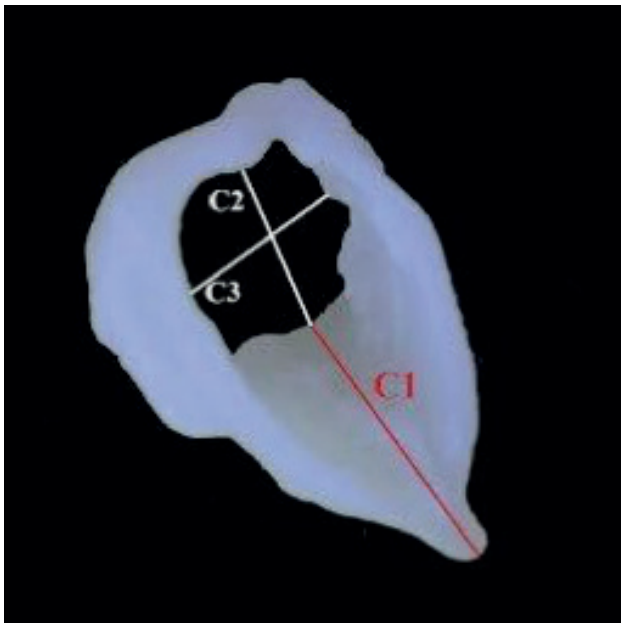

Figure 3. Locations of measurements taken from cricoid cartilage.

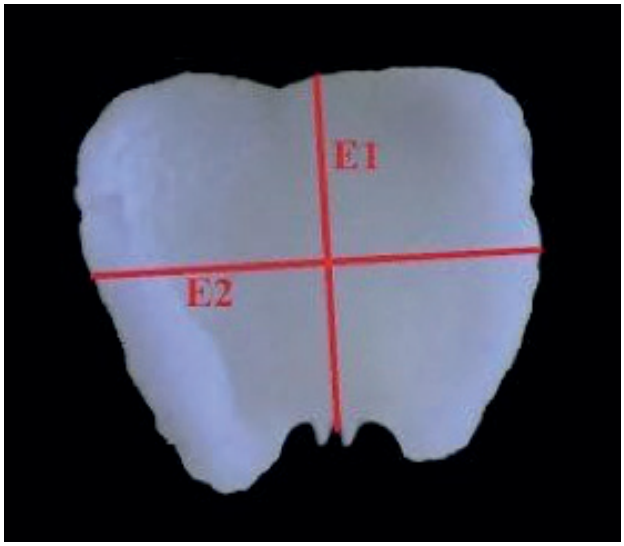

Figure 4. Locations of measurements taken from epiglottic cartilage.

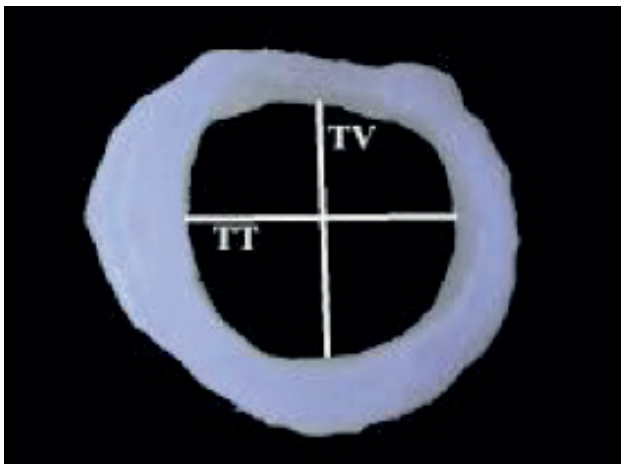

Figure 5. T Locations of measurements taken from trachea.

Results

The cartilages that constituted the larynx in New Zealand rabbits were taken out one by one. The lengths of trachea and their diameters at different regions were measured. The minimum, maximum, mean values of these measurements and their standard deviations were shown on male and female rabbits (Table 1).

According to the Table 1, values obtained from the measurements belonging to thyroid cartilage were bigger in male and statistical differences were observed in the distances between cranial cornua, widths of lamina and lengths of lamina. The differences in the lengths of cranial cornu, the distances between cranial and caudal cornua and the distances between caudal cornua were not statistically significant. The length and the transversal diameters of cricoid cartilage were greater in males whereas vertical diameter of cricoid cartilage were greater in females but they were not statistically significant. All measurements taken from arytenoid cartilage (the distance between processus muscularis and apex, the distance between processus vocalis and apex, and the distance between processus muscularis and processus vocalis) were greater in female New Zealand rabbits but they were statistically insignificant. As for epiglottic cartilage, the width and length of epiglottis are greater in males but statistically insignificant. The length of trachea, vertical and transversal diameters of trachea measured in various regions were greater in female but these values were statistically insignificant.

The proportion of transversal diameter/vertical diameter of trachea was 0.97 in males, and 0.86 in females at the beginning; 0.72 in males and 0.79 in females in the middle and 0.82 in males and 0.93 in females in bifurcatio.

According to Table 1, transversal diameter in male New Zealand rabbits decreased from the beginning to the middle but increased toward bifurcatio. In the females, on the other hand, it gradually decreased from the beginning to bifurcatio. Vertical diameter in both male and female increased from the beginning to the middle but decreased toward bifurcatio.

Table 1. Findings belonging to laryngeal cartilages and trachea in New Zealand rabbits.

	Min	Max	Mean	SD	Male	Female
T1	2.30	3.26	2.76	0.38	2.92	2.60
T2	11.26	14.88	12.70	1.31	13.35	12.05
T3	8.86	15.34	11.62	2.31	13.10	10.14
T4*	9.65	17.87	13.64	2.38	15.29	11.99
T5*	7.05	9.92	8.38	1.05	9.14	7.63
T6*	11.08	18.28	14.43	2.22	16.09	12.76
C1	7.48	9.47	8.51	0.70	8.95	8.07
C2	6.06	8.95	7.20	1.10	7.08	7.33
C3	5.18	7.84	6.00	0.91	6.37	5.64
A1	6.25	7.95	7.00	0.59	6.99	7.01
A2	5.01	6.01	5.54	0.39	5.53	5.56
A3	5.38	6.48	5.90	0.37	5.88	5.93
E1	6.95	9.14	7.95	0.73	8.09	7.81
E2	8.33	10.54	9.47	0.93	9.87	9.06
LT	53.09	72.60	65.16	7.67	69.65	60.67
IVDT	4.41	6.89	5.65	0.88	5.80	5.50
ITDT	4.08	6.03	5.20	0.78	5.67	4.73
MVDT	4.92	7.02	6.02	0.74	6.46	5.57
MTDT	3.53	6.43	4.56	0.90	4.68	4.43
TBiV	3.20	6.50	5.29	1.16	5.91	4.68
TBiT	3.29	5.98	4.61	0.86	4.87	4.36

*: P< 0.05, T: Thyroid cartilage, C: Cricoid cartilage, A: Arytenoid cartilage, E: Epiglottic cartilage, LT: Length of Trachea, IVDT: Initial Vertical Diameter of Trachea, ITDT: Initial Transversal Diameter of Trachea, MVDT: Middle Vertical Diameter of Trachea, MTDT: Middle Transversal Diameter of Trachea, TBiV: Bifurcatio Vertical Diameter of Trachea, TBiT: Bifurcatio Transversal Diameter of Trachea (mm).

Discussion

In the study, of the cartilages that constitute the larynx of the New Zealand rabbit, a statistically significant difference was found between the sexes in the measurements of the distance between the cranial cornua, the width of lamina and the length of lamina of thyroid cartilage. The measurements belonging to cricoid cartilage, arytenoid cartilage and epiglottic cartilage, on the other hand, were found to be statistically insignificant in male and female rabbits. The larynx of the domestic pig does not exhibit sexual dimorphism (Wysocki et al 2010). In a morphometric study that was conducted on CT images of the larynx of adult humans, it was observed that there was a statistically significant difference between males and females in regard to thyroid cartilage. In humans again, the measurements belonging to cricoid cartilage were found to be statistically significant between the genders except for antero-posterior diameter (Jain and Dhall 2010). Kotian et al (2014) conducted on the larynges of adult humans, found that measurements for males were greater. They also observed that cricoid cartilage had a greater diameter in females but this was not statistically significant. Jotz et al (2014) found that the measurements belonging to the larynx were statistically greater in males than females. In human fetal larynx, on the other hand, males had greater values but there was not statistically significant difference between the sexes (Cicekcibasi et al 2008). The larynges of boys and girls were found to be not different from one another (Dalal et al 2009).

In this study it was observed that the length of lamina of thyroid cartilage had greater values than the width of lamina in both sexes as in the gazelle. Moreover, it was pointed out that the laryngeal cartilages of male gazelles were bigger and wider than those of the female gazelles (Duzler et al 2005). It was also similar in the New Zealand rabbit that the measurement values belonging to laryngeal cartilages and trachea were greater in males than in females.

The length of trachea in the New Zealand rabbit was measured to be 69.65 mm in males whereas it was measured to be 60.67 mm in females. The average length of trachea was indicated as 19. 5 cm in the dog (Dabanoglu et al 2001), 257 mm in red sokoto goat (Byanet et al 2014), 54.1±0.73 cm in Arabian oryx (Al-Zhgoul et al, 2013), 3.74 cm in the young and 3.67 cm in adults *Saimiri sciureus* (Pinheiro et al 2012), 78.28±4.03 cm males and 75.39±5.27 cm in females horses (Freitas et al 2001). In this study the length of trachea was statistically insignificant between the genders but it was statistically different in horse (Freitas et al 2001).

In the New Zealand rabbits, the transversal diameter/ vertical diameter ratio of trachea in all regions varied between 0.72 and 0.97 in males, whereas it varied between 0.79 and 0.93 in females. From these ratios, it can be concluded that the shape of trachea is round. The trachea of the giraffe, too, has a round shape (Cano and Perez 2009). In young camels, this ration was between 1.08 and 1.34. Their trachea has a shape that is close to round (Al-Zghoul et al 2006). Dabanoglu et al (2001) pointed out that the ratio was between 1.14 and 1.25 in the dog's trachea and thus its trachea had an invariable shape all around. The trachea of the horse has an elipsoid shape (Freitas et al 2001). The trachea of *Saimiri sciureus* is circular at the beginning, oval towards the middle and oval in the middle and towards the tail in young. In adults, on the other hand, trachea's shape is dorso-ventrally flattened becomming oval with a decreasing diameter (Pinheiro et al 2012).

In the New Zealand rabbit, as in the dog (Dabanoglu et al 2001) and Arabian oryx (Al-Zhgoul et al 2013), transversal diameter decreased towards the middle in males but increased towards bifurcatio. In female New Zealand rabbits, the position of the transversal diameter is exact opposite of the males. Unlike the dog (Dabanoglu et al, 2001), Arabian oryx (Al-Zhgoul et al 2013) and young camels (Al-Zghoul et al 2006), vertical diameter increased towards the middle in both male and female New Zealand rabbits but decreased towards bifurcatio.

In the New Zealand rabbits, transversal diameter was 5.67 mm in males at the beginning, 4.68 mm in the middle and 4.87 mm in bifurcatio; in females, it was 4.73 mm at the beginning, 4.43 mm in the middle and 4.36 mm in bifurcatio. Vertical diameter was 5.80 mm in males at the beginning, 6.46 mm in the middle and 5.91 mm in bifurcatio whereas in females it was 5.50 mm at the beginning, 5.57 mm in the middle and 4.68 mm in bifurcatio. Loewen and Walner (2001) found that trachea in the New Zealand rabbit had an average of 5.81 mm vertical diameter and 5.41 mm transversal diameter at the beginning. In a study conducted by Byanet et al (2014), on the red sokoto goat irrespective of gender and without dividing trachea into parts, the transversal diameter was calculated to be 11.61±0.41 mm, whereas vertical diameter was calculated to be 13.28±0.41 mm. They found a statistically significant difference between transversal and vertical diameters (Byanet et al, 2014).

No statistically significant difference was found between the sexes in the trachea of the New Zealand rabbit. In a study of the horse, when the trachea is in an unstretched position, the width of the last ring and the number of tracheal rings are larger in males than in females, which is statistically significant (Freitas et al 2001).

Conclusion

It was seen that no statistically significant differences were observed between the sexes in terms of arytenoid cartilage, cricoid cartilage and epiglottic cartilage, which constitute the larynges of New Zealand rabbits, but differences were obser-

ved in some measurements of thyroid cartilage. In addition, it was found that trachea did not demonstrate a statistical difference between the sexes among male and female rabbits. It is believed that this morphometric information will contribute to the literature about anatomical information in veterinary medicine and shed light on diagnosis and treatment in a model and clinic that can be established.

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