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Morphometric Study of the Domestic Swine Auditory Tube

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The length and calibre of 60 auditory tubes, collected from 30 longitudinally cut pig heads were measured on Duracryl casts by digital caliper (0.02). It was found that in both sexes, the length was larger at the ventrolateral border compared to the rostrodorsal one. Similar results were obtained for the length of both walls. The small/large diameter ratio of the elliptical *ostium pharyngeum tubae auditivae* showed equal values in male - 0.35 on both sides, whereas in females: 0.28 on the right and 0.27 on the left. The same ratios for *ostium tympanicum tubae auditivae* in males were 0.46 and 0.44 on the right and on the left, and in females: 0.41 and 0.36, respectively. The results allowed assuming the domestic swine's auditory tube was almost identical to that of humans; therefore, this animal species could be successfully used as a model in human medicobiological studies and for transplantology.

Key words: auditory tube, morphometry, domestic swine, corrosion cast

Introduction

The use of mammals as models in research studies on the organ of hearing, whose data with their advantages and disadvantages could be interpreted for men, evidenced a continuously increasing interest over the last three decades [2]. With this regard, the available data in domestic mammalian species are scarce and refer to studies on middle ear diseases in two sheep breeds and one domestic pig breed, having shown that these species were promising for use as human models [6, 8]. Recently, the interest to domestic swine, especially after publication of its genome, was substantially increased as a best-fit model for a number of human biomedical studies, including transplantology [3, 4, 5, 9]. Despite the numerous data proving the anatomical, physiological, biochemical and immunological similarity of men and domestic swine, there are still no detailed data on dimensions of the porcine auditory tube. This was the motivation of the present study, undertaken to elucidate and complete the knowledge on anatomical features of auditory tube of domestic swine.

Materials and Methods

Heads of 20 male and 20 female pigs, six months of age and live weight of 95-110 kg were used in this study. The pigs were slaughtered for meat consumption in a licensed slaughterhouse as per National regulations, and heads were transported in a cooling bag to the Department of Veterinary Anatomy, Histology and Embryology, Faculty of Veterinary Medicine, Trakia University, Stara Zagora, Bulgaria.

Before processing, heads were cut with electric saw into two equal halves along the median line. The surface around *ostium pharyngeum tubae auditivae* was cleaned with a gauze swab. After washing with physiological saline warmed to 37°C, each half was positioned horizontally with the *ostium pharyngeum tubae auditivae* (tube opening) upwards. The tube lumen was filled via opening with the metacrylate polymer Duracryl Plus O (Spofa Dental, Czech Republic). The liquid phase of Duracryl Plus was brought to 20°C. To it, a colorant was added: blue for male pigs and green for female pigs. The coloured liquid was mixed with the powder phase of Duracryl Plus O while stirring slowly and thoroughly at a ratio of 2.5:1 for one minute to prevent the formation of bubbles in the chemopolymerisable resin. Immediately after that, 2 ml of the mixture were manually injected in individual left and right auditory tubes until it flowed freely from the tube (tympanic) opening. Thus prepared models were left for 60 min at room temperature until the final polymerization (curing) of the material. Then, using tweezers, casts were removed from the tube lumen with gentle shaking, cleaned carefully and prepared for measurements.

Morphometry

Length of both medial and lateral wall (PhO-TyOM/PhO-TyOL) of each corrosion cast was defined by measuring the distance from the medial/lateral margin of the cast from pharyngeal orifice to the medial/lateral margin of the cast from tympanic orifice. Morphometric values were defined on corrosion casts of the auditory tube using a digital electronic caliper (accuracy 0.02 mm). (Length of the lateral wall (PhO-TyOL) of corrosion cast from the tube was measured between the lateral margin of the cast from pharyngeal orifice and the lateral margin of the cast from tympanic orifice).

Statistical analysis

Data were processed by GraphPad Prism 6 for Windows (GraphPad Software, Inc., USA) via one-way analysis of variance (one-way ANOVA) followed by Tukey-Kramer's post-hoc test and were presented as mean ± SD. P-values < 0.05 were considered statistically significant.

The terminology was consistent with the Nomina Anatomica Veterinaria [7].

Results

All casts from auditory tube lumens were elliptical, with the shape of flattened truncated cone, with obvious rostrodorsal (cranial) and ventrocaudal borders (walls) (**Fig.1; Fig.2**).

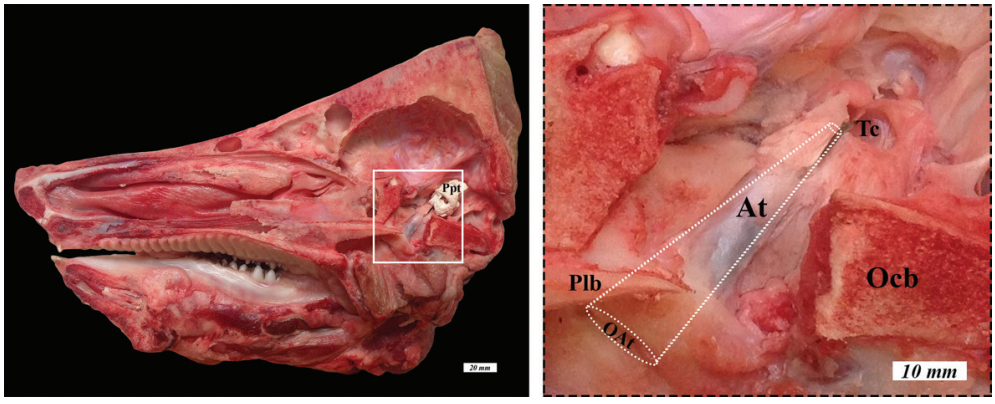

Fig. 1. Native model of porcine right auditory tube. At – auditory tube. Ppt – petrous part of the temporal bone. OAt – opening of the auditory tube. Ocb – occipital bone. Plb – palatine bone. Tc – tympanic cavity. Bar = 20 mm (left); 10 = mm (right).

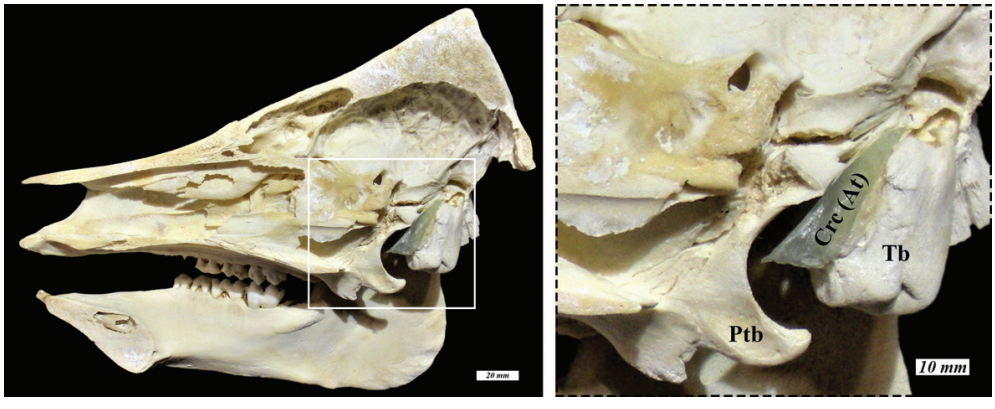

Fig. 2. Macerated acrylate model of porcine right auditory tube. Crc (At) – corrosion cast of the auditory tube (At). Tb – tympanic bulla. Ptb – pterygoid bone Bar = 20 mm (left); 10 = mm (right).

As seen from the data in **Table 1**, tube lengths were higher in female pigs, both from right and left sides.

It should be noted that in male pigs, the difference between the length of the ventrocaudal border was by 2.39 mm higher than the rostrocaudal border in right side casts and by 1.99 mm in left-side casts. The respective values in females were by 0.67 mm (from the right) and by 1.77 mm (from the left). There were also differences in the length of both walls (medial and lateral) measured between two points located in the middle of cast from the respective opening – rostrodorsal and ventrocaudal with higher values for the latter wall. For the right and left tube casts, these differences were 4.34 and 4.59 mm respectively in males and 3.29 and 2.81 mm respectively in females.

The dimensions of the large and small diameters of casts from the right and left ostium pharyngeum tubae auditivae did not show any sex dimorphism (**Table 2**).

The measurements of the calibre of *ostium tympanicum tubae auditivae* of right and left auditory tubes showed equal size of the large diameter in both sexes, while the small diameter of the left tube was larger in male pigs.

The small to large diameter ratio of *ostium pharyngeum tubae auditivae* in males was 0.35 from both sides, and 0.28 (right side) and 0.27 (left side) in females. The same ratios for *ostium tympanicum tubae auditivae* were as followed: in males: right side – 0.46; left side -0.44, and respective values in female pigs were 0.41 and 0.36.

Discussion

This study presents the first detailed morphometric data and statistical analysis of dimensions of auditory tube (caliber) in domestic swine. Our results are a contribution to the body of knowledge on the length of auditory tube in pigs (about 3 cm), similar to that of men [1, 8]. The data from this study were comparable to values reported by [6]

Table 1. Macrometric values regarding the length of the corrosion casts of the lumen of the right and left auditory tubes (PhO-TyOM is the length of the medial wall and PhO-TyOL – the length of the lateral wall of the corrosion casts).

PARAMETERS	Male Pigs	Female Pigs
LENGTH OF THE AUDITORY TUBE		
– Rostrodorsal wall		
Right	26.99 ± 4.71	29.96 ± 2.71
max-min	36.89 – 22.59	34.67 – 26.23
Left	27.44 ± 5.80	29.52 ± 3.72
max-min	36.72 – 19.20	36.75 – 23.92
– Medial length of the tube (PhO-TyOM)		
Right	26.98 ± 4.03	29.43 ± 2.49
max-min	34.30 – 23.09	34.19 – 26.29
Left	27.75 ± 5.54	29.28 ± 3.13
max-min	36.33 – 18.66	33.76 – 24.43
– Lateral lenght of the tube (PhO-TyOL)		
Right	31.32 ±4.26	32.72 ±2.674
max-min	40.31 – 26.90	38.28 – 28.73
Left	32.34 ± 6.74	32.09 ±3.26
max-min	44.83 – 22.99	36.93 – 25.32
– Ventrocaudal wall		
Right	29.38 ± 4.05	30.63 ± 3.83
max-min	38.47 – 25.09	35.87 – 22.25
Left	29.43 ± 5.04	31.29 ± 2.85
max-min	37.62 – 19.93	35.47 – 24.94

Table 2. Macrometric values regarding the large and small diameter of the corrosion casts of the two openings of the right and left auditory tubes

PARAMETERS	Male Pigs	Female Pigs
DIAMETERS OF THE PHARINGEAL OPENING OF THE AUDITORY TUBE		
– Large diameter	13.25 ± 1.84	13.12 ± 0.92
Right	16.09 – 10.08	14.97 – 11.91
max-min	12.02 ± 1.27	12.45 ± 1.71
Left	14.59–10.37	14.48–8.82
max-min		
– Small diameter		
Right	4.65 ± 1.56	3.48 ± 0.80
max-min	7.66 – 2.95	5.06 – 2.47
Left	4.26 ± 0.72	3.36 ± 1.28
max-min	5.17 – 2.98	5.57 – 1.04
DIAMETERS OF THE TYMPANIC OPENING OF THE AUDITORY TUBE		
– Large diameter		
Right	1.53±0.23	1.52± 0.24
max-min	1.23 – 1.93	1.14 – 1.93
Left	1.81± 0.38	1.48± 0.16*
max-min	1.24 – 2.68	1.28 – 1.85
Small diameter	0.70± 0.27	0.63± 0.17
Right	0.32 – 1.17	0.32 – 0.95
max-min	0.80± 0.21	0.53± 0.16*
Left	0.47 – 1.23	0.31 – 0.80
max-min		

*P< 0.05 Significant difference in measurements of left tympanic opening between males and females.

in silicone casts from two sheep breeds - Heathland sheep (30.4 mm ± 2) and Blackface sheep (31.1 mm ± 1.4 mm). This allowed confirming the statements of researchers that both animal species were appropriate models for investigations of disorders in auditory tube and middle ear functions. All data accumulated during the recent year about the similarity between men and domestic swine demonstrated categorically that swine were more relevant in such studies, including middle ear infections [8].

Data about ratios between the small and large diameters of both auditory tube openings were also interesting. It should be noted that there was no statistically significant differences between sexes with regard to lengths of tube casts. Furthermore, small/large diameter ratios were equal for ostium pharyngeum tubae auditivae in male pigs and insignificantly different between right and lift tube in females. The differences were more obvious for ostium tympanicum tubae auditivae only for the left tube opening ($p< 0.05$). The results allowed affirming that the macrometric parameters of the auditory tube have relatively equal proportions in domestic swine from both sexes.

Conclusion

In conclusion, the original data from this study are a contribution to the commonly agreed opinion that the domestic swine is the most appropriate animal mammalian species to serve as model in human medicobiological and transplantation (xenotransplantation) research studies.

References

1. **Bluestone, Ch. D., W. J. Doyle**. Anatomy and physiology of eustachian tube and middle ear related to otitis media. – *J. Allergy Clin Immunol*., **81**, 1988, 997-1003.
2. **dos Reis, A., S. P. Dalmolin, E. Dallegrave**. Animal models for hearing evaluations: a literature review. – *Revista CEFAC*, **19**, 2017, 417-427.
3. **Eberlova, L. V. Liska, H. Mirka, T. Gregor, Z. Tonar, R. Palek, M. Skala J. Bruha, O. Vycita, K. Kalusova, S. Haviar, M. Kralickova, A. Lametschwandtner**. Porcine liver vascular bed in Biodur E20 corrosion casts. – *Folia Morphol*., **75**, 2015, 154-161.
4. **Eberlova, L., V. Liska, H. Mirka, Z. Tonar, S. Haviar, M. Svoboda, J. Benes, R. Palek, M. Emingr, J. Rosendorf, P. Mik, S. Leupen, A. Lametschwandtner**. The use of porcine corrosion casts for teaching human anatomy. – *Annals of Anatomy*, **213**, 2017, 69–77.
5. **Kuzmuk, K. N., L. B. Schook**. Pigs as model in Biomedical Science. In: *The Genetic of the Pig*. (Eds. M. F. Rothschild, A. Ruvinsky) CAB International, 2011, 426-444.
6. **Miller, F., A. Burghard, R. Salcher, V. Scheper, W. Leibold, Th. Lenarz, G. Paasche**. Treatment of middle ear ventilation disorders: Sheep as animal model for stenting the human Eustachian tube – a cadaves. – *PLOS ONE*, **24**, 2014, 1-13.DOI:10.1371/journal.pone.0113906
7. Nomina Anatomica Veterinaria. International Committee on Veterinary Gross Anatomical Nomenclature (I.C.V.G.A.N.). 6th ed., 2017, Hanover, Ghent, Columbia, MO, Rio de Janeiro, 152.
8. **Pracy, J. P., A. White, Y. Mustafa, D. Smith, M. E. Perry**. The comparative anatomy of the pig middle ear cavity : a model for middle ear inflammation in the human? – *J. Anat*. **192**, 1998, 359-368.
9. **Runager J., C. Bonnefont, M., O. Hesselager, S. R. Bislev, J. Borch-Jensen, E. Bedixen**. Pig as a model system for biomedical research. From the journal: EuPA 2013 – Scientific meeting. 2013; 7. EuPA Congress, Saint Malo, FRA, 2013-10-14-2013-10-17, 248-248.