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Prenatal development of the human trachea

Ewa Adamiec, Edyta Dzięciołowska-Baran, Florian Czerwiński, Danuta Miklaszewska, Iwona Teul

Department of Anatomy, Pomeranian Academy of Medicine, Szczecin, Poland

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The tracheas of 46 human foetuses were examined: 26 male, 20 female with C-R length of 99–255 mm. The analysis of the total length of the trachea was carried out and its transverse dimension was presented on three levels: on the first tracheal cartilage, in the mid-length of the trachea, and at the bifurcation into the main bronchi; also the proportions between these dimensions and the C-R length were analysed.

The length of the trachea was measured in a straight line — from the end of larynx to the bifurcation of the trachea. Comparing tracheas to a tunnel with two openings, it was observed that the transverse dimension, the "laryngeal", is greater than the "bronchial" — in the case of smaller foetuses by 2 mm, but in foetuses with C-R length of over 250 mm by 1 mm. Moreover, no significant differences between male and female sex were noticed. All the measurements were taken with the use of a slide caliper.

The results should be useful in the detection of abnormalities in the structure of the trachea, in problems with respiratory physiology and in endotracheal intubation, endoscopy or tracheostomy.

key words: trachea, human foetal development

INTRODUCTION

There is a large volume of literature devoted to studies of the development of the trachea and lungs [1, 3–5, 8]. However, most of them refer to either a very early stage of gestation or the final phase of the growth of alveoli and surfactant formation [2, 4, 6, 7]. Little attention is devoted to the transient period between 3–8 months of gestation [3, 5]. At this period the trachea already has its main structural elements developed and all the processes refer to morphological changes. This relatively long period of morphological development is significant in endoscopic techniques of early diagnosis of bronchial diseases [3, 7]. The results of this study should also be useful in the detection of diseases in the bottom part of the lower respiratory tract.

MATERIAL AND METHODS

The tracheas of 46 human foetuses were examined: 26 male and 20 female, obtained from spontaneous abortions with no macroscopic developmental defects. Their C-R length varied from 99 to 255 mm. The age of the foetus was estimated on the basis of C-R length with reference to Pineau tables; it ranged from 13–17 weeks of gestation. The tracheas were isolated in the tissue bundle with larynx and extrapulmonary bronchi taken from foetuses fixed in 10% formalin. With the use of a slide caliper the total length of the trachea from the larynx to the bifurcation was measured, its transverse dimension on three levels, i.e. on the level of the first tracheal cartilage, in the mid-length and at the tracheal bifurcation into the main bronchi. Relations between

Address for correspondence: Ewa Adamiec, Department of Anatomy, Pomeranian Academy of Medicine, Al. Powstańców Wielkopolskich 72, 70–111 Szczecin, Poland, tel: +48 91 466 14 80, fax: +48 91 466 10 15

these dimensions and C-R length were analysed. In order to expose the tracheal rings, the specimens were first examined under a microscope then an X-ray picture was taken in a-p position.

RESULTS

The examinations revealed that in the early gestation the basic elements of the morphological structure of the trachea, including cartilaginous rings, are formed. Thus, we can assume that cartilaginous elements develop very early in foetal life. Furthermore, the number of tracheal rings ranges from 16–20 and is constant and not sex-dependent. The results are comparable to the findings of other researchers dealing with the same problem. Our study also proved that in the early gestation the cartilaginous rings are not homogeneous, they often have irregular surfaces and are segmented. This refers mainly to the first cartilage, which is either higher or additionally divided, or consists of uneven cartilaginous elements formed in a semi-ring; it is rarely lower than other cartilages. On the basis of the ratio of the tracheal length to the C-R length with reference to sex, it was stated that both parameters increase proportionally in both sexes. However, the growth of the trachea by 1 mm of C-R length in younger female foetuses is slightly faster than in males (Fig 1). With gestation age the differences disappear and are of no statistical significance.

The transverse measurements of tracheas showed that in more than 70% of foetuses with C-R length up to 250 mm the "laryngeal" end is 2 mm wider than the "tracheal" end (Fig. 2). In older foetuses with C-R length of more than 250 mm the difference between the ends of the trachea is only 1 mm. This can be linked with the change of shape of the tracheal lumen. In younger foetuses the tracheas are flattened in the a-p plane, which makes the cross-section of the trachea elliptical. The older the foetuses are, the more the tracheal lumen becomes cylindrical and the more the antero-posterior dimension increases.

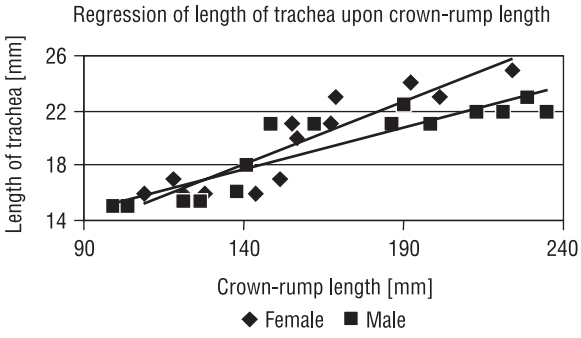

Figure 1. The regression of length of trachea upon crown-rump length with reference to sex.

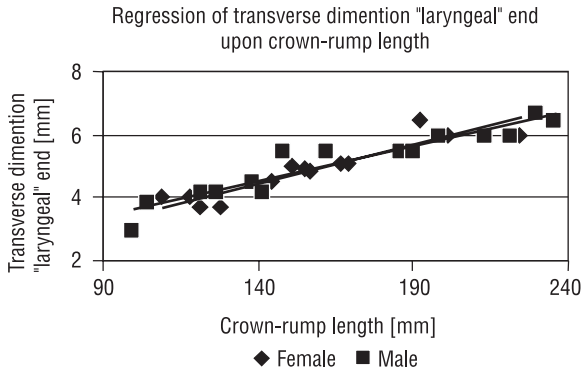

Figure 2. The regression of transverse dimention "laryngeal" end upon crown-rump length with reference to sex.

DISCUSSION

Our method of assessment of the morphological development of foetal tracheas, like previous methods based on post mortem material, has limitations. It is mainly connected with the fact that spontaneous abortions can be accompanied by latent defects. While clearly seen growth abnormalities are easy to identify and eliminate from the material under study, the marginal abnormalities may be overlooked. In general, post mortem autolysis produces laxity of soft tissues, whereas fixation produces contraction. Another problem is the question of the influence of the adjacent organs, their fall and pressure, on the shape of the tracheal lumen. Most researchers face similar problems when assessing post mortem material. We believe, however, that these results will contribute to the study of the development of the respiratory system in the prenatal period. Our study, just like Griscom and Wohl [4, 5], shows that the number of tracheal rings varies from 16–20 regardless of sex and that they are developed at a very early stage of gestation. We state that the prenatal tracheas are tunnel-shaped, the top end being larger than the bottom end.

The difference in the transverse dimension in the younger foetuses is 2 mm and with crown-rump length of more than 250 mm the difference decreases to 1 mm. Similar results were obtained by Wailoo and Emery [8]. His material comprises 452 children ranging from 28 weeks' gestation to 14 years of age. He shows that the above-mentioned differences in

transverse dimensions reach 1 mm in young foetuses and small children and 0.1 mm in children with C-R length of 600 mm. He also claims that the ratio of the length of cartilage to the length of muscle remains constant throughout childhood.

The results of our study show the linear growth of the tracheal length in relation to crown-rump length regardless of sex. Calculating, however, the tracheal growth by 1 mm of C-R length, we observed faster growth of the trachea in smaller female foetuses with C-R length up to 150 mm. At greater lengths no differences between the sexes were noticed, which correlates with studies of other authors who used somewhat older material. Retrospective studies by Menu and Lallemand [6] on 170 subjects ranging from 1 month of gestation to 16 years of age proved the linear dependence of the tracheal length on age. He also pointed out that the transverse dimension of the trachea in the cervical and thoracic part is identical in 43% of children, while in 30% of children the trachea in the thoracic part is wider; the difference in transverse dimensions is 1 mm.

CONCLUSIONS

1. Comparing the trachea to a tunnel with two openings it was observed that the transverse "laryngeal" dimension is wider than the "bronchial" in smaller foetuses by 2 mm, whereas in foetuses of crown-rump length of more than 250 mm by 1 mm.
2. In smaller foetuses the trachea presents antero-posterior flattening, but in older ones the tracheal lumen becomes cylindrical.
3. The greatest tracheal length growth was observed in C-R length of 99–150 mm.
4. No significant differences in sexes were observed.
5. It was stated that the number of tracheal rings is relatively constant and is not sex-dependent.

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