THE AIRSPACE IN THE NOSE

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The airspace in the nose seems to be well known and already described in the anatomical literature. However the enlargement of the nasal cavity in the height and width at different areas has not yet calculated exactly. This is of course not only a theoretical problem because the shape of the airspace is playing an important role in the aerodynamic of the nose. In this way the nose is able to guide the airstream and to produce pressure.

In 1942 Van Dishoeck calculated the hydraulic radius in order to determine the inflow resistance of the nose. He found the hydraulic radius being 2 mm at the valve area. Proetz (1953) believed that the relationship of the nasal cavity to the choana would regulate the aerodynamical conditions in the nose. In my opinion this might be only one of many factors in regulating the airflow.

In 1967 I published some measurements concerning the areas and circumferences of frontal sections in the nose. This sections were taken from a cadaver specimen not convertible to the enlargement of a living nose.

The best way to get approximate optimal results might be to compute the airspace of a nose by means of X-ray-tomograms. About 880 X-ray-pictures has been taken on 46 persons different ages and sex of the white race with normal breathing noses in order to get a representative view for this task.

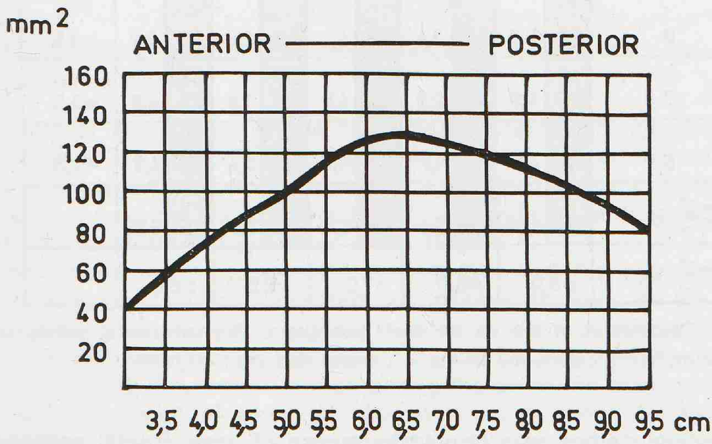

Figure 1. Relationship between areas in mm^2 and frontal sections of the nasal cavity calculated on 1749 X-ray-tomograms of white race.

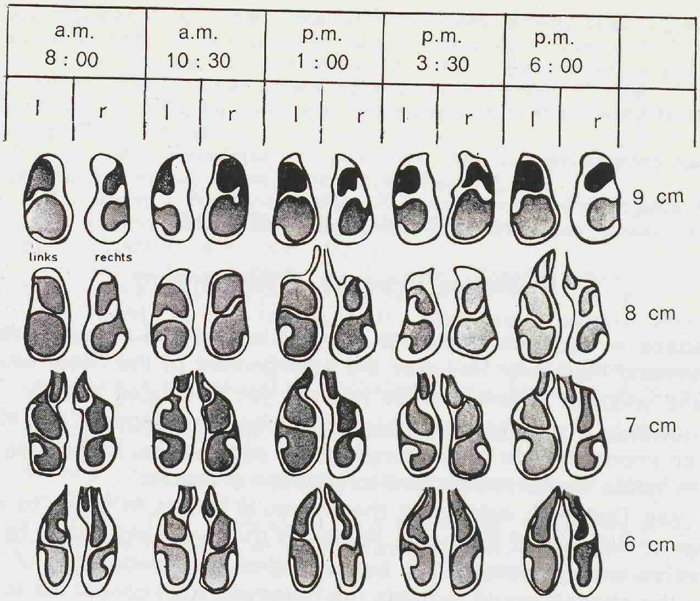

Figure 2a. X-ray-tomograms of a nose taken in 4 planes and 2½ hours distances during daytime.

Time	a.m. 8 : 00		a.m. 10 : 30		p.m. 1 : 00		p.m. 3 : 30		p.m. 6 : 00		
	l	r	l	r	l	r	l	r	l	r	$\sum d_h$
9	2,9	5,9	8,0	3,0	2,4	5,7	7,4	3,3	2,6	6,7	≈ 4,5
8	2,8	5,0	5,2	2,4	2,2	4,1	4,7	2,8	3,0	5,2	≈ 3,5
7	2,7	4,8	5,2	2,9	2,6	4,8	4,6	1,8	2,4	4,8	≈ 3,5
6	3,0	4,5	4,2	1,7	2,2	4,4	4,5	2,4	2,0	4,3	≈ 3,5
$\sum d_h$	2,85	5,05	5,65	2,5	2,35	4,75	5,3	2,55	2,5	5,25	
$\sum d_h$	≈ 8,0		≈ 8,0		≈ 7,0		≈ 8,0		≈ 8,0		

Figure 2b: Calculation of the dh on each tomogram. The valvues of tomograms are keeping a significant constancy in the 4 planes also over daytime.

Our computing method was proved by means of nasal frontal sections of a freshly slaughtered calf. measured and afterward X-rayer in this typical manner. It turned out that the error of our computation was not more than 6%.

Results

By taking 1749 values we found the nasal frontal areas increasing from 50 mm^2 in ventral to a point of 120 mm^2 in the middle of the nose (Figure 1). Behind this point the values are decreasing to about 80 mm^2. This curved line is identical to the shape of roof of the inner nose but is not giving an answer to the aerodynamical conditions of the airspace.

In order to compare the airspace of different noses with different shape the hydraulic radius (r_h) or hydraulic diameter (d_h) should be determined.

In a tube of noncircular shape the hydraulic radius will be

$$r_h = \frac{F}{U} = \frac{\pi R^2}{2 \pi R} = \frac{R}{2} = \frac{d}{4}$$

F = area;
U = circumference;

$$d_h = 4\frac{F}{U}$$

Our measurements based on the hydraulic diameter of the nasal cavity are dealing with the functional airspace related to the movements of the turbinates. Computing 160 values the hydraulic diameter of the nose was found in average 5,28 ± 0,28 mm with a standard deviation of 1,76 and confidence belt of 95%. No particular differences were observed between the values of the ventral and dorsal area (Figures 2a and b). Obviously the same constancy of the values was found in a seria of X-ray-pictures taken in 2½ hour distances during daytime (Figure 3).

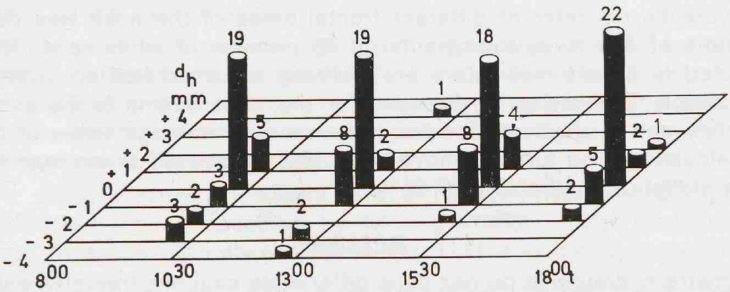

Figure 3. Calculation the d_h in 26 control series on daytime. The constancy of the middle values are obvious.

The periodical movements of the turbinates evidently change the airspace of one side of the nose. The hydraulic diameter of this movement was calculated in average of 4,0 ± 0,12 mm with a standard deviation of 0,18. These movements involve the whole turbinate and no significant difference was found between the anterior and posterior areas (Figure 4).

Summarizing the results it seems to be obvious that the nose is trying to keep the airspace-system as constant as possible. In doing so the nose will produce a specific inflow and outflow resistance which consequently induces the optimal pathway through the nose. Only in this way is the nose able to fulfill all the needed functions like preparing the air to the pulmonary system, having a good sense of smell and by collecting further informations from the airstream. This principle gives an explanation to some phenomenona in the nose such as the so-called compensatory hyperplasia of the inferior turbinate in case of extreme septum deviation to the opposite side.

RESULTS		NUMBER OF TOMOGRAMS n	HYDRAULIC DIAMETER $\bar{x}=d_h$ mm	STANDARD DEVIATION s	STATISTICAL CONFIDENCE BELT
AIRSPACE OF THE INNER NOSE	TOTAL	160	5,28 ± 0,28	1,76	95 %
	VENTRAL AREA	308	3,11 ± 0,04	0,4	95 %
	DORSAL AREA	308	3,03 ± 0,02	0,15	95 %
AIRSPACE IN NASAL CYCLE	TOTAL	250	4,0 ± 0,12	0,81	95 %
	VENTRAL AREA	125	4,14 ± 0,18	0,18	95 %
	DORSAL AREA	125	3,85 ± 0,02	0,02	95 %

Figure 4. Results in calculating the d_h of the total and partial nasal airspace also in nasal cycle.

SUMMARY

The hydraulic diameter of different frontal areas of the nose was calculated by means of 880 X-ray-tomograms on 46 persons of white race. The areas calculated in square-millimeters are showing a curved line according to the nasal shape. The hydraulic diameter for the nose seems to be constant in all planes and in daytime. For the white race an average value of 5,28 mm was calculated. The turbinal movements was calculated in average to 4 mm with a statistical probability of 95%.

RÉSUMÉ

Le diamètre hydraulique du nez dans différentes couches frontales est calculé à l'aide de 880 tomogrammes provenant de 46 personnes de race blanche. En même temps les coupes sont calculées en mm². On arrive au résultat que les coupes médianes nasales sont les plus grandes. Le diamètre hydraulique semble être constant pour toutes les couches internes du nez aux différents moments de la journée. Pour les nez de personnes de race blanche, on a constaté, sur une base statistique, une valeur moyenne de 5,28 mm. Les mouvements de la conque nasale sont de 4 mm en moyenne pour une plage de confiance statistique de 95%.

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