Journal of Gerontology: MEDICAL SCIENCES
2005, Vol. 60A, No. 3, 396–398

Endonasal Geometry Changes in Elderly People: Acoustic Rhinometry Measurements

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Background. Skeletal nasal changes in elderly people have been extensively investigated, but data on variation of the endonasal architecture with age do not exist. We evaluated endonasal parameters in an elderly population as compared with those in a young group.

Methods. Acoustic rhinometry measurements were performed on 165 participants in the age range of 20–93 years. The rhinograms provided the endonasal volume from the nostril entrance to a 7.0 cm cephalic point (V0-7) and the minimal cross-sectional areas (MCA1 and MCA2). Statistical analysis was performed by Pearson correlation and one-way analysis of variance, using age as a continuous or categorical variable.

Results. There was no statistical difference in gender distribution within each age group. The results obtained for the left and right nostrils were similar. Endonasal volume V0-7 and the narrowing areas MCA1 and MCA2 significantly increase with age, except for men over 80 years in which a relative decrease was observed.

Conclusion. Acoustic rhinometry examination of the endonasal architecture in a healthy young and elderly population demonstrated a gradual increase of endonasal volumes and minimal cross-sectional areas with age.

ELDERLY patients may complain about having difficulties in breathing through the nose, despite showing a wide-open nose on physical examination. The aging nose undergoes changes in all of its structural components, including skin, muscles, cartilages, and bones. However, the changes in the nasal cartilages are the most important in shaping the aged nose. The upper and lower lateral cartilages are attached in a scroll-like manner. With aging, these cartilages become thinner and lose their convexities, and their edges become stretched, fragmented, and more detached from each other. The connective tissue between the nasal cartilages becomes atrophic and loose, resulting in widening of the distance between them (1). Consequently, prolongation of the nose and drooping of its tip are commonly encountered (1–3), which initiated the development of a variety of surgical interventions (3–5).

Atrophic changes involving the nasal mucosa of older people (6) were demonstrated in macroscopic and histological sections of cadavers (1) and in cephalometric measurements (7). These, and other changes involving the nasal skeleton, are probably linked to the decline of the sense of smell, beginning around the fifth decade (8), as well as to subjective nasal obstruction (9).

We have carefully searched the English-language literature, and have found no data regarding endonasal changes in elderly people. As an increasing proportion of our population is surviving into older age, it is imperative to expand our knowledge on the structural endonasal changes associated with old age. Accordingly, we investigated the variation of endonasal geometry with age.

Methods

Population

A cross-sectional survey of endonasal acoustic rhinometry was approved by the ethical committee of the Sheba Medical Center. It was performed on 165 participants, including 101 elderly participants treated in the geriatric division and rehabilitation center (mostly for hip fractures) and 64 young staff volunteers. Informed consent was obtained from all participants. The population of participants was divided into four age groups: <50 ($n = 55$), 50–64 ($n = 24$), 65–79 ($n = 41$), and ≥ 80 years ($n = 45$). Exclusion criteria included chronic nasal discharge or stuffiness, previous nasal surgery, and the use of any type of nasal drops.

Experimental Protocol

Acoustic rhinometry measurements were taken of both nostrils using the Eccovision acoustic rhinometer (Hood Laboratories, Pembroke, MA) and anatomically shaped nosepieces, which were not inserted into the nostrils. The measured data were automatically presented in a rhinogram, which describes sequential cross-sectional areas as a function of the distance from the nostril (Figure 1). In measurements from a normal healthy nose there are three valleys in the curve that represent minimal cross-sectional areas and that are denoted by MCA1, MCA2, and MCA3. The location-anatomical meaning of MCA3 is still ill-defined and infrequently described (9); therefore, we investigated only the values of MCA1 and MCA2 and their distances L1 and L2 from the nostrils. The endonasal volume between the entrance to the nostril (0 cm) and 7 cm cephalically (V0-7) was also calculated.

Statistical Analysis

The relationship between the acoustic rhinometry-measured data and the participants' age as a continuous variable was examined by the Pearson correlation coefficient. Differences in study parameters between men and women were

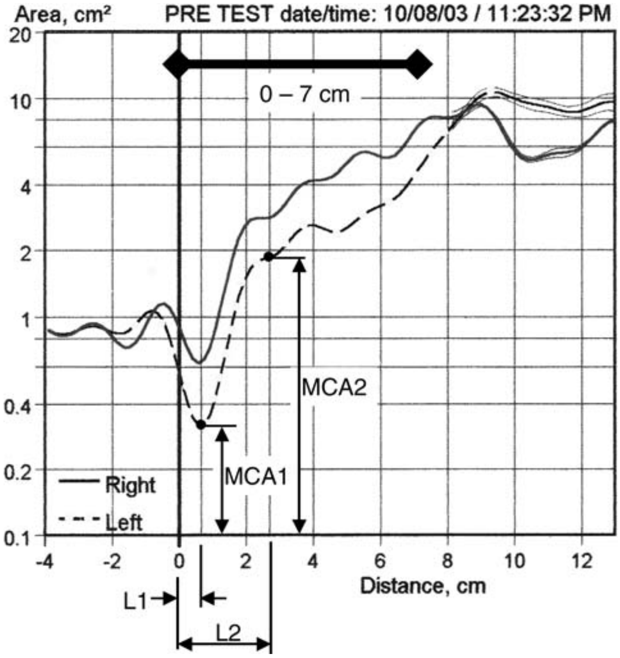

Figure 1. Example of a rhinogram with all the parameters marked.

tested by *t* test, and between the four age groups by one-way analysis of variance.

Results

A total of 81 men and 84 women were examined (age range 20–93 years). There was no statistical difference in gender distribution within each age group. The results obtained for the left and right nostrils were similar; therefore, results of only one side (left) are presented.

The average endonasal volumes (V0-7) of the young group (<50 years) were 27.4 cm^3 and 22.4 cm^3 for men and women, respectively. It significantly increases with age ($p=.001$), except for the oldest male group (≥80 years) in which V0-7 decreases to values similar to those for the group aged 50–64 years (Figure 2). For each age group, endonasal volume was greater in men than in women, except for those aged ≥80 years.

By using age as a continuous variable, we observed a positive correlation between age and nasal volume in both men and

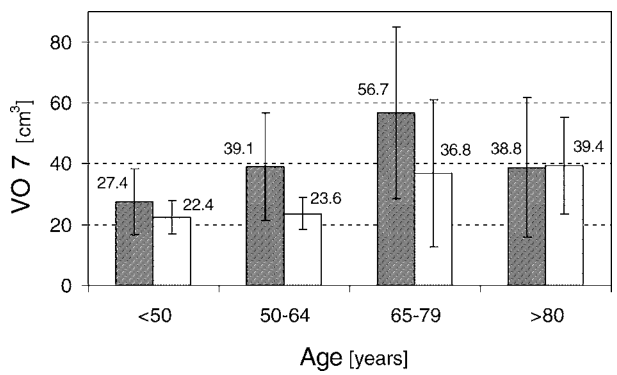

Figure 2. Variation of the left endonasal volume (LV0-7) with participants' age (men, diagonal lines; women, dotted area).

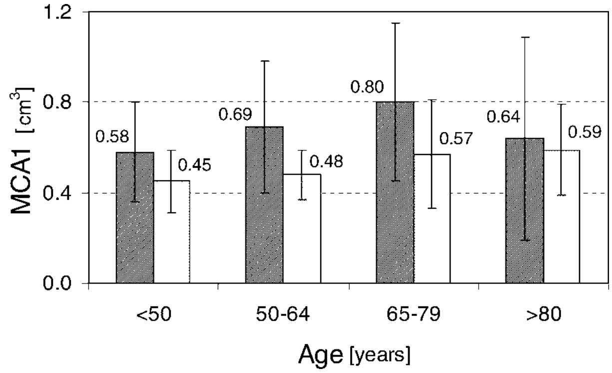

Figure 3. Variation of the left nose first area narrowing (MCA1) with participants' age (men, diagonal lines; women, dotted area).

women; correlation coefficients were 0.44 and 0.36 (women and men, respectively; data not shown).

Average values of the endonasal narrowing areas (MCA1 and MCA2) in the youngest group (<50 years) were 0.58 cm^2 and 1.20 cm^2, respectively, for men and 0.45 cm^2 and 1.11 cm^2, respectively, for women. The variation with age was similar to that of endonasal volume. It exhibited a clear increase with age for both men and women, except for a slight decrease in men aged ≥80 years (Figures 3 and 4). By using age as a continuous variable, we noted a positive correlation between age and either MCA1 or MCA2, more prominent in women than men. The correlation coefficients for MCA1 were 0.18 and 0.35 for men and women, respectively, and 0.30 and 0.46 for MCA2 for men and women, respectively (data not shown).

Comparison by gender revealed all values (V0-7, MCA1, and MCA2) to be smaller among women compared with men. No correlation was found between age and L1 or L2.

Discussion

Acoustic rhinometry was used to study the variation of endonasal geometry in the aging population. The rhinometric measurements obtained for the left and right nostrils were similar without a statistical difference. Because endonasal changes in the course of aging were evaluated from the precise location of anatomical structures (e.g., head of inferior turbinate) of each side of the nose, averaging data from both sides of the nose may yield a less accurate pattern of the changes. Hence, the results are presented in Figures 2, 3, and 4 only for the left nose.

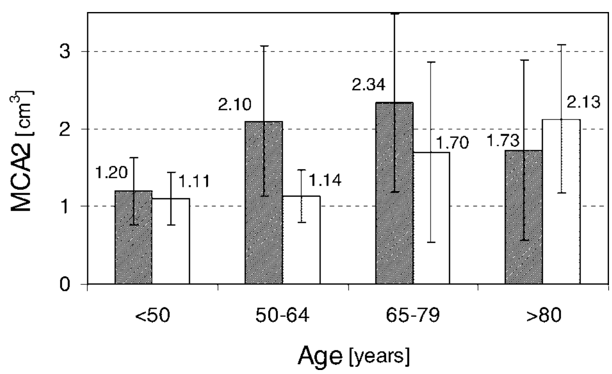

Figure 4. Variation of the left nose second area narrowing (MCA2) with participants' age (men, diagonal lines; women, dotted area).

The average minimal values of the left endonasal volume were measured for the youngest group (<50 years). Assuming symmetry between the two sides of the nose, we calculated that the smallest nasal volumes for men and women are 54.8 cm^3 and 44.8 cm^3, respectively. These values approximate the range of 10–52 cm^3, which is reported in the literature for nasal volumes (10). The variation of nasal volume with age demonstrated a linear increase except for men, where a clear decrease is observed in the oldest group ($\geq$80 years).

The narrowest point in the nasal cavity, MCA1, is considered to be the isthmus nasi or the nasal valve, but a disagreement exists regarding its precise anatomic definition. Some referred to the interface between upper and lower lateral cartilages (10), whereas others used the term ''nasal valve area'' to describe the area lying between the inter-cartilaginous line and the pyriform aperture which is related to the head of the inferior turbinate (11). Nevertheless, the narrowest nasal area, which was observed at about 2 cm from the nostril, is believed to be responsible for half of the total amount of airway resistance (12). In the present study we found that in all of the population MCA1 may vary between 0.58 cm^2 and 0.80 cm^2 in men and between 0.45 cm^2 and 0.59 cm^2 in women. Previous measurements without decongestive agents on examinations showed that mean values for MCA1 were 0.7 cm^2 (range 0.57–1.45 cm^2) (9,13,14), whereas values less than 0.4 cm^2 were obtained in participants who expressed subjective feelings of nasal obstruction (9,15).

The second endonasal narrowing, MCA2, in all the population was found to range between 1.20 cm^2 and 2.34 cm^2 in men and between 1.11 cm^2 and 2.13 cm^2 in women. There is a wide variation in the literature regarding the values of MCA2, and the reported values in some studies range from 0.42 cm^2 to 4.0 cm^2 with an average of 1.3 cm^2 (13,14). Similarly to the variation of nasal volume with age, MCA2 also increased linearly with age except for the oldest men ($\geq$80 years) where a slight decrease was observed. The increase of the area at MCA2 with age may be attributed to mucosal atrophy at the middle turbinate.

The anatomical definition for the location of MCA2 is controversial in the literature. Some described it as the area at the head of the inferior turbinate, and measured a distance of 3.3 cm from the nostril with insertable nosepieces (13). Others suggested that MCA2 represents the area under the head of the middle turbinate (15), and measured its location at about 4 cm from the nostril with anatomically shaped nosepieces (9). We found MCA2 to be located at L2 = 3.4–3.7 cm in men and at L2 = 3.6–3.8 cm in women; these values are similar to the reported values when considering MCA2 as the head of the middle turbinate. The variability of definitions of MCA2 may be attributed to the use of different types of nosepieces. Using the anatomically shaped nosepieces prevents possible protrusion into the nasal vestibule, and thus, minimizes the distortion of the soft tissues of the nasal vestibule. As a result, more accurate measurements may be obtained (9).

The results of the present study reveal significant differences by gender; in all age groups, the values measured in men are larger than those measured in women. This finding is in contrast with reports of similar values of MCA1 and MCA2 in men and women under the age of 30 (15). Moreover, even larger nasal volumes (V0-7) were measured in women (13). These differences may be explained by the following: (a) the measurement of V0-7 in a women with a short maxilla may include part of the nasopharynx and (b) different insertable nosepieces may have been used. Nevertheless, the results of this study are in agreement with those of Millqvist and Bende (16), who found that MCA1 is smaller in women and that there is a positive correlation between nasal volume and MCA1; however, their study group was limited to younger patients.

Conclusion

Acoustic rhinometry measurements of nasal geometry in a healthy young and elderly population demonstrated a gradual increase of minimal cross-sectional areas and endonasal volumes with age. These age-related differences were more prominent among women, and may be explained by an excessive drop of the tip of the nose in men. The results of this study should serve as objective reference values of acoustic rhinometry in the elderly population. Knowledge of the age-related changes of endonasal architecture will be helpful in clinical planning of medical or surgical interventions, because such data may potentially make a difference in patients' medical management.

Acknowledgments

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Received August 4, 2003
Accepted September 30, 2003
Decision Editor: John E. Morley, MB, BCh