Rhinology, 33, 138–140, 1995

Errors arising in cross-sectional area estimation by acoustic rhinometry produced by breathing during measurement*

A. Tomkinson, R. Eccles

Common Cold and Nasal Research Centre, Department of Physiology, University of Wales College of Cardiff, United Kingdom

SUMMARY *Standardization of acoustic rhinometry is becoming increasingly important as the use of this technique becomes more widespread. The effects of breathing through the nose during acoustic rhinometry were investigated to determine if this affected the measurements of minimal cross-sectional area. During inspiration, and inspiration with the contralateral nasal airway obstructed, the minimal cross-sectional area decreased by 12.48% ($p < 0.05$) and 56.68% ($p < 0.01$), respectively, from the measurement made during a breathing pause. During expiration the reverse was observed, with increases in the minimal cross-sectional area of 13.95% ($p > 0.05$) and 40.20% ($p < 0.05$), respectively. In all but quiet expiration, the minimum cross-sectional area recorded during respiratory manoeuvres, differed significantly from those measured during a breathing pause. We recommend that in order to avoid changes in nasal measurements during breathing, acoustic rhinometry should be performed during a brief breathing pause.*

Key words: acoustic rhinometry, standardization

INTRODUCTION

Acoustic rhinometry is increasingly being used in a variety of situations to measure cross sectional area in the nasal cavity (Lenders and Pirsig, 1990; Elbrond et al., 1991; Fisher et al., 1993). There is, as yet, no standard procedure for the use of this instrument. In the present situation it is difficult to compare results between laboratories.

This paper highlights nasal breathing during measurement as a potential source of error that may arise if the subject's respiratory activity is not carefully controlled during acoustic rhinometry measurements.

MATERIAL AND METHODS

Subjects

Five healthy adults were assessed (two female, three male), the age ranged from 25–40 years. Two subjects were noted to have minor septal deviations.

Acoustic rhinometry

The apparatus used to make acoustic reflection measurements has been described recently (Hilberg et al., 1989). In brief, the method involves measuring reflected sound from the nasal cavity. An acoustic pulse is produced by a spark generator which traverses a Bakelite wave tube connected to the nasal cavity via a nosepiece. A 7.5-cm long plastic nose piece with an internal diameter of 1.3 cm nose piece was used which was inserted a few millimetres into the nose. The acoustic rhinometer and software were supplied by GM Instruments Ltd. (Kilwinning, UK). Three acoustic rhinometry readings were generated for each nostril of each subject and the mean minimum cross-sectional area recorded. Five situations were explored, firstly during a breathing pause, for a few seconds, and subsequently during quiet inspiration and expiration, and inspiration and expiration, with the contralateral nostril occluded. For each nasal passage the mean cross-sectional area recorded during a breathing pause was taken as the baseline cross-sectional area. Readings taken during the varying breathing manoeuvres were then compared to this baseline. The data were analyzed using the paired Wilcoxon signed-rank test.

RESULTS

The results of the study demonstrate that the minimum cross-sectional area of the nose is influenced by breathing, especially if one of the nasal passages is obstructed.

* Received for publication May 16, 1994; accepted January 23, 1995

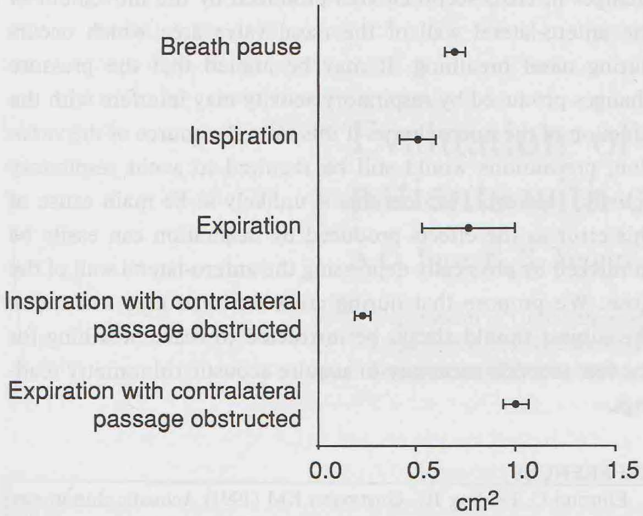

Figure 1. Effects of breathing through the nose on minimum cross-sectional area. The mean minimum cross-sectional area with corresponding 95% confidence interval is illustrated for various breathing manoeuvres. Each point represents the mean of three measurements in the right nasal cavity of one subject.

Figure 1 illustrates the mean values of the minimum cross-sectional area, with their corresponding 95% confidence intervals, of the right nasal cavity of one subject, during various breathing manoeuvres. During a breath hold the minimum cross-sectional area was 0.69 cm^2; with normal inspiration through the nose this value dropped to 0.51 cm^2 and with inspiration against an obstructed contralateral nasal passage the cross-sectional area fell further to 0.23 cm^2. The reverse was seen in nasal exhalation, with increases in minimum cross-sectional area to 0.76 cm^2 and 1.00 cm^2, respectively. Figure 2 illustrates the pooled data for all subjects (10 nasal cavities in total). The minimum cross-sectional area obtained during a breathing pause is taken as a baseline for each case. Subsequent values obtained during each breathing manoeuvre are then quoted as a percentage change in minimum cross-sectional area. An average of the changes seen in minimum cross-sectional area, in all subjects, during each breathing manoeuvre is shown, and the 95% confidence intervals for each situation are included. These changes reached statistical significance in all but quiet expiration (Table 1). The data analyzed above only refer to the minimum cross-sectional area. Figure 3 illustrates the effect in one of the subjects on the acoustic reading of the subject's entire nasal cavity during the various breathing manoeuvres. Clearly the dimensions of the whole nasal cavity are affected as the dimensions of the minimum cross-sectional area decreases and this is of particular concern if one is interested in volume changes.

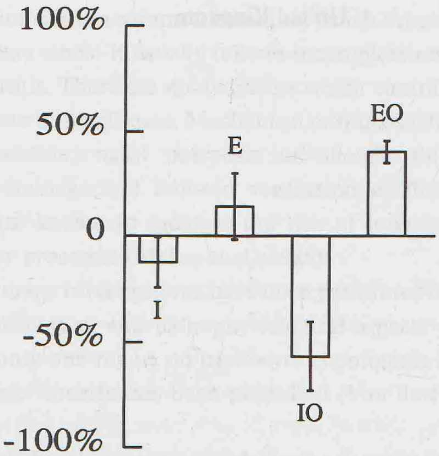

Figure 2. Effects of breathing through the nose on minimum cross-sectional area. The mean percentage change in minimum cross-sectional area from the area measured during a breathing pause is illustrated for various breathing manoeuvres. Each point represents the mean of measurements 10 nasal cavities with corresponding 95% confidence intervals (I: inspiration; E: expiration; IO: inspiration with the contralateral nasal passage obstructed; EO: with the contralateral nasal passage obstructed).

Table 1. Changes in the minimum cross-sectional area measured during respiratory manoeuvres are compared to the minimum cross-sectional area measured during a breath pause. Changes are quoted as a percentage of that measured during a breath pause.

comparisons	percentage change in minimum cross-sectional area	tied p-value
inspiration	12.48% decrease	$p<0.05$
expiration	13.95% increase	$p>0.05$
inspiration with contralateral passage obstructed	56.68% decrease	$p<0.01$
expiration with contralateral passage obstructed	40.20% increase	$p<0.05$

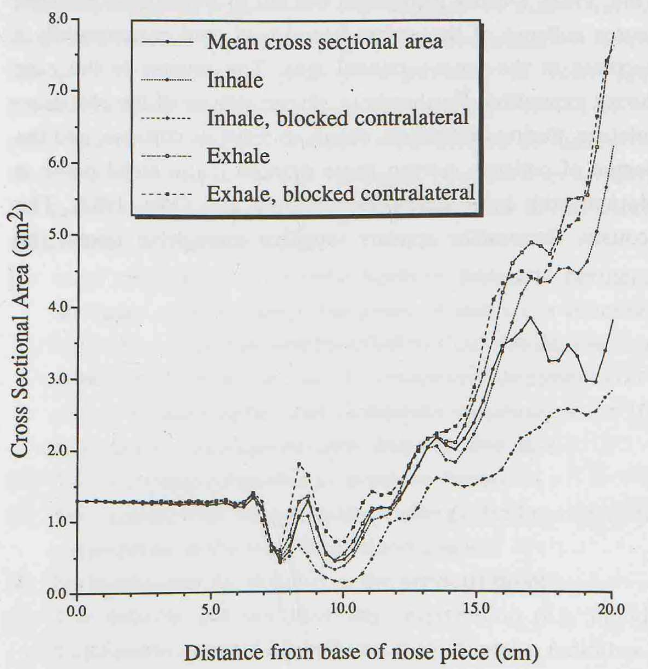

Figure 3. Effects produced by various breathing manoeuvres on the acoustic rhinometry trace of a human nasal cavity. The mean minimum cross-sectional area was taken during a breath pause. Subsequent readings were taken during inhalation and exhalation, and inhalation and exhalation while the contralateral nostril was obstructed. A change in the dimensions of the nasal valve area is seen during these manoeuvres and a simultaneous changes in the dimensions distal to this region are also apparent.

DISCUSSION

In this study it is clear that even quiet respiration has an effect on the minimum cross-sectional area of the nose. This effect becomes much more profound if the contralateral nasal passage is obstructed. Potentially gross errors in the estimation of nasal cross-sectional area could, therefore, arise in an individual with nasal pathology in one nasal passage, if they were to breathe through the nose during measurement. Efforts are presently being made to standardize the use of acoustic rhinometry. No previous report has highlighted the potential error that may be introduced if the timing of the measurement is not carefully controlled. It is also of interest that swallowing, or any simultaneous respiratory noise, such as throat clearing, et cetera, also had a marked effect on the readings. The nasal valve is usually the narrowest point in the nose and has been the region of greatest interest to nasal physiologists and clinicians alike. The term 'nasal valve' was originally used by Mink (1940), who identified this structure as the aperture between the nasal septum and the lower border of the upper lateral cartilage. Although the term nasal valve is in common usage, it usually now refers to a broader area sometimes described as the nasal valve area (Kasperbauer, 1987). It is triangular in cross-section and is composed of: 1) a medial wall, formed by the caudal septum; 2) a postero-inferior wall, made up of the head of the inferior turbinate and floor of nose; and 3) an antero-lateral wall, which combines the alar cartilages together with the connective tissue between these and the bony pyriform aperture (Kasperbauer, 1987). The antero-lateral wall is easily deformed and its movement during respiration has been well documented (Haight and Cole, 1983). During inspiration the fall in transmural pressure causes collapse of the antero-lateral wall, and consequently a decrease in the cross-sectional area. The reverse is the case during expiration. Furthermore, phasic activity of the alar musculature, during inspiration, occurs to resist its collapse, and the degree of collapse is even more marked if the facial nerve is blocked with local anaesthesia (Haight and Cole, 1983). The acoustic rhinometer appears sensitive enough to detect the changes in cross-sectional area produced by the movement of the antero-lateral wall of the nasal valve area which occurs during nasal breathing. It may be argued that the pressure changes produced by respiratory activity may interfere with the function of the microphone. If this were the source of the variation, precautions would still be required to avoid respiratory activity. However, we feel this is unlikely to be main cause of this error as the effects produced by inspiration can easily be mimicked by physically depressing the antero-lateral wall of the nose. We propose that during cross-sectional area evaluation the subject should always be instructed to cease breathing for the few seconds necessary to acquire acoustic rhinometry readings.

REFERENCES

1. Elbrond O, Felding JU, Gustavsen KM (1991) Acoustic rhinometry used as a method to monitor the effect of intramuscular injection of steroid in the treatment of nasal polyps. J Laryngol Otol 105: 178–180.
2. Fisher EW, Scadding GK, Lund VJ (1993) The role of acoustic rhinometry in studying the nasal cycle. Rhinology 31: 57–61.
3. Haight J, Cole P (1983) The site and function of the nasal valve. Laryngoscope 93: 49–55.
4. Hilberg O, Jackson AC, Swift DL, Pedersen OF (1989) Acoustic rhinometry: Evaluation of nasal cavity geometry by acoustic reflection. J Appl Physiol 66: 295–303.
5. Kasperbauer JL (1987) Nasal valve physiology: Implications in nasal surgery. Otolaryngol Clin N Am 20: 699–719.
6. Lenders H, Pirsig W (1990) Diagnostic value of acoustic rhinometry: Patients with allergic and vasomotor rhinitis compared with normal controls. Rhinology 28: 5–16.
7. Mink PJ (1940) Physiologie der oberen Luftwege. Acta Otolaryngol (Stockh) Suppl 42.

A. Tomkinson
Common Cold and Nasal Research Centre
Department of Physiology
University of Wales College of Cardiff
Museum Avenue
Cardiff CF1 1SS
United Kingdom