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Patency tests of the maxillary ostium in health and disease

M. Jannert, L. Andréasson and A. Ivarsson, Malmö, Sweden

SUMMARY

Three different maxillary ostial function tests (simultaneous pressure recording in nose and sinus; simultaneous differential pressure and flow recording across the ostium; presssure recording at a constant artificial air-flow into the sinus) have been evaluated on healthy subjects and used in clinical materials. No quantitative evaluation of the ostial function was possible when using the simultaneous naso-sinusal pressure recording method. The ostial function can be expressed as ostial resistance or as corresponding equivalent ostial diameter with the pressure-flow and the constant artificial air-flow methods. An isolated determination of the ostial function in both sinu-nasal and naso-sinusal directions during nasal breathing was only possible with the pressure-flow method. No impaired ostial function was found in cases with maxillary pain and intrasinusal cysts, but in chronic sinusitis the ostial function was considerably deteriorated. In cases with impaired ostial function the constant artificial air-flow method does not mirror the true functional state due to the non-physiological air-flow level used. Thus, the pressure-flow method seems to be the most physiological one.

Many more or less physiological test methods have been used to evaluate the maxillary ostial function. Most studies have been performed on diseased sinuses. Therefore three different methods have been evaluated in a material consisting of 20 healthy volunteers (35 maxillary sinuses). The methods were: I. Simultaneous pressure recording in the sinus and the nasal cavity during nasal breathing. II. Air-flow recording through and differential pressure across the ostium during nasal breathing. III. Registration of the pressure increase within the sinus with the application of a constant artificial air-flow of 16.7 $cm^3 \cdot s^{-1}$ into the sinus. All methods have earlier been tested on a nose-sinus model. The selection criteria of the subjects were: no history of sinusitis or recent upper respiratory tract infection; normal findings of ENT examination including roentgenologic and ultrasound examinations; and no abnormality in their blood samples.

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The three test methods were also applied to patients in order to compare their ostial function with that of healthy subjects. The selection of the patients was done in order to obtain one group where an impaired ostial function could be expected (chronic sinusitis). The other groups (maxillary pain and intrasinusal cysts) were selected as no analysis of the ostial function in such cases has previously been described.

TEST PERFORMANCE

Rhinomanometric evaluation of the nasal airway resistance was performed in sitting and recumbent positions at rest, and after physical effort in the sitting position. The maxillary sinus was punctured after local anaesthesia through the canine fossa using a specially designed cannula. All test method (I–III) were then performed both in sitting and recumbent positions.

RESULTS

Healthy subjects

The pressure relationship between the maxillary sinus and the ipsilateral nasal cavity (Method I) was found to be 1:1 in sitting as well as in recumbent positions. For simultaneous pressure recording in the sinus and the contralateral nasal cavity the pressure relationship was < 1. No time-lag was observed.

Determination of the ostial resistance during inspiration in the sitting position during nasal breathing (Method II) could be performed in 13 sinuses, but in the remaining 22 the ostial resistance was < 25 mm $H_2O/1000\ cm^3 \cdot s^{-1}$ at a flow of $2.0\ cm^3 \cdot s^{-1}$ and could not be measured exactly. The equivalent ostial diameters were estimated from a log-log diagram (Figure 1) in 12 sinuses, while the remaining 23 ostia were > 2.5 mm and thus not measurable with method II. When using a constant artificial air-flow (Method III) the equivalent ostial diameters could be estimated in all sinuses by the use of the log-log diagram (Figure 1). The mean equivalent ostial diameter was 2.54 mm (S.E. ± 0.13) with a range of 1.13–4.5 mm. In comparable cases no statistical difference was found between equivalent ostial diameters estimated with methods II and III. The equivalent ostial diameters showed a statistically significant reduction in recumbency when measured with methods II and III.

Patient groups

No impairment of the ostial function was observed in the groups with maxillary pain and intrasinusal cysts (methods I–III), when compared with values obtained in healthy subjects.

In the group with chronic sinusitis (6 sinuses) three types of naso-sinusal pressure changes were found during nasal breathing (method I): equal pressures in the ipsilateral nasal cavity and the sinus; lower pressure changes within the sinus than

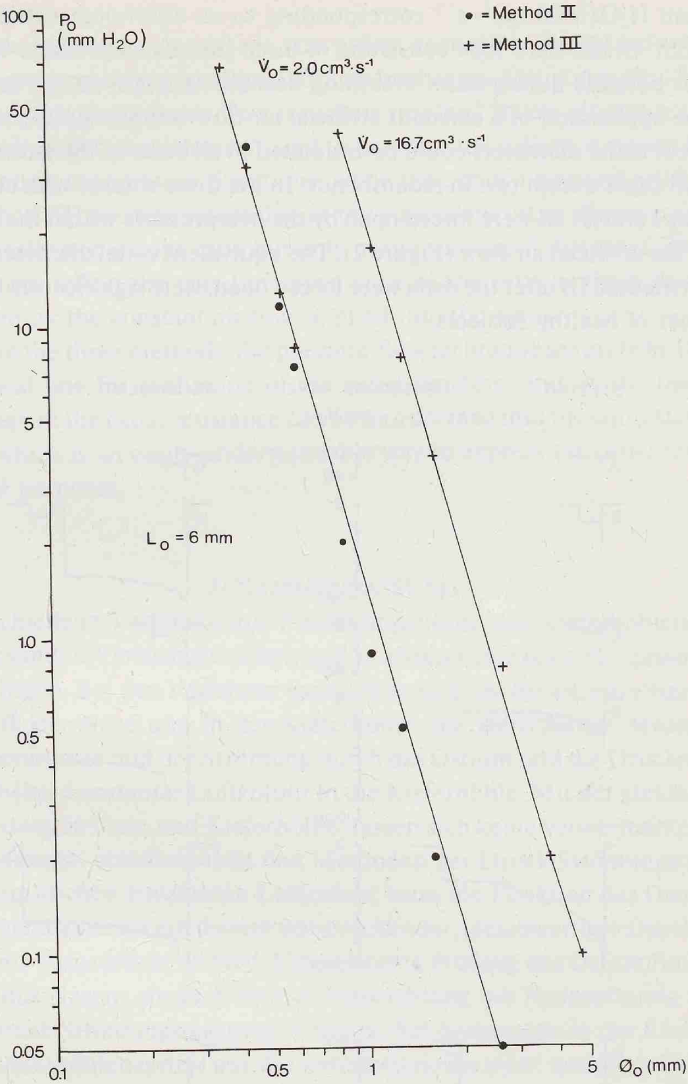

Figure 1. Diagram for estimation of the equivalent ostial diameters from the pressure-flow relationship at $\dot{V}_0 = 2.0\ cm^3 \cdot s^{-1}$ (method II) and pressure increase at constant artificial air-flows of 16.7 $cm^3 \cdot s^{-1}$ and 2.0 $cm^3 \cdot s^{-1}$ (method III).

in the nasal cavity of the ipsilateral side; no pressure changes within the sinus. The results obtained from patients with chronic sinusitis could also be separated into three different types by estimating the ostial resistance and equivalent ostial diameters (method II). The first type consisted of two sinuses with ostial resistances < 25 mm $H_2O/1000\ cm^3 \cdot s^{-1}$ corresponding to equivalent ostial diameters > 2.5 mm. The second type (one sinus) showed measurable ostial resistance

>25 mm $H_2O/1000$ $cm^3 \cdot s^{-1}$ corresponding to an equivalent ostial diameter <2.5 mm. In the third type consisting of three sinuses no pressure-flow recording was possible during nasal breathing because of a non-patent ostium. With the application of a constant artificial air-flow into the sinus (method III) equivalent ostial diameters could be estimated in all cases in the sitting position and in all cases except one in recumbency. In the three sinuses with closed ostia (methods I and II) all were forced open by the overpressure within the sinus, created by the artificial air-flow (Figure 2). The equivalent ostial diameters, estimated with method III after the ostia were forced open, were significantly lower than the values of healthy subjects.

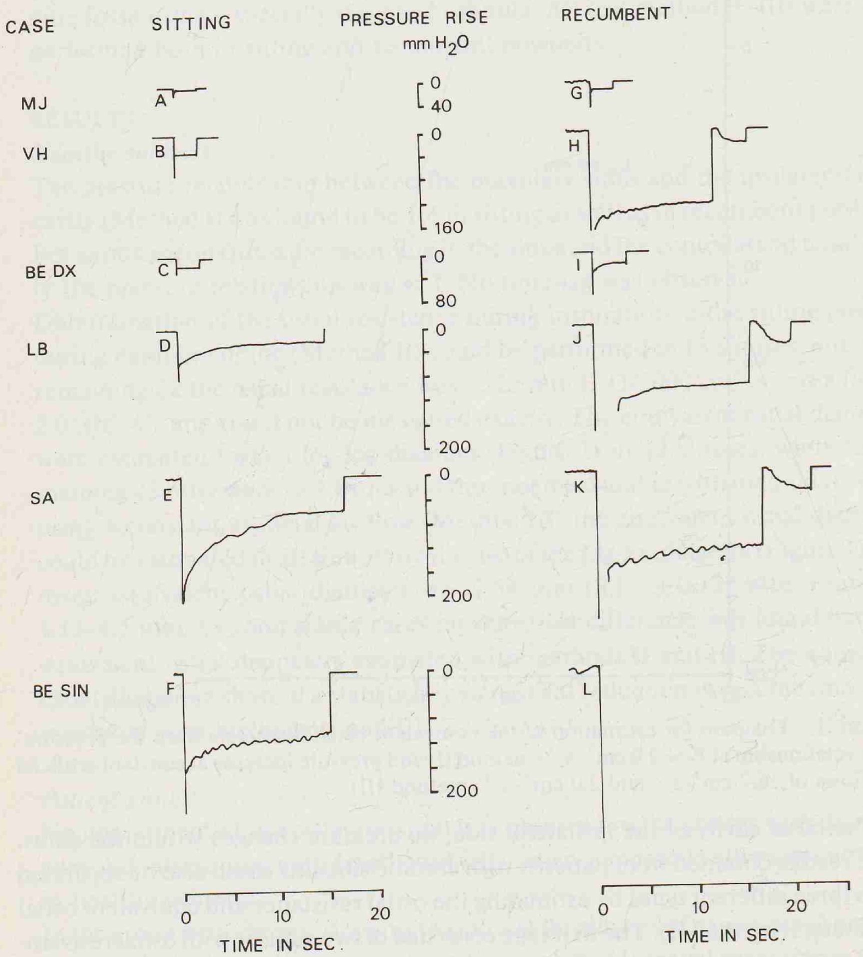

Figure 2. Recording of the intrasinusal pressure rise with a constant artificial air-flow of 16.7 $cm^3 \cdot s^{-1}$ into the sinus (method III) in cases with chronic sinusitis.

CONCLUSIONS

The ostium can be judged as patent, non-patent or partially obstructed with naso-sinusal pressure recording (method I) but no further grading of the ostial function is possible. With the pressure-flow recording (method II) the ostial function can be evaluated under physiological conditions when the ostium is patent in sinu-nasal as well as naso-sinusal directions; while the use of a constant artificial air-flow (method III) permits estimation of the equivalent ostial diameters even in physiologically non-patent ostia but only in the sinu-nasal direction. The latter values do not reflect the true functional state of the ostia as these have to be forced open by the constant air-flow applied into the sinus.

Thus, out of the three methods, the pressure-flow technique seems to be the most physiological one for evaluation of the ostial function, and by the use of the log-log diagram the ostial resistance can be transformed into the equivalent ostial diameter which is an easily understandable way to express the ostial resistance for clinical purposes.

ZUSAMMENFASSUNG

Drei verschiedene Verfahren zur Funktionsprüfung des Kieferhöhlenostiums sind an gesunden Versuchspersonen und in klinischen Fällen mit einander verglichen worden. Bei den Verfahren handelte es sich um die gleichzeitige Druckmessung in der Nase und in der Kieferhöhle, die gleichzeitige Messung des Druckunterschieds und der Strömung durch das Ostium und die Druckmessung bei künstlicher konstanter Luftzufuhr in die Kieferhöhle. Mit der gleichzeitigen Druckmessung in Nase und Kieferhöhle liessen sich keine verwertbaren quantitativen Aussagen ermitteln. Mit den Methoden der Druck-Strömungsmessung und der künstlichen konstanten Luftzufuhr kann die Funktion des Ostiums als ein Widerstand oder als ein diesem entsprechender, gleichwertiger Durchmesser des Ostiums ausgedrückt werden. Eine isolierte Prüfung des Ostiumfunktion in sowohl Sinus-Nasen- als auch Nasen-Sinusrichtung bei Nasenatmung war nur mit der Druck-Strömungsmessung möglich. Bei Schmerzen in der Kieferhöhle und bei Kieferhöhlenzysten war die Ostiumfunktion nicht gestört, während sie bei chronischer Sinuitis eine beträchtliche Verschlechterung aufwies. In Fällen mit verschlechterter Ostiumfunktion entsprechen die mit künstlicher Luftzufuhr erhobenen Messwerte nicht der wirklich vorliegenden Funktion auf Grund der angewandten unphysiologischen Luftströmungsrate. Somit erscheint uns das Druck-Strömungsverfahren als die der Physiologie am besten entsprechende Methode.

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Magnus Jannert, M.D.
Dept of Otolaryngology
University of Lund
Malmö General Hospital
S-214 01 Malmö
Sweden