Rhinology, 29, 213-221, 1991

Patency of nasofrontal duct during the healing process of trephined acute frontal sinusitis. A clinical application of modern rhinomanometry.

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SUMMARY

Thirty-one patients suffering from acute frontal sinusitis were treated by trephination. The patency of the nasofrontal duct was measured daily via the ventilation tube by computerized rhinomanometry until the tube was removed. According to the air flow changes inside the frontal sinus during normal nasal breathing, the duct was assessed as open, partially open or obstructed. The further healing process was assessed by clinical and radiological examination during a two-month post-operative follow-up. Statistical analysis of the results shows that both the favourable healing process and recurrences can be predicted with this method to a very high level of significance. The method is simple and rapid and it helps to determine the correct time for the withdrawal of the irrigation tube in individual patients.

INTRODUCTION

Viral infection and exposure to various allergens or irritants may lead to the obstruction of the nasofrontal duct. Together with disturbances in mucociliary transport, this predisposes to bacterial invasion and the production of a suppurative frontal sinusitis (Toremalm, 1984). In severe or complicated acute cases, trephination of the frontal sinus is indicated. The goal is to establish drainage with minimal trauma to the nasofrontal duct area. After trephination, the patency of the nasofrontal duct is usually tested by installation of a physiological saline solution into the sinus through an inserted drain. When the

Paper presented at the 13th Congress of the European Rhinologic Society including the IXth I.S.I.A.N., London (United Kingdom), June 1990.

clinical symptoms have subsided and the passage of fluid is adequate, the drain is removed and the patient is discharged for further controls. However, after frontal sinus trephination, recurrences are frequent.

One crucial point in the treatment is the time when the trephination drain is removed. In a healthy frontal sinus, the nasofrontal duct is open and the pressure changes caused by breathing are measurable inside the sinus (Zippel and Vogt, 1976). The irrigation of the nasofrontal duct is not a physiological test to evaluate the normalization of the ostial patency (Andréasson et al., 1983). More physiological tests have been introduced. Zippel et al. (1974) presented an electromanometric method to study the patency of the nasofrontal duct to air or liquid. Vogt and Schrade (1979) calculated the hydrodynamic pressure of the nasofrontal duct by recording both the pressure and flow of constantly injected saline solution. In 1975, Mann et al. used sinumanometry in a pressure chamber to measure the ostial resistance between nasal cavity and frontal sinus. Andréasson et al. (1983) recorded both the resistance of the ductus nasofrontalis and the pressure changes caused by respiration and Valsalva's manoeuvre inside the sinus frontalis. With this method it was possible to define groups in which recurrences might be expected because of impaired function of the nasofrontal duct. All these methods used rather complicated instruments, required mathematical calculations and were time consuming for routine clinical practice.

In the Department of Otolaryngology, Turku University Hospital, acute frontal sinusitis is a problem with yearly increasing numbers of patients (Antila and Suonpää, 1990). Encouraged by the results of the previous studies, we have used modern computerized rhinomanometry for monitoring the pressure changes in the frontal sinus during normal and forced nasal breathing and during Valsalva's manoeuvre. In this paper we present this method and an investigation in which the patency of ductus nasofrontalis was recorded daily during the post-operative healing process of acute frontal sinusitis after trephination.

MATERIAL

Thirty-one consecutive patients (mean age 33 years) with acute symptoms of radiologically-verified frontal sinusitis which did not respond to conservative treatment were trephined, from September to December 1989. The decision to operate was made when severe headache and/or eyelid oedema did not subside in 2–3 days and radiological re-examination revealed no decrease in the sinus opacification. The subjects were 20 males (mean age 31 years) and 11 females (mean age 41 years).

METHODS

The trephination was carried out under local anaesthesia. A sample for bacteriological culture was suctioned and the irrigation drain (diameter 4.2 mm)

was inserted. Irrigation through the drain was performed twice a day and medical therapy was continued and re-evaluated according to the bacteriological cultures. When needed, maxillary sinus lavation was performed daily during the hospital stay. The drain was removed when no secretion was found at irrigation and no force was needed to irrigate. The patients were discharged for further ambulatory controls carried out during the following two months. At the follow-up visits the status of the trephined sinus was controlled radiographically and nasal examination and evaluations of the subjective symptoms were repeatedly performed by an otolaryngologist. In the case of recurrences the patients were rehospitalized for further treatment.

Global evaluation of the post-operative healing process was made after the 2-month follow-up. On the basis of the healing of subjective symptoms, clinical status and the radiographic normalization of the frontal sinus mucosa, the subjects were divided into three groups:

A. Patients with recurrence or marked prolongation of the disease.
B. Patients with delayed radiological healing without marked subjective or clinical symptoms.
C. Patients with complete recovery.

The patency of the nasofrontal duct was recorded by rhinomanometer daily before the irrigation, beginning from the first post-operative day until the drain was removed. The test procedure is shown in Figure 1. The patient breathes through a mask which is connected to the rhinomanometer's flow transducer. The pressure channel is connected via a 25 cm long plastic tube to the irrigation drain inside the frontal sinus. Using modern Finnish computerized rhinomanometry, the flow caused by nasal breathing and the simultaneous pressure changes can be monitored on the screen and printed out as well as stored in the computer memory. In each session three separate respiratory tests, normal breathing (NB), forced breathing (FB) and Valsalva's manoeuvre (VM) were monitored (Figure 2). The final assessment of the status of the sinus ostium, at the last examination before the drain was removed, was based on the recordings of normal nasal breathing:

1. Obstructed ostium: no regular respiratory flow occurred inside the sinus.
2. Partially open ostium: a regular respiratory flow occurred inside the sinus but its mean was less than 50% of the corresponding nasal flow.
3. Open ostium: the mean of the respiratory flow in the sinus was at least 50% of the corresponding nasal flow.

The grading of the ostial patency for forced breathing and for Valsalva's manoeuvre was based on similar ranges and is shown in Figure 2.

When the saline solution was instillated into the frontal sinus, the pressure needed for lavation was also roughly estimated. The results were graded as normal or elevated. If the solution did not pass into the nose the ostium was regarded as obstructed for liquid.

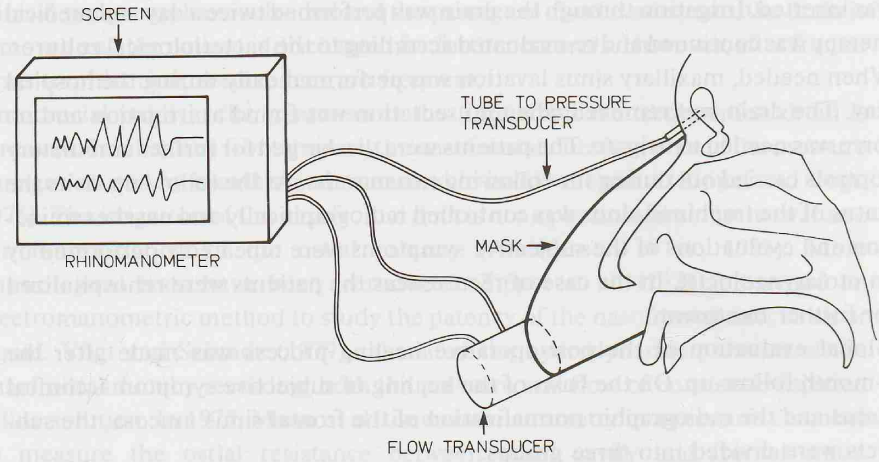

Figure 1. The rhinomanometric test procedure for evaluation of the nasofrontal duct. The other pressure channel of rhinomanometer acts as a reference level and measures the pressure in the room.

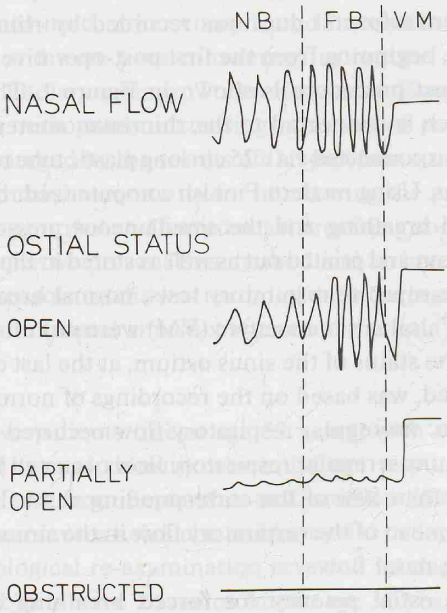

Figure 2. Example of flow and pressure curves representing the principles according to which the nasofrontal duct was regarded as open, partially open or totally obstructed. Each pressure change obtained inside the frontal sinus is compared to the changes in nasal flow during the different tests. NB is normal breathing, FB is forced breathing and VM is Valsalva's manoeuvre.

RESULTS

Altogether 36 sinuses of 31 patients were trephined. The operation was bilateral in six cases and unilateral in 25 patients (right sinus 17, left sinus 8). Purulent maxillary sinusitis was initially found in 24 patients and subsided in all cases during the hospital stay. The duration of hospitalization ranged from 5 to 18 days (mean 9.2 days).

The patency of the nasofrontal duct to air in all 36 sinuses at the first and at the last examination are shown in Figure 3. On the first post-operative day, no ostium was open for normal breathing (NB). It was partially open in six cases and total obstruction was found in 30 sinuses. After the post-operative irrigations (mean 8.4 days) the ostium was open for NB in 12 (33%) sinuses, partially open in 20 (56%) sinuses and total obstruction still persisted in four (11%) cases.

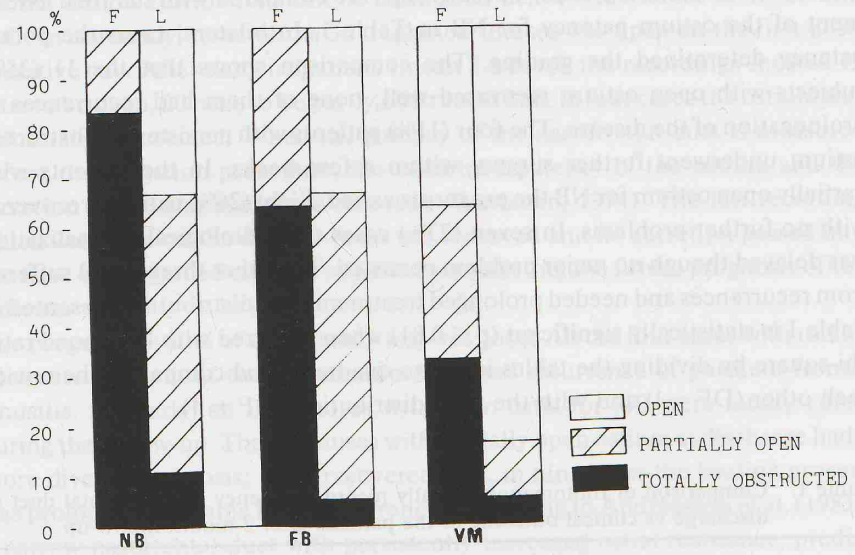

Figure 3. Patency of the nasofrontal duct after the first (F) and the last (L) post-operative irrigations (mean 8.4 days) in 36 trephined frontal sinuses. NB is normal breathing, FB is forced breathing and VM is Valsalva's manoeuvre.

At the first examination, forced breathing (FB) could not be monitored normally in any of the sinuses. The obstruction was partial for FB in 13 (36%) and total in 23 (64%) cases. On the last examination day, only two ostia were totally obstructed for FB. The progress was favourable in 34 cases.

During Valsalva's manoeuvre (VM), the air pressure inside the sinus rose to a maximum in 13 (36%) sinuses on the first post-operative day. Some grade of pressure elevation was found in 11 (31%) sinuses and total obstuction occurred in

12 (33%) cases. At the last recording, the maximum air pressure could be monitored during VM in 29 (83%) sinuses, slight pressure increase was found in five (14%) sinuses and total obstruction still persisted in two (6%) sinuses. Post-operative irrigations were continued for 8.4 days on average. In the 12 sinuses with open ostium for NB at the last examination, also the irrigation solution passed freely to the nose. In this group the mean duration of irrigations was 6.6 days. In the 20 sinuses with partial obstruction for NB the irrigation pressure was regarded as normal in 15 cases and elevated in five cases. The irrigation time of these 20 sinuses was on average, 8.1 days. In the four sinuses where total obstruction for NB persisted at discharge from hospital, the liquid passed through to the nose, although elevated pressure was needed. In these cases the mean irrigation time was 13.5 days.

Global evaluation of the post-operative healing process was made by grading the 31 patients into three groups. These groups are compared with the final assessment of the ostium patency for NB in Table 1. In bilateral cases the poorer patency determined the grading. The comparison shows that the 11 (35%) subjects with open ostium recovered well; none of them had recurrences or prolongation of the disease. The four (11%) patients with persistently obstructed ostium underwent further surgery within a few weeks. In the patients with partially open ostium for NB the prognosis varied. Eight (26%) patients recovered with no further problems. In seven (23%) cases the radiological normalization was delayed though no major problem persisted. The other three (10%) suffered from recurrences and needed prolonged treatment. The distribution presented in Table 1 is statistically significant ($p < 0.01$) when analyzed with likelihood ratio chi-square by dividing the tables into two quadrants and comparing them with each other (DF = 1) and with the total distribution (DF = 4).

Table 1. Comparison of rhinomanometrically recorded patency of nasofrontal duct at discharge vs clinical outcome of the patients after 2-month follow-up.

patency for normal breathing (NB)	clinical outcome: recurrent disease (A)	prolonged healing (B)	free of disease (C)	total
totally obstructed	4 *	0	0	4
partially open	3	7 **	8	18
open	0	0	9	9
total	7	7	17	31

Likelihood ratio chi-square G^2:
Total table 25.145, DF = 4
Upper quadrant (*) 7.191, DF = 1
Lower quadrant (**) 8.247, DF = 1
In all $p < 0.01$

DISCUSSION

In previous studies, measurement of ostial patency of the frontal sinus has been performed using rather complicated equipment and time consuming mathematical models. The aim of the present study was to bring the modern rhinomanometer into routine use in this field of rhinological practice. The registration procedure is rapid and easy. The time needed is about five minutes per patient including information storage and output sheet printing. The recording is painless and can be performed by a medical assistant or nurse. Although the grading of the results into three categories is rough, it proved to be practical in routine work. If necessary, individual changes may be followed by more accurate calculations.

The nasofrontal duct was considered to be open when normal nasal breathing could be easily recorded via the inserted drain. According to Mann et al. (1977), normal airflow fluctuations can be monitored below a resistance of 15–20 mm H_2O. In our study, none of the 36 trephined sinuses was open on the first postoperative day. After daily irrigations (mean 8.4 days), the recordings showed 12 ostia to be open, 20 ostia to be partly obstructed and, in four cases the ostium was still totally obstructed. When the patency of the nasofrontal duct is measured before the irrigation procedure, the combined patency of the ostium and the secretion inside the sinus was recorded (Rantanen, 1974). The last recording which was done on the day the drain was removed and no secretion passed into the nose was regarded as more reliable for predicting the future prognosis of the patients.

The prognostic value of our patency test was good. All the four cases with totally obstructed ostium at the last examination, had recurrence of purulent frontal sinusitis. Similarly, all the sinuses with open ostia for NB were totally cured during the follow-up. The 20 sinuses with partially open ostium at discharge had a more diverse prognosis; eight recovered well, in nine cases the healing process was prolonged and three had a recurrence. According to Andréasson et al. (1983), a narrow nasofrontal duct with persistently increased ostial resistance, predisposes to recurrent frontal sinusitis. In our study, partial obstruction of the nasofrontal duct may refer to the same phenomenon. In these cases special attention must be given to the possible underlying causes in the anterior ethmoid region and at the inferior infundibulum of the nasofrontal duct. Obstructive processes in this region may be treated secondarily by functional endoscopic sinus surgery (Stammberger, 1986; Kennedy et al., 1987), as was done also in three of our patients. The irrigation time in the 20 sinuses with partially obstructed ostium for NB was 8.1 days on average. According to Mann et al. (1979), the mean time interval until restoration of normal frontal sinus ventilation was, in acute frontal sinusitis, 16.8 days. Longer irrigation of our patients might have led to the total opening of the nasofrontal duct in some of the sinuses. However, the aim of the present study

was to record the ostium patency on the day when irrigation solution passed freely into the nose.

The opening of the nasofrontal duct during the post-operative healing process could also be seen in the recordings made during forced breathing (FB) or during Valsalva's manoeuvre (VM). In the present study, the maximum air pressure during VM could be monitored inside 83% of the frontal sinuses at the last recording (after 8.4 days). Similarly, Andréasson et al. (1983), demonstrated air passage during Valsalva's manoeuvre in 86% of cases on the sixth post-operative day. Our results show that the opening of the nasofrontal duct to such an unphysiologically high intranasal pressure does not predict a favourable further healing process. However, in cases with partial obstruction these observations may give additional information on the actual status of the ostium.

In all the seven patients who underwent further surgery because of a recurrence, the irrigation fluid passed quite easily into the nose at the end of the initial hospitalization. This confirms the need for a more accurate method to evaluate the status of the nasofrontal duct before the drain is withdrawn. The earlier passage of saline irrigation compared to the opening of the nasofrontal duct for respiratory airflow may be due to changes in the viscosity of the mucus (Mann, 1977) or lowered surface tension (Flisberg et al., 1963) when saline is used. An additional cause is the increased fluid pressure which results in compression of the swollen mucosa.

With a simple rhinomanometric test it is possible to predict the further prognosis of a trephined acute frontal sinusitis, especially in cases where ductus nasofrontalis is whether open or totally blocked for normal breathing when the drain was removed. If the ductus remains to be partially open the prognosis varies. In this group three of our patients experienced a purulent recurrence, and the rhinomanometric forced respiration or Valsalva's tests did not help to predict this poor prognosis. Prolonged lavation therapy and specific examinations (CT-tomography) of the ethmoidal sinuses are advisable in cases where the ductus nasofrontalis is only partially open for normal breathing.

ACKNOWLEDGEMENTS

We are grateful to Professor Pekka Laippala for the statistical treatment of the results.

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