Rhinology, 44, 197-200, 2006

The effects of ventilated and non-ventilated nasal packs on Eustachian tube function: nine-step inflation-deflation test results*

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SUMMARY

The effects of different types of nasal packs on Eustachian tube function have been a source of debate. Past study results have been based on single tympanometric evaluations. To our knowledge, this study is the first to use the nine-step inflation-deflation test for evaluation of Eustachian tube function in patients undergoing nasal packing. No significant difference was observed between ventilated or glove-finger nasal packs, in terms of preserving Eustachian tube function in our patient population.

Key words: nasal surgery, ventilated nasal packs, glove finger nasal packs, eustachian tube function, nine step inflation-deflation test

INTRODUCTION

Despite reports suggesting septal suturing alone, rather than additional splinting or packing, many surgeons still employ nasal packs for homeostasis and for stabilization of bony and cartilaginous structures after nasal operations such as septoplasty [1-3]. Secondary Eustachian tube (ET) dysfunction due to nasal packing has been implicated as a factor contributing to a bothersome postoperative period [4-10]. Therefore different nasal packs including ventilated nasal packs, have been developed in attempts to improve the patients' comfort after nasal surgeries [11-13].

Several studies have reported alterations of ET function due to nasal packing [4-9]. In one animal model study, forced-response testing, inflation-deflation testing and continuous pressure monitoring were used to assess ET function in ferrets [7]. However, in all the other reports in the literature, tympanometric tests were used as the sole technique for assessing ET function. Thus, these previous study results were based only on middle ear pressure measurements.

The nine-step inflation-deflation test was first described by Bluestone and has been used successfully in assessing ET function in several articles [14-17]. The test depends on consecutive measurements of middle ear pressures after changing the ear canal pressure and the response of the ET via swallowing movements, and thus is thought to represent a more physiological assessment of ET function. In our study, the effects of both ventilated and glove-finger nasal packs on ET function are assessed by the nine-step inflation-deflation test.

MATERIALS AND METHODS

Patients and treatment

The research was conducted prospectively, with 43 patient volunteers (86 ears) who underwent nasal septal surgery with postoperative packing under general anesthesia. Patients were randomly selected for either the ventilated nasal pack (Group 1) or the glove-finger nasal pack (Group 2) groups. Patients with a history of active or chronic ear disease were excluded. Each patient had a routine head and neck exam including otoscopy before surgery. Patients with tympanic membrane perforations, adhesive membranes or significant tympanosclerosis interfering with tympanometry, were also excluded from the study. Additionally, pure tone audiograms were performed on each patient to rule-out possible ossicular chain dysfunction or other middle ear pathology not be observed during otoscopy. All subjects had the nine-step inflation-deflation test before surgery using the standard techniques as previously described [14-17]. Additionally, the values obtained from each individual step were recorded for further evaluation. Eustachian tube dysfunction was defined as a pressure change less that 10 mm H_20 in any step of the test.

All patients subsequently underwent septoplasty under general anesthesia. Commercially available ventilated nasal packs (Merocel®, Medtronics Inc, MN, USA) or glove-finger packs filled with sterilized gauze strips were randomly inserted into each nasal cavity at the end of the surgery. All patients were placed on oral antibiotics and analgesics during the postoperative period.

Otoscopic examinations and the nine-step tests were repeated on the second postoperative day immediately prior to pack removal. The postoperative status of ET function and middle ear pressures at each step were recorded in the same manner as before the surgery.

*Received for publication: December 15, 2005; accepted: May 16, 2006

Statistics

Statistical analyses were performed using SPSS 11.5 (SPSS Inc., Chicago IL, USA) software. Descriptives were quoted as mean ± SD. Pre- and postoperative values were compared with Wilcoxon signed rank test. Chi-square analysis was used to investigate the relations among the categorical variables. P value was set at $p \leq 0.05$.

RESULTS

There were 4 female (29.2 ± 6.5) and 16 male (37.4 ± 10.7) patients in Group 1, for a total of 40 ears studied. There were 2 female (37.0 ± 21.2) and 21 male (26.5 ± 8.7) patients in Group 2, for a total of 46 ears; however, one subject refused postoperative testing in one ear, therefore, a total of 45 ears were studied in this group.

Preoperative ET function was determined to be intact in 8 (20%) of 40 ears in Group 1 and in 20 (44.4%) of 45 ears in Group 2. Groups 1 and 2 were then divided into two subgroups in terms of preoperative ET function or dysfunction as assessed by the nine-step inflation-deflation test. Postoperative ET function was preserved in 5 of those 8 (62.5%) preoperatively functional ETs in Group 1, and was preserved in 12 of 20 (60%) in Group 2. The difference between these two groups was not significant. (χ^2=0.692 and p=0.595).

All the subjects reported that they were still able to breathe nasally before the pack removal on the second postoperative day, despite complaining of various degrees of increased difficulties compared to the first postoperative day. Having no objective criteria to classify the patients according to their ventilation capacity, all subjects were considered as having the same level of nasal ventilation during the analyses.

Pressure differences between each individual step of the nine step tests were calculated in order to estimate the air flux via the ET in pre- and postoperative tests. Air flux differences for each step in pre and postoperative nine step inflation-deflation testing, were found to be insignificant for both Groups 1 and 2 (Table 1). On otoscopy, no patient showed evidence of ET dysfunction as manifested by tympanic membrane, retraction or middle ear effusion. Patient tolerance of the nine-step testing was acceptable, although 1 patient of the 43 total did refuse testing in one ear.

DISCUSSION

The Eustachian tube has three major physiological functions, although prior studies regarding the effects of nasal packs assessed only middle ear pressure regulations. The other ET functions are protection of the middle ear from unwanted nasopharyngeal secretions, and clearance of middle ear secretions into the nasopharynx. Actually, the ET should be considered as a component of an entire physiological system consisting of the soft palate, nasal cavity, nasopharynx, middle ear and mastoid cavity [18]. Numerous physiological or pathological factors may alter this intricate system. Kaneko et al. elicited variable tubal compliance with aging [19]. Moreover, Leclerc et al. revealed that ET function might change with different body positions and be affected by nasal cycles [20]. Eustachian tube dysfunction in healthy subjects by viral infections has been previously described in two prospective studies [21, 22]. In a meta-analysis investigating nasal and ET function, atopy was determined to have a negative impact on these two functions [18]. Nasogastric tubes have been shown to predispose to ET dysfunction, even though nasal breathing may not be totally interrupted [23]. Based on these previous studies, it is reasonable to assume that a single modality testing may not be adequate to assess such a complex and highly variable system.

Nasal packs are frequently used for homeostasis and stabilization of bony and cartilaginous structures after septal surgery and are considered to have an impact on ET function. In fact, etiopathogenesis of the effects of nasal packs on ET function are a matter of controversy. McCurdy et al. revealed that both anterior and posterior nasal packing resulted in reduced middle ear pressure and he attributed this entity to stasis in the peritubal lymphatic plexus rather than to nasal obstruction per se [4]. Johannessen and Poulsen considered mucosal edema to be the most important factor in postoperative ET occlusion [8]. Thompson et al. measured the reduction in middle ear pressures in 55 (46%) of 126 ears after nasal packing, although 42 of these 55 patients (76%) normalized within 24 hours after pack removal. Their conclusions were that both surgical edema and the direct effects of nasal packing led to ET dysfunction [5].

Although its precise etiology has not yet been clearly elucidated, nasal packs do reduce middle ear pressure. Nasal airway obstruction secondary to packing is a well- recognized patient

Table 1. Pressure differences between each steps of pre and postoperative nine step inflation-deflation tests for Group 1 and 2. No significant difference was observed in any step. (D1: pressure difference between step 2 and 1; D2: pressure difference between step 3 and 2; D3: pressure difference between step 4 and 3; D4: pressure difference between step 5 and 4).

Pressure Differences		Pre-surgery	Post-surgery	Z	p
GROUP 1	D1	9.95±8.38	10.88±10.62	0.380	0.704
	D2	8.33±6.15	8.43±7.75	0.625	0.532
	D3	38.81±11.13	40.43±18.05	0.052	0.959
	D4	38.67±11.09	36.58±11.71	0.983	0.326
GROUP 2	D1	19.36±20.16	22.68±30.04	0.399	0.690
	D2	17.33±22.64	19.96±25.36	0.317	0.751
	D3	54.60±39.19	47.66±32.05	0.175	0.861
	D4	48.12±30.26	46.57±30.47	0.134	0.893

complaint immediately after nasal surgeries. Ventilated nasal packs were intended to preserve ET function and to relieve aural fullness via facilitating nasal breathing. Nevertheless, Ruddy et al. found no significant difference in nasal obstruction or in patient discomfort levels using either ventilated or glove-finger packs [11]. Arya et al. compared two different types of commercially available nasal packs, one with the ventilation tube and the other without. They concluded that there was no significant difference in pain scores between groups, with either nasal pack in place [12]. Morgan et al. compared the effects of cannulated and non-cannulated nasal packs on ET function after nasal operations and determined that middle ear pressures were reduced in both groups without significant difference [6]. Contrary to these results, however, Egelund and Jeppesen reported significantly fewer patient symptoms in a ventilated nasal pack group. It is important to note that in their study, the packs were left in place for 4-6 days, a time period exceeding that commonly used today [9].

Improved ET function after septoplasty was initially presented as evidence of a relationship between a deviated nasal septum and some middle ear disorders. McNicol conducted a study on 54 volunteer divers who presented with nasal septal deviation and ear problems, termed "nose-ear distress syndrome" by the author. The study reported that 94.4% of the divers increased their pressure equalizing ability six weeks after submucosal resection surgeries [24]. Low and Willatt reported that middle ear pressure levels ipsilateral to nasal blockage were significantly increased after septal surgeries in an average of 7.5 months [25]. Moreover, Deron et al. reported that such improvement in Eustachian tube opening pressures remained stable postoperatively [26]. In our study, 28 of 85 (32.9%) ears demonstrated good ET function prior to septoplasty, and this was determined to be 17 of 85 (20%) by the second postoperative day. The high incidence of poor preoperative ET function in our patient population was attributed to the septal deviations, which were indeed the main indications for surgery.

All these studies that have been discussed so far used only one method of ET assessment, based purely on tympanometric evaluations. Middle ear pressure may be altered in seconds with soft palate movements like swallowing and speaking. Reaching a conclusion on ET function relying only on a single test may lead to erroneous results. Hence, in our study, we assessed ET function using the nine-step inflation-deflation test. To the best of our knowledge, this is the first report to utilize this test to assess ET function in response to nasal packing. The nine-step tympanometric inflation-deflation test was first described by Bluestone in 1975 [14]. This test is appealing not only because it assesses ET function in a comprehensive fashion, but also because it is non-invasive and easily performed using only impedence audiometry, which can be found in every institution [17]. It is also very well tolerated, as only 1 of our patients refused testing of one ear due to discomfort.

Alternations in middle ear pressure by less than 10 mm H20 in any step signify a dysfunctional ET in the nine-step inflation-deflation test assessment. Using this criterion, ET function was determined to be preserved in 5 of 8 (62.5%) patients in Group 1 and in 12 of 20 (60%) patients in Group 2, on the second postoperative day immediately before the packs removals. The difference between the groups was insignificant. The alterations of air pressures that were caused by air flux into and out of the middle ear cavity during testing were also found to be insignificant in both Groups 1 and 2, pre- and postoperatively. Accordingly, we did not observe any difference in ET function in patients who were packed with either ventilated or glove-finger nasal packs.

The results of our study, which were obtained by means of the nine-step inflation-deflation test, were in accordance with prior study results, which solely relied on middle ear pressure assessments.

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