Point Prevalence of Barotitis in Children and Adults After Flight, and Effect of Autoinflation

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The most common cause of barotitis is pressure changes during descent in aviation. Equilibration is normally achieved by swallowing, jaw movements, yawning, or chewing, but some have to perform a Valsalva maneuver several times during descent and even by these means some fail. The aim of the study was to estimate the point prevalence of barotrauma in children and adults after flight, and to test the effect of an autoinflation device (Otovent®), in improving negative middle ear pressure after flight. Questionnaires and Otovent®, were distributed to all air passengers in eight incoming flights. The questionnaires enquired about nasal allergy, nasal congestion, previous and actual ear pain, use of decongestants and experience of inflating the Otovent set during descent. After flight, the passengers were offered an ear examination including otoscopy and tympanometry both before and after a Valsalva maneuver, as well as after Otovent inflation. Otoscopic signs of barotitis were found in 10% of the adults and in 22% of the children. Negative middle ear pressure of more than 10 hPa after landing was found in 20% of the adults and in 40% of the children. The Valsalva maneuver normalized the pressure in 46% of the adults and in 33% of the children. Of the adults, 73%, and of the children, 69% with an unsuccessful Valsalva maneuver could improve or normalize the middle ear pressure by inflating the Otovent set. In conclusion, we recommend autoinflation using the Otovent set to air passengers with problems clearing the ears during flight.

INSUFFICIENT EQUALIZATION of middle ear pressure during descent in civil aviation is the most common cause of middle ear barotrauma and barotitis (1). Barotitis is characterized by the onset of pain and impaired hearing in the affected ear and occasionally by vertigo (7). In rare cases sudden deafness caused by rupture of the round or oval window may occur (9,10). With the increase in air travel, barotitis is likely to become more frequent. Equilibration of negative middle ear pressure is usually achieved with minimal effort by swallowing, jaw movements, yawning or chewing, while some passengers may have to perform a formal Valsalva maneuver several times during descent and, even by these means, some fail.

For children, the equilibration procedures, especially the Valsalva maneuver, may be difficult to learn and it is almost impossible to control that the maneuver is correctly performed. Further, many children suffer from Eustachian tube dysfunction and will be at even higher risk of developing barotitis (4,5). The sound of children crying from severe otalgia during descent is a frustrating experience and makes many parents reluctant to fly with their children.

The interventional treatment of barotitis media, which is usually undertaken by a specialist, may be quite uncomfortable for the patient. Traditional treatment modalities include Politzer inflation, myringotomy with or without grommet insertion (16).

An ideal way to prevent barotitis would be a noninvasive, painless measure which is acceptable to air travellers of all ages. Use of the Otovent® autoinflation has previously been shown to increase the middle ear pressure in children suffering from secretory otitis media (3,11). The treatment is relatively popular among children and has no side effects. The autoinflation can be performed as soon as, or rather before, the descent has started.

The aim of this study was to estimate the point prevalence of barotitis in children and adults following flight and to assess the effect of Otovent inflation as a potential prophylactic measure by studying it's effect in improving the middle ear pressure in ears with established negative pressures after flight.

METHODS

In May 1996, questionnaires and Otovent autoinflation sets were distributed to all passengers in eight incoming flights before landing at Copenhagen Airport, Denmark. The questionnaires enquired about a history of nasal allergy, the presence of current nasal congestion, previous ear problems during flight, otalgia and use of any decongestants during the present flight.

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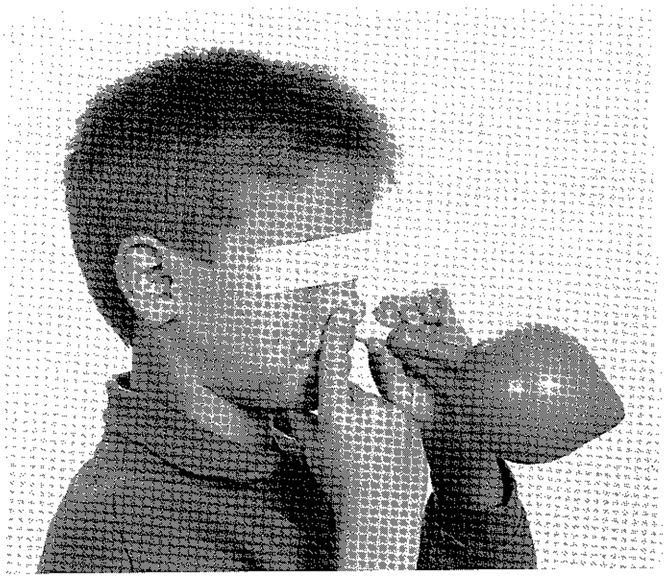

Fig. 1. Inflation of the Otovent® balloon. The ball shaped end is held tightly to one nostril, the opposite nostril is compressed with a finger and with the mouth closed the balloon is inflated through the nose.

Enclosed with the questionnaire there were instructions on how to use the Otovent set. The Otovent set consists of a nose tube mounted with a medical balloon (**Fig. 1**). During the inflation phase, a positive pressure of 60 hPa is created in the nasopharynx. If this fails to equalize the middle ear pressure the inflation can be followed, immediately, by a swallowing maneuver. During this deflation phase, Politzer equivalent, the pressure in the nasopharynx is about 40 hPa, which, in combination with the possible active opening of the Eustachian tube during the swallowing, may equilibrate the middle ear pressure.

The passengers were asked to inflate the Otovent set during the descent if they felt pain in the ears or sinuses and also to indicate if the inflation relieved their symptoms. After landing, all the passengers were offered an ear examination, including otoscopy and tympanometry, before and after the Valsalva maneuver, as well as after inflating the Otovent set. Otoscopy was performed by otolaryngologists. The otoscopic findings were classified according to Teed's classification (14). In the present study, Barotitis was defined as Teed, grade 2,3 and grade 4. A Tympanometer (Madsen 901), with a printout of all data, was used for the assessment of the middle ear pressure.

TEED'S CLASSIFICATION OF MIDDLE EAR BAROTRAUMA (14):

Grade 0: Normal
Grade 1: Retraction with redness in Schrapnell's membrane and along the manubrium
Grade 2: Retraction with redness of the entire myringa
Grade 3: Same as grade 2 plus evidence of fluid in the tympanum or hemotympanum
Grade 4: Perforation of the myringa

After the initial tympanometry, children as well as adults were instructed how to perform a Valsalva maneuver and tympanometry was repeated. Both children and adults were then instructed how to inflate the Otovent balloon and tympanometry was again repeated. In cases where the youngest children were unable to inflate the Otovent balloon, one of the parents orally inflated the balloon which was then held to the child's nostril using the deflation of the balloon as a Politzer inflation.

A total of 412 out of 591 (70%) adult passengers, 134 female and 278 male, median age 42 yr, range 15 to 85 yr, had filled in the questionnaire during the recent flights. Of 412 adult passengers, 49 (21 female and 28 male; 12%) attended the ear examination when leaving the airplane. Because the number of children among the passengers in the selected flights were very small, in parallel, children in transit were recruited with the permission of their parents to undergo a similar examination. Their parents also filled in a questionnaire on their behalf. A total of 45 children, 22 girls and 23 boys, aged 2 to 14 yr, median 8 yr, were included in the study.

Evaluation of the otoscopic and tympanometric findings were based on the ear with the most pronounced pathology. In cases with identical findings in the right and left ears the right ear was chosen. The Mann and Whitney rank sum test for independent samples, the χ^2 test and the McNemar change test for matched samples were used for evaluation of the outcome. The level of significance was chosen as $p < 0.05$.

RESULTS

Questionnaire Results

From **Table I** is seen that children reported ear pain, nasal congestion and use of nasal decongestants more frequent than adults. Ear pain during the recent descent was reported by 21 out of 38 children (55%) and by 95 out of 409 adults (23%). There was no difference between children and adults regarding nasal allergy, 18% and

TABLE I. QUESTIONNAIRE RESULTS REPORTING DIFFERENT PRESSURE SYMPTOMS DURING PREVIOUS AND ACTUAL FLIGHT.

	Adults		Children		χ^2-test
Questionnaire Results	Yes/No	Yes %	Yes/No	Yes %	p-value
Previous ear pain	193/219	46.8	28/15	65.1	<0.05
Actual ear pain	95/314	23.2	21/17	55.3	<0.001
Actual nasal allergy	80/331	19.5	8/37	17.8	n.s.
Actual nasal congestion	58/351	14.2	18/27	40.0	<0.001
Actual decongestion	26/383	6.4	14/24	36.8	<0.0001
Inflated the Otovent	175/235	42.7			
Relieved after Otovent	133/42	76.0			

TABLE II. EAR PAIN IN ADULTS AND CHILDREN CORRELATED WITH OTHER SYMPTOMS DURING THE RECENT FLIGHT.

	Ear Pain During the Actual Flight					
	Adults			Children		
	n	%	χ^2-test p-value	n	%	χ^2-test p-value
Nasal allergy						
Yes	22	28	n.s.	4	57	n.s.
No	78	22		17	55	
Nasal congestion						
Yes	22	39	<0.01	13	81	<0.05
No	72	21		8	36	
Previous ear pain						
Yes	82	43	<0.01	19	79	<0.0001
No	13	6		2	17	

20% respectively. During descent 175 adults (43%) had used the Otovent set and 133 (76%) reported a positive effect on the pressure symptoms.

Table II shows that there was no correlation between a history of nasal allergy and ear pain during the recent flight. However, correlation was found between nasal congestion and ear pain during the recent flight ($p < 0.05$). Among the children reporting nasal congestion, ear pain occurred in 13 out of 16 (81%) compared with 22 out of 57 adults (39%). Otalgia during the recent flight correlated well with such experience during previous flights. This was reported by 19 out of 24 children (79%, $p < 0.0001$) and by 82 out of 192 adults (43%, $p < 0.01$).

Otoscopic Findings

Table III demonstrates the frequency and grade of barotitis seen by otoscopy after landing. In children, 9 out of 45 ears (20%) and in adults 7 out of 49 ears (14%) showed grade 1 barotitis, while manifest barotitis (grade 2 & 3) was seen in 10 out of 45 children (22%) compared with 5 out of 49 adults (10%). Grade 4 barotitis was not seen. Unilateral sign of barotrauma was found in 10 children and in 6 adults, while bilateral barotrauma were seen in 9 children and in 6 adults.

Tympanometric Findings in Children

Table IV shows that only 3 out of 45 children (7%) had a positive or equalized middle ear pressure after flight. A negative pressure of more than 10 hPa was seen in 18 out of 45 children (40%).

Table V demonstrates a significant increase ($p < 0.05$) in middle ear pressure following a Valsalva maneuver, 13 out of 40 ears (33%) were equalized and in 7 out of 40 ears (18%) the maneuver resulted in a partial equilibration. No improvement of the negative pressure was seen in 20 ears (50%).

Table VI demonstrates the results of Otovent inflation. Out of 27 ears with a persistent negative pressure after a Valsalva maneuver, 10 ears were normalized (38%), and in 8 ears (31%), the middle ear pressure was improved after inflation of the Otovent set ($p < 0.001$).

Tympanometric Findings in Adults

Table IV shows that positive or neutral middle ear pressure was found in 8 out of 49 adults (16%) while negative middle ear pressures of more than 10 hPa were seen in 10 out of 49 of the adults (20%).

In adults with a negative middle ear pressure after flight there was a significant increase in middle ear pressure following a Valsalva maneuver ($p < 0.01$, Table V). Of 41, 19 (46%) had normalized their middle ear pressures, 7 had reduced the negative pressure, but in 15 ears (37%) the pressure was unchanged or even more negative than before.

Table VI demonstrates the effect of Otovent inflation in ears with a persistent negative pressure after a Valsalva maneuver. A significant increase or normalization ($p < 0.0001$) in middle ear pressure after Otovent inflation is seen in 16 out of 22 ears (73%).

DISCUSSION

In most airplanes, the cabin pressure during cruise level at 40,000 ft is usually restricted to a maximum equal to 10,000 ft air pressure (700 hPa) (8). During ascent, the

TABLE III. GRADE OF BAROTITIS IN ADULTS AND IN CHILDREN, ACCORDING TO TEED (12), AND INDICATION OF EAR PAIN.

	Adults, n = 49			Children, n = 45		
	n	%	(Ear Pain) (%)	n	%	(Ear Pain) (%)
Grade 0	37	76	(39)	26	58	(42)
Grade 1	7	14	(57)	9	20	(67)
Grade 2	3	6	(100)	8	18	(63)
Grade 3	2	4	(100)	2	4	(100)
Grade 4	—	—	—	—	—	—

TABLE IV. TYMPANOMETRIC FINDINGS AFTER FLIGHT.

Middle Ear Pressure in hPa	Children n = 45		Adults n = 49	
	n	%	n	%
Positive or zero	3	7	8	16
Negative to −10	24	53	31	63
Less than −10	18	40	10	20
Mann-Whitney:	I------$p < 0.05$-------I			

relative positive pressure in the middle ear is readily equalized, as air can easily escape through the eustachian tube. During descent, with a descent rate of approximately 400 $ft \cdot min^{-1}$ (12 $hPa \cdot min^{-1}$), the situation is different, since the eustachian tube acts as a flutter valve, if the pressure differential reaches a critical level (100 to 120 hPa). This is attained if equalization has not occurred every 8 to 9 min during descent, and then otic barotrauma is likely to occur (6). From U.S. Air Force chamber flight tests, the relative frequency of barotitis among 101,716 USAF trainees was reported to be 17% (6). In a study on Australian Defense Force (ADF) personnel (2), subjective postchamber barotrauma was reported by 29% out of 80 subjects and identified by otoscopy in 52% of those experiencing symptoms. In the same study, the value of tympanometry in predicting otic barotrauma was evaluated and the results showed that there was no correlation between prepressure and the occurrence of barotrauma, but there was a significant correlation between postpressure and otic barotrauma. From the questionnaires in our study, subjective barotrauma was reported by 23%. Among those adults attending the examination, 48% indicated ear pain during the recent descent, barotrauma could be identified by otoscopy in 39% of those experiencing symptoms. Of the children indicating ear pain, otoscopic barotrauma was found in 62%.

The high incidence of barotitis in the adults who attended the ENT examination, may be explained by a possible, unintentional, selection of the group. The examination may primarily have attracted those who had experienced ear problems during the recent flight.

The generally accepted experience that "clearing the ears" is more difficult in patients with nasal congestion, is in accordance with our results. Interestingly, however, passengers with nasal congestion using nasal decongestants reported ear pain as frequently as those who did not use decongestants.

The present study shows that no more than 33% of the children and 46% of the adults were able to equalize the negative middle ear pressure by Valsalva maneuver after

TABLE V. EFFECT OF VALSALVA'S MANEUVER IN CHILDREN AND ADULTS WITH A NEGATIVE MIDDLE EAR PRESSURE AFTER FLIGHT.

Middle Ear Pressure	Children, n = 42		Adults, n = 41	
	n	%	n	%
Normalized	13	33	19	46
Improved	7	18	7	17
Unchanged	20	50	15	37
Not measured	2		—	

TABLE VI. EFFECT OF OTOVENT INFLATION IN CHILDREN AND ADULTS WITH A PERSISTENT NEGATIVE MIDDLE EAR PRESSURE AFTER VALSALVA.

Middle Ear Pressure	Children, n = 27		Adults, n = 22	
	n	%	n	%
Normalized	10	38	13	59
Improved	8	31	3	14
Unchanged	8	31	6	27
Not measured	1		—	

instruction from a doctor. In the group of children and adults who could not equalize the negative middle ear pressure by performing the Valsalva maneuver, inflation of the Otovent set normalized the pressure in 38% of the children and in 59% of the adults.

One problem with the present study was that we did not know the middle ear condition before the flight. From a cohort study by Tos et al. (15) on epidemiology of natural history of secretory otitis media, it can be calculated that of the 45 children in our study, 6 children (14%) should have had significant negative middle ear pressure before the flight. We found significant negative middle ear pressure in 40% of the children. Reports concerning the point prevalence of significant negative middle ear pressure in adults is difficult to find, but the point prevalence in 16-yr-olds, is reported to be 5% (12). In the present study we found negative pressure in 20% of the adults after flight. It is reasonable to postulate that the difference in point prevalence of significant negative middle ear pressure between the subjects in our study and in the above mentioned cohort studies is caused by the pressure changes during the recent flight.

When a patient is instructed to perform a Valsalva maneuver, it is difficult to be sure that the maneuver is being correctly performed. In the present study, some of the children as well as the adults had a more negative middle ear pressure after performing the Valsalva maneuver than before the maneuver, apparently they had performed a Toynbee maneuver instead of a Valsalva maneuver. Inflating the Otovent balloon gives a visual feed-back, as an inflated balloon ensures that a positive pressure has been created in the nasopharynx. Of the youngest children, 29% were unable to inflate the Otovent balloon. From clinical experience it is known that many of these children could have learned to inflate the balloon if tuition from their parents had started one or two days before the flight.

CONCLUSIONS

The results of our study indicates that air passengers with a previous history of ear or sinus pain during flight are at a high risk of developing barotitis. Nasal congestion predisposes barotrauma, especially in children. The Valsalva maneuver is effective in clearing a negative middle ear pressure in one third of children and about half of adults. Otovent inflation is effective in increasing the middle ear pressure in children and adults also if the Valsalva maneuver is unsuccessful. The treatment can be performed as soon as, or even before the descent starts, in order to prevent the development of painful ear and sinus conditions.

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