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Research Article

Adenoid Hypertrophy in Young Children is Associated with Increased Respiratory Morbidity and Might be Connected to Supine Feeding Position

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- Adenoid hypertrophy
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Abstract

Background: The pathogenesis of adenoid hypertrophy is unknown. The purpose of the study is to describe the increased morbidity associated with adenoid hypertrophy in young children and to evaluate the connection with reported supine feeding position in the first year of life.

Methods: 298 young children with adenoid hypertrophy were retrospectively compared to 338 children of the same age range with gastrointestinal or urinary tract infection during years 2003-2018. All the children were followed at Clalit Health Services by one of the co-authors (AA).

Results: Children with adenoid hypertrophy showed a male preponderance and a significantly increased general morbidity (primary physician visits, urgent medical care center and emergency room visits/hospitalizations), performed more chest X-rays, had more ICD-9 respiratory related diagnoses, more recurrent pneumonias and purchased higher amounts of antibiotics, bronchodilators and steroids. There was no significant difference in the occurrence of gastro-esophageal reflux and no significant difference in eosinophil or IgE levels between the groups. There was no significant correlation between the different feeding positions and the degrees of adenoid hypertrophy, but the supine-fed children had significantly more bilateral perihilar infiltrates than those fed in upward/semi-supine position Within the group of adenoid hypertrophy, the great majority (88.5%) of the children fed in a semi-supine or supine position during the first year of life had moderate to severe adenoid hypertrophy.

Conclusions: Adenoid hypertrophy in young children is associated with increased respiratory morbidity and supine feeding position should be considered as a possible contributing factor in the pathogenesis of adenoid hypertrophy.

INTRODUCTION

The existence of the adenoid was first noted by Conrad Victor Schneider from Germany in 1661. Two centuries later, in 1868, Hans Wilhelm Meyer from Denmark was the first to demonstrate the relationship of the adenoid to ear disease and to develop a surgical operation to remove the hypertrophied adenoid [1]. The anatomical location of the adenoid gland is at the end of the nasopharynx, above the soft palate and cannot be seen under direct vision during regular physical examination. This hidden location reduces the awareness of physicians to the adenoid and might postpone the diagnosis of adenoid hypertrophy until there is a significant obstruction of the nasal passages.

Infants are born with rudimentary adenoid tissue and adenoid hypertrophy occurs during the first years of life. The pathogenesis of adenoid hypertrophy is not clearly understood, with allergy [2-4], gastro-esophageal reflux [5,6], and chronic viral infections [7,8] being implicated as important factors in its development. In adults, adenoid hypertrophy has been connected to allergy, chronic adjacent infection, obstruction, pollution and smoking [9]. Flexible bronchoscopies performed in our institution in neonates with congenital stridor generally show rudimentary adenoid tissue with patent nasal passages while those performed at the end of the first year or second year of life in order to elucidate causes of chronic cough or recurrent pneumonias generally show different degrees of adenoid hypertrophy. In a previous study [10], we followed for 12 months a group of 3-month-old infants where mothers were instructed to feed with the infant head in an upward position and we could find less respiratory and ear problems, fewer episodes of prolonged fever and less treatment

with antibiotics and bronchodilators than in a comparable group of infants without the behavioral intervention. In that study, we suggested the possible association between supine feeding position and the development of adenoid hypertrophy secondary to prolonged stasis of food in the posterior nasopharynx.

It is unclear if the adenoid enlargement at the earlier stages is due to hypertrophy or to infection (adenoiditis). To our experience, it seems that children with adenoid hypertrophy present with a prolonged and emphasized respiratory clinical picture, with increased needs for health care services than children with infections in other body systems like the urinary or gastrointestinal systems.

In the present study, we retrospectively analyzed the medical records of children with adenoid hypertrophy diagnosed between years 2003-2018 and compared the differences in morbidity and treatment of this group with that of children with gastrointestinal or urinary tract infection. The rationale in choosing this control group was to take a group of children suffering from infections in organs far from the ears, throat, sinuses and lungs since these organs are geographically close, connected and interacts with each other. All children were treated by one of the authors (AA) within Clalit Health Services, the largest centralized healthcare provider and insurer in Israel.

PATIENTS AND METHODS

This retrospective study included 298 children aged 0-5 years with a diagnosis of adenoid hypertrophy (A.H group) and 338 children of a similar age range with gastro-intestinal or urinary tract infection (control group). All methods were carried out in accordance with relevant guidelines and regulations. The experimental protocol was approved by the Clalit Medical Services Helsinki Ethics Committee (0098-19-COM2).

Inclusion criteria

A.H group: Diagnosis of adenoid hypertrophy based on clinical symptoms and readable nasopharyngeal X-ray.

Control group: Diagnosis of gastro-intestinal or urinary tract infection without a history of adenoid hypertrophy.

Data collection from centralized database

As an integrated health care provider and insurer, Clalit Health Services has a centralized database warehouse collating clinical and administrative data from the majority of medical encounters of all members. All these data are linked through a unique identifier. The data warehouse uses a single, universally adopted Electronic Health Record system throughout the entire organization. Clinical, administrative, and financial data are captured from hospitals (inpatient and emergency department settings), primary care clinics, specialty clinics, pharmacies and laboratories, diagnostic and imaging centers.

The following data were extracted from the medical records of the patients in both groups:

Background and diagnostic data: Gender, age at diagnosis.

Health care utilization data: number of primary physician visits, number of urgent medical care center visits, emergency room visits and hospitalizations.

Morbidity data: All ICD-9 related diagnoses of pneumonia, bronchitis, asthma, allergy, gastro-esophageal reflux, otitis and tonsillitis.

Imaging data: Mean number of chest X-rays performed per child and per group.

Laboratory data: Child and group means for total WBC count, number of children with total WBC count >10000, % eosinophils, number of children with total eosinophils >300, IgE level and number of children with IgE >40.

Pharmacy data: Mean doses of antibiotics (amoxicillin, amoxicillin-clavulanic acid, azithromycin, cephalexin, zinacef, ceftriaxone), bronchodilators (salbutamol, ipratropium bromide, by inhalers or inhalations), corticosteroids (systemic or inhaled), antihistamines and anti-reflux drugs (omeprazole, ranitidine, cisapride) purcha

Data collection from non-centralized medical records

The following data were extracted by co-author (AA) from in-clinic medical records of the patients in A.H group:

Food type during the first year of life (breast feeding, regular formula, hypoallergenic formula, anti-reflux [AR] formula).

Parent report of infant feeding position (supine, semi-supine or upward) during the first year of life.

Degree of A.H evaluated from nasopharynx X-rays by co-author (AA) as degree of nasal passages obstruction (mild<50%, moderate 55-70% or severe >75%).

Site of infiltrates on chest X-rays performed around time (within 3 months) of diagnosis of adenoid hypertrophy, evaluated by co-author (AA).

Statistical analysis

Chi-square or exact Fisher tests were used for categorical variables. Mean, median and standard error were used for continuous variables. Mann-Whitney test was used for comparisons between groups. The Kruskal Wallis test was used for comparisons of three groups or more. Logistic regression was used to adjust for gender as a confounding variable. $p<0.05$ was considered significant.

RESULTS

The age distribution at time of first diagnosis of adenoid hypertrophy was from 4 months to 5 years, with 5% < 6 months, 33% < 1 year and 74% < 2 years. There was a significant male preponderance in the adenoid hypertrophy group compared to the control group (65.3% and 49.1%, respectively, $p=0.00005$).

There was an increased general morbidity in the adenoid hypertrophy group evaluated as greater healthcare utilization, mean primary physician visits, mean urgent medical care center visits and mean emergency room visits/hospitalizations [Table 1]. There were significantly higher ICD9 based respiratory (bronchitis, pneumonia), allergy-asthma related diagnoses and greater number of chest X-rays performed in the A.H group [Table 1]. More children in the A.H group had recurrent (>2) pneumonias than in the control group (48 and 25 respectively,

Table 1: General healthcare utilization, ICD-9 related diagnoses and amount of chest X-rays performed in the adenoid hypertrophy (A.H) and control groups (means and standard errors S.E).

	A.H group (S.E)	Control group (S.E)	p value
Primary physician visits	2.458 (0.098)	1.583 (0.058)	<0.000001
Urgent medical care center visits	1.536 (0.149)	0.796 0.085)	0.000004
Emergency room/hospitalizations	0.467 (0.050)	0.314 (0.036)	0.033
Bronchitis, pneumonia	1.243 (0.057)	0.791 0.045)	<0.000001
Asthma	0.078 (0.015)	0.021 (0.007)	0.001
Allergy	0.130 (0.021)	0.065 (0.014)	0.011
Chest X-rays performed	0.617 (0.055)	0.100 (0.018)	<0.000001
Gastro-esophageal reflux	0.097 (0.017)	0.056 (0.012)	0.061

p=0.002). There were no significant differences in the occurrence of gastro-esophageal reflux or otitis (p=0.289) between the two groups.

There was a significantly higher mean total WBC count in the A.H group, but no significant difference in the number of children with total WBC>10000 between the groups. There were no significant differences in mean % eosinophils, number of children with total eosinophils>300, mean IgE or number of children with IgE>40 between the two groups [Table 2].

There was a significant difference in the amount of antibiotics, inhaled and systemic steroids, bronchodilators and antihistamines purchased between the two groups [Table 3], but not in anti-reflux treatment. These results in morbidity parameters and medications purchased remained significantly higher in the A.H group after adjusting for gender.

The food type during the first year of life could be specified in 238 of the children with adenoid hypertrophy. 161 children were fed regular formula, 22 were breast-fed for 6 months, and 30 for 12 months. 15 children were fed with hypoallergenic formula and 10 with A.R formula. There was no correlation between the different food types and the degrees of adenoid hypertrophy (p=0.849).

Feeding position could be specified in 212 of the children with adenoid hypertrophy. 154 children were fed in a supine position, 28 in a semi-supine position and 30 in an upright position. Children fed in a supine position had more bilateral perihilar infiltrates (p=0.0113) than the children fed in an upward/semi-supine position [Table 4]. There was no significant correlation between the different feeding positions and the different degrees of adenoid hypertrophy (p= 0.526) but, from 182 children fed in a semi-supine or supine position, 161 (88.5%) had moderate or severe adenoid hypertrophy.

The morbidities, number of chest X-rays performed and medications of 30 young children fed only breast-milk for 1 year were compared to those of 161 children fed regular formula. No significant differences were found in any of the evaluated categories of morbidity or treatment between the two groups [Table 5].

DISCUSSION

In the present study we compared a group of young children with adenoid hypertrophy to a control group of children of a similar age range with gastro-intestinal or urinary tract infection. The children with adenoid hypertrophy needed a significantly greater use of healthcare system, with more primary physician visits, urgent medical care center visits, emergency room/

Table 2: Laboratory results: Mean WBC counts, number of children with WBC>10000, mean IgE level, number of children with IgE>40, mean % eosinophil levels and percent of children with total eosinophils>300 in adenoid hypertrophy (A.H) and control groups.

	A.H group	Control group	p-value
Mean WBC count	10600	9964	0.003
Children with WBC>10000	204	208	0.217
Mean IgE level	115.2	150.7	0.388
Number of children with IgE > 40	47	50	0.84
Mean percent eosinophil count	3.5	3.3	0.879
Percent children with eosinophils >300	0.911	0.0648	0.377

Table 3: Medications purchased in adenoid hypertrophy (A.H) and control groups (means and S.E)

	A.H group (S.E)	Control group (S.E)	p-value
Antibiotics	9.090 (0.493)	6.506 (0.423)	0.000003
Systemic steroids	14.857 (2.292)	4.151 (0.758)	<0.000001
Inhaled steroids	10.049 (1.563)	4.607 (0.937)	0.000002
Inhaled bronchodilators	3.571 (0.320)	1.399 (0.153)	0.000001
Antihistamines	1.601 (0.163)	0.970 (0.082)	0.000228
Anti-reflux drugs	0.136 (0.027)	0.089 (0.017)	0.569

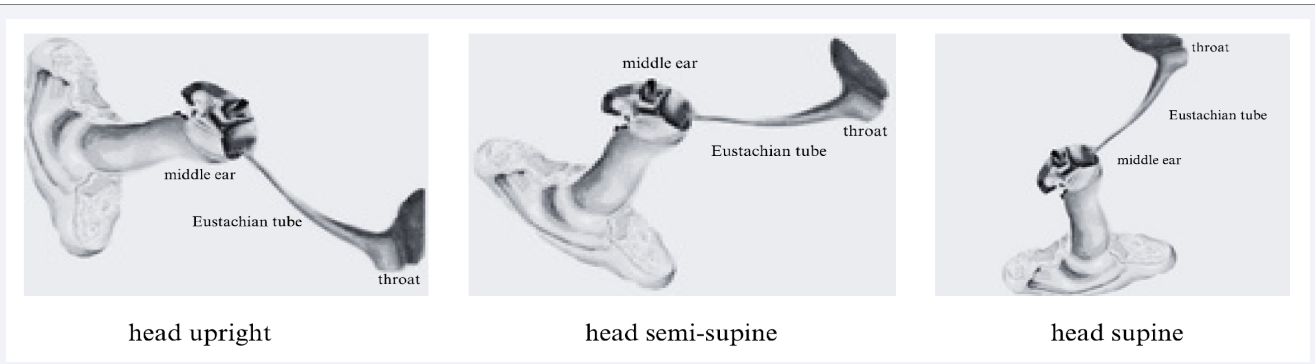

Figure 1 Relationship of middle ear, Eustachian tube and throat in different head positions (upright, semi-supine, supine).

hospitalizations. The main increased morbidity was in the respiratory system, with more ICD-9 related diagnoses of pneumonia and bronchitis, more recurrent pneumonias and more chest X-rays performed.

Adenoid bronchosinusitis has been described in 1944 by Clifford et al. [11], as a chronic disease with increased blood sedimentation rate, elevated white blood counts even in the periods between the exacerbations of the disease and a uniform distribution between 11 months to 8 years. Lower respiratory tract infections secondary to adeno-tonsillar hypertrophy have also been described by Konno et al. [12]. In that study, the authors included esophageal pressure monitoring during sleep studies in 19 children aged 2-10 years before and after adeno-tonsillectomy. They found, before surgery, elevation of the negative intra-thoracic inspiratory pressure to 4–6 times above normal values during deep sleep, returning to normal values after surgery. Contrast fluid (lipiodol) instilled into the oropharynx during sleep was aspirated and found in lung fields on chest X-rays more frequently before (8/10 children) than after surgery (1/7 children). The authors concluded that upper airway obstruction by enlarged tonsils and adenoids caused active aspiration of infected secretions during sleep.

We found that asthma and allergy related ICD-9 diagnoses and medications purchased were also significantly higher in the adenoid hypertrophy than in the control group but we did not find any significant difference in eosinophil counts or IgE levels between the two groups [Table 4].

In the present study, the diagnosis of adenoid hypertrophy was performed at a young age, with a mean age of 19.8 months and with 74% of the children under the age of 2 years. We have found a clear male preponderance in the A.H group. The increased morbidity in the adenoid hypertrophy group was not due to this male preponderance since all the morbidity parameters and the increase in purchased medications remained significant after adjusting for gender. This male preponderance of adenoid hypertrophy has been found in other studies in children [13,14], and adults [9], and the reason is unclear. In adults it has been suggested that it could be connected to more outdoor activities and exposure to pollutants.

Gastro-esophageal reflux has been widely implicated in the pathogenesis of adenoid hypertrophy. Niu et al. [5], performed a meta-analysis with a sample-size of 548 cases and found a strong correlation between adenoid hypertrophy and gastro-esophageal reflux with a pooled odd's ratio of 4.12. In our study, we did not find any significant difference in gastro-esophageal reflux diagnosis or in related treatments between the two groups.

In our previous study [10], we found that instructing mothers of 3 months-old infants to feed them with the infant head in an upward position led to less respiratory and ear morbidity and treatment. In the present study we could not find any significant

Table 4: Feeding position and chest X-rays results in adenoid hypertrophy group.		
Chest X-rays infiltrates	**Supine**	**Upward/semi-supine**
Normal	8	4
Right perihilar infiltrates	8	6
Left perihilar infiltrates	2	7
Bilateral perihilar infiltrates	85	23
Right upper lobe infiltrates	3	0
Left upper lobe infiltrates	1	0
Right middle lobe infiltrates	1	0
Right lower lobe infiltrates	7	1
Left lower lobe infiltrates	7	2
Hyperinflation bilateral	0	1
p=0.0113		

Table 5: General healthcare utilization, mean related morbidities, chest X-rays performed and medications purchased in 12 months breast-fed infants and in children fed regular formula.

Morbidity and treatment	Breast-fed 12m (n=30)	Regular formula (n=161)	p value
Primary physician visits	2.30	2.40	0.50
Emergency/hospitalization	0.30	0.50	0.60
Respiratory related morbidity	1.10	1.35	0.22
Allergy related morbidity	0.10	0.16	0.48
GER related morbidity	0.03	0.11	0.22
Chest X-rays performed	0.73	0.70	0.79
Antibiotics purchased	9.97	8.89	0.60
Inhaled steroids purchased	7.47	11.78	0.74
Systemic steroids purchased	11.70	13.67	0.13
Bronchodilators purchased	3.47	3.92	0.49

difference in the occurrence of otitis between the two groups and the reason is unclear.

The real cause of adenoid hypertrophy is unknown. From our study, we could not support the theory that GER or allergy play an important role in the pathogenesis of adenoid hypertrophy. Adenoid hypertrophy does not exist at birth, starts to appear in the second part of the first year of life, peaks at the ages of 2-4 years (when bottle feeding is still common), disappears after the age of 5-7 years and rarely occurs in adults (unless there is obstruction or an adjacent chronic infection). Mammal cubs are breast fed when their head is in an upward or downward (not backward) position. Bottle feeding of animals is performed with their head in an upright position. In humans, the newborn is not able to sit before the age of six months and mothers tend to feed them in a supine or semi-supine position. Most lactation consultants advise mothers to lie down for breastfeeding and the infants are fed in a horizontal position. This supine feeding position is also adopted for bottle-feeding and might unfortunately continue until the age of 2–4 years.

Adequate drainage of fluids from the middle ear and clearance of liquid food from the mouth is an important key in keeping proper hygiene. The position angle of the Eustachian tube is 25–45-degree angle in adults while in young children, it is almost horizontal, with an angle between 0-10 degrees [15]. Supine feeding position in young children, not only prevents adequate drainage of fluids from the middle ear to the throat, but liquid food (formula or breast milk) can enter by simple gravitation from the throat to the middle ear as was shown by Tully et al. [16], and illustrated in Figure 1. A prospective study with home tympanography every 2-4 weeks until the age of 2 years in a cohort of 698 healthy infants found that supine feeding position and early initiation of group child care were associated with earlier onset of otitis media with effusion [17].

In part of a prospective multiethnic multidisciplinary cohort study from fetal life onwards conducted in the Netherlands [18], prolonged breastfeeding (for >12 months) and nocturnal bottle-feeding were associated with increased occurrence of dental caries at the age of 6 years (OR 1.35 and 1.52, respectively), independent of family socioeconomic status, ethnic background or sugar intake. A meta-analysis article from Australia [19], showed a higher risk (OR 1.99) to develop dental caries in children breast-fed beyond 12 months and the pooled OR rose to 7.14 in the children with nocturnal bottle-feeding. We assume that in both studies, the children breast-fed for more than 12 months and the children with nocturnal bottle feeding were fed, at least during the night, in a supine position and the development of dental caries is just another evidence of the late consequences

of prolonged periods of impaired drainage of liquid food from the oral cavity and poor mouth hygiene.

In the present study we retrospectively analyzed the medical files of all the children with adenoid hypertrophy, including food type and parent reports of feeding position. The supine-fed children had significantly more bilateral infiltrates in chest X-rays than the children fed in an upward or semi-supine position [Table 4], suggesting recurrent aspirations of infected post-nasal drip secretions secondary to the adenoid obstruction. Although we could not find a significant correlation between the different feeding positions and the degrees of adenoid hypertrophy, the great majority (88.5%) of the children fed in a semi-supine or supine position had moderate to severe adenoid hypertrophy.

We tried to evaluate if breast feeding for the whole first year of life induced any attenuation effect on the morbidity related to adenoid hypertrophy. We therefore compared two groups of children with adenoid hypertrophy, 30 that were only breast-fed for 12 months and 161 children fed regular formula. There was no significant difference in morbidity, amount of chest X-rays performed or in the quantitative use of bronchodilators, antibiotics or steroids between these two groups [Table 5].

Our study has several limitations. No data were collected on feeding position in the control group and there is a difficulty in obtaining the actual feeding position of the children at home, especially during nights.

In summary, adenoid hypertrophy in the first few years of life is a medical burden to the families and to medical organizations. Its pathogenesis is unclear, and we need more studies, especially prospective studies, to reinforce the theory connecting direct effect of supine feeding position to the development of adenoid hypertrophy. Not all newborns fed in a supine position will develop adenoid hypertrophy but, in our study, the vast majority of the children with moderate to severe adenoid hypertrophy had a history of supine or semi-supine feeding position in the first year of life. Instructing parents to feed newborns and young children with their head in an upright instead of a horizontal position could be a simple behavioral intervention to try to reduce the development of adenoid hypertrophy.

DATA AVAILABILITY

The data that support the findings of this study are available from Clalit Health Services but restrictions apply to the availability of these data, which were used under license for the current study, and so are not publicly available. Data are however available from the first author (Avraham Avital) upon reasonable request and with permission of Clalit Health Services. All data will be de-identified before transfer.

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