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REVIEW ARTICLE

Oral health in pre-school children with asthma – followed from 3 to 6 years

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Objective. The aim of this study was to investigate caries and its determinants in preschool children with and without asthma, followed from 3 to 6 years.

Methods and subjects. Caries, plaque, and gingivitis were examined at 3 and 6 years of age in 64 asthmatic children and 50 matched, healthy control children. Furthermore, at 6 years radiographic examination and saliva sampling were conducted. The parents were interviewed about various oral health-related factors.

Results. Initial caries increment between 3 and 6 years of age was statistically significant higher for children with asthma compared with children without asthma ($P < 0.05$). Asthmatic children had more bleeding gingivitis and a higher consumption of sugary drinks than healthy children at 3 years of age ($P < 0.05$). At both 3 and 6 years of age, the asthmatic children were more frequently mouth breathers than healthy children, only statistically significant for 6-year olds ($P < 0.05$).

Conclusion. Preschool children with asthma at 3 years of age run a higher risk of developing caries lesions until 6 years of age compared with children without asthma. Children with asthma have a higher prevalence of bleeding gingivitis, a higher intake of sugary drinks and are more frequently mouth breathers than preschool children without asthma.

Introduction

Asthma is a chronic inflammatory disorder of the airways, characterised by episodic and reversible symptoms of airflow obstruction[1]. It has become one of the most common conditions during childhood and has been increasing throughout the world during the last few decades[2]. Among Swedish preschool children, approximately 10% are affected by asthma symptoms, whereas the figure for children under the age of 2 is approximately 20%[3]. Considering that asthma is such a common disorder among preschool children, only a limited number of studies have investigated the effect of asthma and its treatment on the oral environment. Previous attempts have produced conflicting results, as some authors have reported an association between asthma and oral health in preschool children[4–7], whereas others have found no such connection[8–11].

Possible reasons for the inconsistent and different results could be that the majority of studies have a cross-sectional design, small samples, incoherent age groups, or differences in terms of medication and the severity of the asthma disease. When it comes to investigating oral health in asthmatic preschool children, a longitudinal approach has advantages. A defined group of children followed for some years may facilitate analyses of the interaction between disease pattern, medication, dietary habits, and oral health. The aims of this study were therefore to follow a group

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of asthmatic and nonasthmatic children from 3 to 6 years of age and, to investigate caries incidence and caries-associated factors in preschool children with and without asthma and to investigate whether factors connected with the asthma disease trigger caries development in preschool children.

Subjects and methods

The study was approved by the Ethics Committee at Linköping University, Sweden, and informed consent was given by the parents or caregivers before the children were examined at both 3 and 6 years of age. This prospective cohort case–control study is based on dental examinations, saliva samples, and interviews in children both with and without asthma.

Participants

At 3 years of age, 70 children with asthma were invited to participate in the study. They were selected from the Department of Paediatrics at the County Hospital, Ryhov, Jönköping, Sweden, and from three child welfare centres in the Municipality of Jönköping and they comprised all 3-year olds with asthma born between April 2001 and January 2002. Furthermore, a control group, consisting of 70 age- and gender-matched children, without a diagnosis of asthma or other known diseases (confirmed by the parents), was selected from the County Council's register of persons residing in the Municipality of Jönköping. All the children in the study came from geographical areas with a high socioeconomic profile. At 6 years of age, the asthma group included only children diagnosed as having asthma at 3 years of age. At 3 years of age, four children in the asthma group and eight in the control group dropped out of the study. At the examination at 6 years of age, another two children in the asthma group and 12 in the control group did not participate. The main reasons for dropping out at both 3 and 6 years of age were moving out of the area or unwillingness to participate. One child in the control group developed asthma during the follow-up period and was therefore excluded. As a result, 64 children in the asthma group and 50 in the control group were examined at both 3 and 6 years of age. At the two dental examinations, the children (n = 114) were 3 years ± 2 months and 6 years ± 2 months, similar in the two groups. The number of girls/boys in the asthma group was 16/48, whereas it was 13/37 in the control group. Despite the drop-outs, the same ratio was preserved (0.25/0.75) in both groups.

Of the 114 participants, 18 children in the asthma group and 22 in the nonasthmatic group had an immigrant background, defined as at least one parent born outside the Nordic countries.

Preventive oral health programme

In the County of Jönköping, all children are invited to participate in a basic dental preventive programme, starting at 1 year of age. It includes information about preventive measures and the parents are recommended to brush their children's teeth twice a day with a fluoride toothpaste. For children with special needs, such as a high caries risk, chronic disease or mental, or physical disabilities, intensified preventive programmes are designed individually.

Asthmatic children

At both 3 and 6 years of age, a senior paediatrician divided the asthmatic children into four groups (*mild*, *moderate*, *severe* and *very severe*), according to the classification of severity of asthma symptoms in the Swedish guidelines on the management of asthma (Swedish Paediatric Society, Section of Paediatric Allergy). At 3 years of age, the children were divided into three groups according to the debut of the disease: <1, 1–2, and >2 years of age, respectively. According to the length of exposure to asthma drugs, the 6-year olds were divided into four groups: exposed for <2, 2–3, >3–5 years, respectively, and children exposed for > 5 years. Furthermore, according to the regularity of inhaled steroid medication, the children were divided into two groups: intermittent use in periods of ≥ 1 time/day and regular daily use ≥ 1 time/day.

Methods

Clinical examination

All the children were examined at 3 and 6 years of age by one of the authors (M.S) at the children's ordinary public dental service clinics (n = 10). Before the start of the examinations and during the study, the examiner was repeatedly calibrated against an experienced dentist in terms of the diagnostic criteria. A more detailed description of the clinical and radiographic examinations, interviews, saliva samplings, and diagnoses of the asthma disease has been given previously[6].

Caries. Caries data were given as defs (decayed, extracted, and filled tooth surfaces). Initial caries was defined as initial loss of tooth surface appearing as chalky spots in the enamel surface layer without breakdown of the surface in the form of cavitation when explored with the probe. Manifest caries was defined as loss of tooth substance having reached the stage of cavitation that can be diagnosed with certainty by clinical examination with mirror and explorer after drying with air, not having the character of erosion or hypoplasia, and appearing on a tooth surface not earlier restored; pits and fissures, not earlier restored, where the probe with a little pressure sticks without doubt and requires a definite pull for removal[12]. In order to avoid interference with exfoliated teeth, initial and manifest caries was only diagnosed on primary molars and canines at 6 years of age.

Oral hygiene. Gingival inflammation was diagnosed as ''bleeding'' or ''no bleeding'' in all primary molars after gentle probing, according to criteria suggested by Lőe and Silness[13]. The presence of visible plaque was recorded on all primary molars after drying the teeth with compressed air corresponding to Plaque Indices 2 and 3 according to Silness and Lőe[14].

Radiographic examination

Two posterior bitewings were taken in the 6-year olds. Initial proximal caries was defined as a caries lesion in the enamel that has not reached the enamel–dentine junction or a lesion that reaches or penetrates the enamel–dentine junction but does not appear to extend into the dentine. Manifest proximal caries was defined as 'a caries lesion that clearly extends into the dentine[15]. The radiographs were analysed separately by two of the authors, where one of the examiners was not aware of the group to which the child belonged. In the event of disagreement, the findings from the bitewings were discussed until consensus was reached.

Saliva sampling

At 6 years of age, a paraffin-stimulated whole saliva sample was collected. The number of colony forming units (CFU) of mutans streptococci was counted on the MSB agar and identified by their characteristic colony morphology. All CFU in SL agar were considered to be lactobacilli. The number of CFU was transformed to logarithms before the statistical analysis. The detection level of microorganisms was 200 CFU/mL.

Interview

In connection with the clinical examination, a parental semi-structured interview was performed; it included questions about prior and current medication, mode of administration and duration of asthma medication, toothbrushing habits, use of fluorides, mouth breathing and dietary habits (number of daily intakes of caries-risk products). The intake frequency of each risk product was registered and calculated according to Wendt and Birkhed[16].

Statistical analysis

The data were analysed using SAS software ver. 9.1.3 (Copyright, SAS Institute Inc., Cary, NC, USA), Statistica ver. 8, (Copyright Stat Soft, Inc., Tulsa, Oklahoma, USA, 2008) and SPSS ver. 16.0 (SPSS Inc., Chicago, IL, USA). χ^2 tests were used to test the association between caries as dependent variable with categorical independent variables. Mann–Whitney U-tests were used for continuous dependent variables. Univariate and multivariate

logistic regression analyses were performed to explore the effects on caries (as dependent variable) with variables with relevance to oral health (explanatory variables), such as early childhood caries, dietary habits, and presence of plaque, bleeding on probing (gingivitis) and mouth breathing, as well as the asthma disease, the debut of the disease and the period of exposure to medication. In the uni and multivariate analysis the different levels of defs were coded as 0, 1, 2, 3, and 4. Normally odds ratio for the first level is presented, in this paper we present odds ratio for each level of defs. To decide if a variable should be included in the multivariate analysis in this study was a significance level of $P < 0.2$. Some of the confidence interval is wide, as there are few children in that subgroup. Results for some continuous variables are presented as mean ± SD. The level of statistical significance was set at $P < 0.05$.

Results

Caries

At 3 years of age, children in the asthmatic group had statistically significantly more carious lesions compared with children in the nonasthmatic group ($P < 0.05$; Table 1). During the follow-up period, the number of children with caries increased from 29% to 61% in the asthmatic group and from 16% to 36% in the nonasthmatic group ($P < 0.05$). At 3 years of age, 9% of the asthmatic children had six or more caries lesions compared with no child in the nonasthmatic group ($P < 0.05$; Table 2). The corresponding figures at 6 years of age were 17% and 8%, respectively ($P < 0.05$). All the children with manifest proximal caries lesions in molars at 3 years of age were affected by the asthma disease. These children all had six or more caries lesions at 6 years of age.

Oral hygiene. All children were using fluoride dentifrices and there were no statistical significant difference in the frequency of tooth brushing or in oral hygiene habits between asthmatic and nonasthmatic children, at 3 or at 6 years of age. At both ages, children in the asthmatic group had more surfaces with bleeding gingivitis than children without asthma, although this was only statistically significant for the 3-year olds ($P < 0.01$; Table 2).

Dietary habits. At 3 and 6 years of age, 36% and 72%, respectively, of the children in the asthmatic group consumed sugary drinks > 1 time/day compared with 16% and 58% in the nonasthmatic group (only significant at 3 years of age; Table 2).

Mouth breathing. Mouth breathing was reported more frequently in children with asthma compared with their controls at both 3 ($P < 0.05$) and 6 years of age ($P < 0.001$; Table 2).

Immigrant status. At 3 years of age, children with asthma and an immigrant background had a mean of 2.0 ± 2.8 defs compared with 0.3 ± 0.7 for the nonasthmatic children with an immigrant background ($P < 0.01$). The corresponding figures at 6 years were 4.6 ± 6.2 *vs* 2.6 ± 4.5 (NS).

Microbiological factors. One child in the asthma group and six in the control group did not cooperate during the saliva sampling. Mutans

Table 1. Mean defs (SD) in primary canines and molars in children with and without asthma at 3 years of age followed to 6 years of age.

	Asthma group (n = 64)			Control group (n = 50)		
Lesions	**Baseline 3 years**	**Follow-up 6 years**	**Increment**	**Baseline 3 years**	**Follow-up 6 years**	**Increment**
Initial lesions	0.2 (0.5)*	1.5 (1.8)	1.3 (1.7)	0.04 (0.3)	0.7 (1.7)	0.7 (1.6)
Manifest lesions	0.1 (0.5)	1.3 (3.4)	1.2 (3.2)	0.0 (0.0)	1.1 (3.2)	1.1 (3.2)
Total	0.3 (0.9)	2.8 (4.4)*	2.5 (3.5)	0.04 (0.3)	1.8 (3.2)	1.8 (3.7)

* $P < 0.05$

Table 2. Caries-related factors in children with and without asthma at 3 years of age followed to 6 years of age.

	3 years old*			6 years old**		
	Asthma (*n* = 64) %	Control (*n* = 50) %	*P*-value	Asthma (*n* = 64) %	Control (*n* = 50) %	*P*-value
Sugary drinks > 1 times/day	36	16	0.02	72	58	0.16
Visible Plaque > 4 surfaces	23	22	0.9	69	52	0.12
Gingivitis (bleeding)	14	0	0.005	13	4	0.18
Mouth breathing (frequently)	24	10	0.05	53	16	0.0
defs ≥ 6	9	0	0.03	17	8	0.016
defs ≥ 10	3	0	0.03	8	4	0.04

*Caries in all primary teeth.
**Caries in primary molars and canines.

streptococci were detected in 32% of the children in the asthmatic group and in 40% of the children in the nonasthmatic group (NS). The corresponding figures for lactobacilli were 37% and 23%, respectively (NS).

Multiple logistic regression analyses. The results of the multiple logistic regression analyses for different explanatory variables are presented in Table 3. Some of the high odds ratios and the wide confidence intervals is because there are very few children in some of the classified groups (i.e., defs > 6–8 and 9). The intake of sugary drinks at 3 years of age showed a statistically significant increase in the risk of caries development between 3 and 6 years of age ($P < 0.01$).

Medication and severity of the asthma disease. Of the children with asthma at 3 years of age, 63% had no medication at 6 years. According to the classification, the majority of children had mild to moderate asthma at 6 years of age. One child, who had been diagnosed as having very severe asthma at 3 years, was in remission at 6 years of age. Concerning the length of medication and the severity of the asthma disease, no statistically significant correlation was found.

Discussion

This study showed an association between the asthma disease at 3 years of age and caries development up to 6 years of age. A more important finding is, however, that the asthma disease appears to trigger caries development and causes a more serious caries situation. At both 3 and 6 years, statistically significantly more asthmatic children had six or more caries lesions compared with nonasthmatic children. Furthermore, all the children with proximal caries lesions in molars at 3 years of age belonged to the asthmatic group.

The severity and the medication of the asthma disease often fluctuate over time. This contributes to the difficulty involved in correctly diagnosing asthma in small children. Martinez *et al.*[17] found that asthma symptoms during the first 3 years of life had a benign prognosis and that many of these children were without asthma symptoms at 6 years of age. This is in line with the results of this study, where 63% of the children, diagnosed as having asthma and exposed to medication at 3 years, had no asthma symptoms at 6 years of age. Even if the majority of the asthmatic children had recovered from the disease, there was a difference in caries prevalence at 6 years of age between children with and without asthma at 3 years of age, especially in terms of initial carious lesions. As the caries disease often progresses slowly, this may indicate that very young children with asthma run a high risk of developing manifest carious lesions in the future. More studies of asthmatic schoolchildren and adolescents, with asthma at an early stage, are therefore needed.

Contrary to other studies that have investigated caries prevalence in relation to asthma disease[18,19], this study was not able to show any differences in the number of cariogenic bacteria in asthmatic and nonasthmatic

Table 3. Logistic regression analyses.

Independent variables at 3 years of age	All children (*n* = 114)						Asthma (*n* = 64)						Control (*n* = 50)					
	Univariate			Multivariate			Univariate			Multivariate			Univariate			Multivariate		
	OR	CI	P	OR	CI	P	OR	CI	P	OR	CI	P	OR	CI	P	OR	CI	P
Asthma	1.8	0.4–7.6	0.4	1.7	0.4–7.9	0.46												
Sugary drinks > 1 times/day	0.9	0.4–1.9	0.7	3.9	1.6–9.9	0.003	0.7	0.2–2.1	0.5				0.7	0.2–0.4	0.6			
Visible plaque	1.6	0.7–3.9	0.3				2.1	0.6–8.3	0.3				1.1	0.3–4.5	0.9			
Gingivitis	0.8	0.2–3.3	0.8				0.5	0.1–1.9	0.3									
Mouth breathing	2.2	0.8–6.3	0.1	1.6	0.5–5.7	0.44	2.1	0.6–8.7	0.3				1.3	0.2–8.9	0.8			
Immigrant	1.2	0.5–2.6	0.7				1.5	0.5–4.8	0.5				1.4	0.4–0.45	0.6			
Caries experience	1.7	1.1–2.6	0.007															
defs = 0	1.0		0.04	1.0		0.12	1.0		0.09	1.0		0.1	1.0		0.8	1.0		0.7
defs = 1–2	2.1	1.1–4.7		2.0	0.9–5.3		2.2	0.90–6.4		2.3	0.9–7.7	0.1	1.2	0.2–5.6		1.5	0.2–7.7	
defs = 3–5	4.6	1.2–22.0		4.0	0.8–27.7		4.8	0.86–40.9		5.2	0.9–59.1	0.1	1.4	0.05–31.7		2.1	0.1–59.0	
defs = 6–8	9.8	1.3–103.5		8.1	0.7–146.3		10.5	0.84–261.4		12.0	0.8–454.7	0.1	1.7	0.01–179.0		3.0	0.02–453.6	
defs = ≥ 9	20.9	1.4–485.9		16.2	0.6–771.0		23.0	0.80–999.9		27.5	0.7–999.9	0.1	2.1	0.002–999.9		4.4	0.00–999.9	

CI, 95% confidence interval; OR, odds ratio; *P*, *P*-value.
Independent variables at 3 years of age in relation to caries (dependent variable) at 6 years of age in children with and without asthma.

preschool children. One reason for the low prevalence of mutans streptococci and lactobacilli could be that all the participating children came from geographical areas with a high socioeconomic profile and therefore had a lower caries prevalence than a random sample of preschool children from the Municipality of Jönköping[20]. Although this, children with asthma at 3 years of age develop more caries lesions than children without asthma at 3 years of age. This strengthens the validity of the study results.

One increasing problem in child populations today is the skewed distribution of caries lesions. If the caries prevalence is low, as it is in this study, this problem is accentuated[19]. Despite this problem, this study indicates an association between asthma disease and caries prevalence in preschool children. This is in line with another longitudinal study[21] that reported more extractions and fillings in asthmatic preschool children compared with healthy children. One factor that could contribute to this is that frequent mouth breathing was more common in asthmatic children compared with nonasthmatic children. This is in line with other studies[22,23]. Nascimento *et al.*[23], for example, found that mouth breathers ran a higher risk of developing carious lesions than nose breathers. Furthermore, the asthmatic children in this study had a higher intake of sugary drinks than their healthy controls. Thus, it is important to underline that potential confounders as mouth breathing and higher intake of sugary drinks could explain the higher caries prevalence in the asthmatic children compared with the nonasthmatic children and not the asthma disease as such. Although, it is reasonable to presume that the asthma disease contribute to the more frequent mouthbreathing habits and the higher consumption of sugary drinks found in the asthmatic children in this study.

In conclusion, preschool children with asthma have a higher caries incidence, a higher prevalence of bleeding gingivitis, a higher intake of sugary drinks, and are more frequently mouth breathers than preschool children without asthma. Preschool children with asthma therefore require special attention

from both medical and dental personnel and individually designed preventive programmes should be developed, especially for asthmatic children who already have carious lesions at 3 years of age.

Conclusions

The results of this follow-up study show that:

Preschool children with asthma have a higher caries prevalence than healthy children, although the oral hygiene regiments and fluoride exposure were the same in both children with and without asthma.

The asthma disease *per se* does not cause caries, but in preschool children with asthma more frequent mouth breathing and higher consumption of sugary drinks were found, which in turn triggers the caries development and causes a more serious caries disease.

Asthma, the intake of sugar-containing drinks > 1 time/day and caries prevalence at 3 years of age were the strongest predictors of developing further carious lesions until 6 years of age.

What this paper adds

- This paper indicates that preschool children with asthma at 3 years of age run a higher risk of developing caries lesions until the age of 6 years compared with children without asthma.

Why this paper is important to paediatric dentists

- This study points the importance of developing preventive dental programmes for preschool children with asthma, for their parents and for medical and dental caregivers.

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