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Research Article

Middle ear problems in children with cleft palate: A cross-sectional study

Abstract

Background: Cleft lip and/or palate is the most common congenital craniofacial anomaly. Otitis media with effusion is almost universally present in young children with a cleft palate. OME results in a conductive hearing loss and -if persistent- often requires the placement of ventilation tubes or adjustment of hearing aids in selected cases. Also, a higher incidence of middle ear sequelae e.g. tympanic membrane perforation, chronic otitis media with or without cholesteatoma is reported in the cleft palate population.

Objective: To determine the prevalence of middle ear problems in different age categories of children with cleft palate and to determine factors that may influence the middle ear status.

Material and methods: Data for this cross-sectional study were obtained from the patient files of cleft palate children visiting the craniofacial team of the Ghent University Hospital, Belgium, between May 2016 and April 2017.

Results: In total, 166 children, aged up to 18 years old, were enrolled; 58 had a cleft palate, 108 a cleft lip and palate. The presence of otitis media with effusion or ventilation tubes was very common [62%] in children aged below 6 years old. After the age of 6 years old, the prevalence of otitis media with effusion and or need for ventilation tubes progressively decreased, but is still present in 13.3% of the 9-18-year olds. In our patient group 22,2% had developed myringosclerosis, an atrophic and/or retracted/atelectatic tympanic membrane, 5,4% a tympanic membrane perforation and 3,6% a cholesteatoma. These middle ear sequelae or complications mainly emerged after the age of 6 years old. Gender, presence of an associated cleft syndrome, severity of the cleft, early placement of ventilation tubes during palatoplasty and the type of VT did not independently affect the middle ear status nor the risk on middle ear sequelae or complications.

Conclusion: Otitis media with effusion remains an important concern in children with cleft palate and is most prevalent under the age of 6 years old, which is crucial in the development of speech and language skills. A significant number of cleft children develop middle ear sequelae or complications at a later age. Therefore, we suggest a standardised otological follow-up for these patients up until the age of 18 years and preferably lifelong in case of otological manifestations. Additional research remains necessary to detect risk factors of adverse ear and hearing outcome in this vulnerable population.

Introduction

Cleft lip and/or palate is the one of most common birth defects [1]. The incidence varies between 1 and 1.82 among 1000 new-borns, varying with geographic and ethnic background [2]. Cleft patients are generally divided into three main categories: those with a cleft palate [CP], a cleft lip [CL] and a cleft lip and palate [CLP], all of which can occur isolated or as part of a craniofacial syndrome [3]. Due to the orofacial cleft, multiple problems can arise with feeding, dental development, speech development, appearance and psychological well-being, making cleft children a vulnerable population that requires specialised care on these different levels [4].

Children with a cleft palate are prone to developing middle ear problems, especially otitis media with effusion [OME] [5]. The most important factor in the pathogenesis of otitis media is the anatomical malformation of the paratubal muscles, which compromise the strength of the tensor veli palatini muscle, causing repetitive failure to open the Eustachian tube and ventilate the middle ear cavity. [6]. As a result, middle ear pressure declines and local secretions accumulate leading to OME [7,8].

By the age of two, more than 95% of the cleft palate children will experience at least 1 episode of OME [9,10]. Furthermore, the rate of spontaneous clearing of fluid is decreased, and middle ear problems tend to be more severe and persist longer

[7]. Where the incidence of OME rapidly declines after the age of six in the general population, cleft palate children show an impaired clearance that may prolong until the age of 12 [11]. This increased incidence and duration of OME consequently enhances the risk of developing OME sequelae. The prolonged presence of fluid in the middle ear combined with negative pressure may damage the structure of the tympanic membrane causing local atrophy and retraction, a situation favourable for the development of cholesteatoma [12,13]. As many children with cleft palate have persistent OME, a large proportion receive ventilation tubes [VT], the primary goal is to restore hearing in this already at-risk population for speech and language development. However, also the placement of ventilation tubes increases the risk of developing a permanent perforation and possibly chronic otitis media, especially in children undergoing repeated VT insertions and when using long-term tubes [14,15].

As a result, cleft palate patients are advised to have a regular ear examination. Once OME has been detected an active observation period of three months is recommended. If the fluid remains present after three months, ventilation tubes are placed. However, therapy of OME is debatable and depends on the individual context. If the OME causes significant hearing loss and the child already suffers from language and speech delay, earlier intervention may be recommended. Existing data support both an aggressive approach with early - even prophylactic-placement of ventilation tubes as well as a conservative in which the hearing loss is carefully assessed, the so-called 'watchful waiting' and/or hearing aids can be used if necessary [9,16-19].

This cross-sectional cohort study aims to provide a clear overview of middle ear problems in children with a cleft palate in our tertiary care hospital. We focus on the incidence of middle ear problems in the different age groups of children and adolescents with cleft palate, critically appraise the current treatment and try to identify risk factors for prolonged middle ear problems and possible sequels and complications in this heterogeneous patient population.

Material and Methods

Patients and procedures

Data for this cross-sectional study were obtained from the patient files of cleft palate children visiting the craniofacial team of the Ghent University Hospital, Belgium, between May 2016 and April 2017.

The study was reviewed and approved by the Ethical Committee of Ghent University Hospital [EC approval number 2016/0885].

An information letter with an opting out form was presented to [the parents of] all patients, aged 0-18 years old, at the time of their visit to the tertiary multidisciplinary craniofacial team. Children with a cleft palate, with or without cleft lip were eligible for inclusion. Where applicable, data from otorhinolaryngologic care that was provided in another hospital was retrieved, only after explicit approval of the patient and his/her caregivers. A

total of 170 patients matched the inclusion criteria, 4 declined to participate and finally 166 were registered in the database. All data were processed anonymously.

Statistical analysis

Statistical analysis was performed using SPSS 25 [IBM Corp, New York, USA] statistic data editor. Descriptive statistics are presented by frequency tables. Kolmogorov-Smirnov tests were performed on continuous variables to determine if they showed a parametrical distribution. Levene's test was conducted to evaluate the variances between independent samples. Parametrical continuous variables with equal variances were compared using the unpaired Student's T-test, parametrical without equal variances using the Welch's t-test and non-parametrical using the Mann-Whitney U test. Categorical variables were analysed using the Chi-squared or Fisher's Exact test. When comparing continuous variables between more than two groups, ANOVA was used for parametric variables, and the Kruskal-Wallis test was used for non-parametric variables. Statistical significance was set at $p < 0.05$.

Results

Patient characteristics

Of the 166 children included, 58 were diagnosed with cleft palate [CP] and 108 with cleft lip and palate [CLP]. Thirteen of the patients with a CLP had an associated syndrome, mainly Van Der Woude syndrome [4 patients] or Branchio-Oculo-Facial syndrome [3 patients]. Twenty-four patients with a CP had an associated syndrome of sequence, mainly Pierre Robin Sequence [11 patients], Van Der Woude syndrome [3 patients] or Stickler syndrome [2 patients]. 154 had already undergone palatoplasty, the remaining 12 were still too young. Demographic and otological characteristics are given in Table 1.

An abnormal otological status at the time of inclusion was found in 79 C[L]P children [47.5%]. This included the presence of a ventilation tube [VT], persistent perforation of the tympanic membrane, cholesteatoma, acute otitis media [AOM], otitis media with effusion [OME] or a history of middle ear surgery [tympanoplasty/ mastoidectomy] in one or both ears.

Middle ear problems for the different age categories

A description of the actual middle ear status depending for the different age categories are listed in Table 2. Oscopic findings of OME or presence of ventilation tubes were combined.

Ventilation tube insertions

126 of the total group of 166 C[L]P children had undergone VT placement [75.9%]. In the group of children <2 years old, 60% had already undergone VT placement. The average number of surgical procedures was 2.20 [± 2.25] in the whole study population. The mean age for the first grommet insertion was 2.23 [± 1.90] years old, 4.04 [± 2.23] years for the first intermediate tube placement and 5.82 [± 3.31] years for the

first long-term tube. Regular grommets were present in 9,6% of the patients, Intermediate tubes [Duravent®] in 11,4% of the patients and long-term tubes [T-Tubes®] in 3,6% of the patients at the time of inclusion.

Table 3 demonstrates the relationship between the frequency of otologic sequelae or complications and the number of VT placement procedures. There is a significant association with the number of VTs and tympanosclerosis. Those who do

Table 1: General characteristics of the study population. Values are given as a number of patients (%) or mean ± SD (min-max). VT= ventilation tube, OME= otitis media with effusion, AOM= acute otitis media. * in one or both ears.

Gender (male/female)	97 (58.4%) / 69 (41.6%)
Age (years)	9.2 ±5.2 (0.1-18.0)
• 0 - <2 years	21 (12,5%)
• 2 - < 6 years	30 (17,8%)
• 6 - < 9 years	36 (21,4%)
• 9 - < 12 years	24 (14,2%)
• 12 - < 15 years	25 (14,8%)
• 15 - < 18 years	32 (19%)
Palatoplasty	154 (92.8%)
Previous middle ear surgery*	
• VT placement	126 (75.9%)
• Tympanoplasty	9 (5.4%)
• Mastoidectomy	6 (3.6%)
Average number of VT surgery	2.20 ±2.3 (0-11)
Otososcopic characteristics *	
• Ventilation tubes	42 (25.3%)
• OME	17 (10.2%)
• Perforation	10 (6.0%)
• Atrophy/retraction/sclerosis	37 (22.3%)
• AOM	3 (1.8%)
Abnormal middle ear status	79 (47.6%)

Table 2: Middle ear problems related to the age of the child in C(L)P patients. Values are given as a number of patients (%). Yo= years old, VT= ventilation tube, OME= otitis media with effusion, AOM= acute otitis media. * in one or both ears.

	0- <2 yo (n=20)	2- <6 yo (n=30)	6- <9 yo (n=37)	9- <12 yo (n=24)	12- <15 yo (n=24)	15-18 yo (n=31)
Previous middle ear surgery						
• Tympanoplasty	0	1 (3.3)	2 (5.4)	2 (8.3)	2 (8.2)	2 (6.5)
• Mastoidectomy	0	0	0	1 (4.2)	2 (8.2)	3 (9.7)
• Ventilation tubes	12 (60.0)	26 (86.7)	29 (78.4)	19 (79.2)	20 (83.3)	20 (64.5)
Otososcopic findings*						
• VT/OME	11 (55.0)	20 (66.7)	11 (29.7)	4 (16.7)	4 (16.7)	2 (6.5)
• AOM	1 (5.0)	0	0	1 (4.2)	1 (4.2)	0
• Perforation	0	0	3 (8.1)	1 (4.2)	3 (12.5)	3 (9.7)
• Atrophy/atelectasis/Sclerosis	0	3 (10.0)	14 (37.8)	5 (20.8)	8 (33.3)	7 (22.5)

Table 3: Relationship between the number of VT placements and otoscopic evaluation. Values are given as a number of patients (%). VT= ventilation tube, TM= tympanic membrane, AOM= acute otitis media. Average ages of this population: 0 VT: 1,2 years old; 1-4 VT: 4,4 years old; >4 VT: 12,3 years old.

	0 VT (%)	1-4 VT (%)	> 4 VT (%)	Sign.
perforation of the TM	0.0	5.8	9.8	.4
Tympanosclerosis	0.0	17.4	24.6	.01 *
Atrophy	0.0	2.9	6.2	.05*
retraction/atelectasis of the TM	7.3	2.9	15.6	.02 *
acute otitis media	0.0	2.9	2.1	1.0

not have VTs also do not have tympanosclerosis. Those who had more than 4 VTs are significantly more likely to contract tympanosclerosis than children with fewer VTs. There is a similar relationship with atrophy. Those who have more than 4 VTs are even more likely to develop atrophy. This also applies to the retraction of the tympanic membrane; in contrary, there are more retractions in children without VTs than in children with 1-4 VTs.

Middle ear and mastoid surgery

Fifteen children underwent previous tympanoplasty or mastoidectomy surgery. Two patients had a tympanoplasty at both ears, and one patient had a mastoidectomy at both ears, making the total number of middle ear and mastoid operations 18. All tympanoplasty operations were performed to repair a permanent perforation [n=11]. These children had all received ventilation tubes in the past to treat OME. Reasons to perform a mastoidectomy included a pars tensa cholesteatoma [n=4], a pars flaccida cholesteatoma [n=2] and an acute mastoiditis [n=1]. Mean age for both types of surgery was 9 years of age for a mastoidectomy and 9,4 years of age for a tympanoplasty, with the youngest patient being four years and the oldest 18 years old. Other characteristics of this patient group are listed in table 4.

Determinants for middle ear complications

Characteristics of C(L)P children with, were compared to those without a middle ear complication. As complications typically occur at an older age, only children aged 6-18 years old were included in this analysis [n=116]. Long-term complications included a present tympanic perforation, cholesteatoma or a history of tympanoplasty or mastoidectomy.

Higher age was, through binary logistic regression analysis, a significant and independent risk factor [P<0.030] with risk for having had a tympanoplasty or a mastoidectomy surgery, corrected for gender, craniofacial syndrome, higher Veau-index, presence of glue during palatoplasty and the age of the performed palatoplasty. Neither the severity of the cleft, the presence of craniofacial syndrome, type of ventilation tube, timing of the placement nor the otological status during palatoplasty proved to be significant. All categorical risk factors were compared to the middle ear outcome with a Chi-square test in which the middle ear outcome was considered the independent variable.

Table 4: Characteristics of children receiving tympanoplasty/mastoidectomy. Value are given as number (%), mean (\pm SD). *0.67(\pm 1.15) in pars tensa cholesteatoma and 1.33 (\pm 1.52) in pars flaccida cholesteatoma.

	Tympanoplasty (n=11)	Mastoidectomy (n=7)
Male/female	6 (55.5) /5 (45.5)	5 (71.4) /2 (28.6)
CLP/CP	9 (81.8) /2 (18.2)	4 (57.1) /3 (42.9)
Age at time of surgery	9.43 (\pm 2.49) (4.2-13.0)	9.00 (\pm 2.90) (4.7-13.9)
Previous number of ventilation tubes	2.45 (\pm 1.51)	1.14 (\pm 1.21) *

Discussion

Cleft lip and/or palate is a complex condition that includes a broad spectrum of phenotypes. Patients are generally divided into three groups according to the clinical features of the cleft: cleft lip [CL], cleft palate [CP] and cleft lip and palate [CLP]. The last two groups are prone to middle ear problems, especially chronic otitis media with effusion, due to malfunction of the Eustachian tube [4]. In C[LP] patients, the prevalence of ventilation tubes varies from 60 to 85%, while the prevalence in non-cleft children till 6 years fluctuates around 10% [5,20,21]. Middle ear problems related to the impaired clearance of middle ear fluid occur most often in toddlers when the Eustachian tube is still immature and has a more horizontal angle [22]. In this cross-sectional analysis, otologic findings and history of a large group of C[LP] patients up to 18 years was collected.

The highest incidence of OME and ventilation tubes in our patient population occurred in the age group <6 years old with a point prevalence of 66.7%. The presence of tympanic tubes at the ages above 6 is a rare finding in the general population, and the estimated prevalence is lower than 3% [23]. Contrary, in our population of children of 6 years old and older and even up to 18 years old 18% still had OME or VT in place. The intrinsic malfunction of the Eustachian tube does not only increase the prevalence of OME, but it also results in a more extended period of middle ear inflammation, hence increasing the risk of middle ear sequels and complications even more.

Intermediate or long-term tubes are a known risk factor for developing tympanic membrane perforation. According to Boston et al., the rate of permanent perforations after expulsion rises from 2.0% in short-term tubes to 4.2% in intermediate and 9.6% in long-term tubes [24], making both types of tubes a considerable factor when examining middle ear problems in cleft patients. There is also a higher risk in repetitive placement.

Episodes of negative ear pressure and middle ear inflammation can result in middle ear and tympanic sequelae such as tympanosclerosis, atrophy and atelectasis [25]. Around 8% of the non-cleft children aged between five and fourteen are diagnosed with one of these sequelae upon middle ear examination [26]. Due to the increased incidence and prolonged duration of OME in cleft children, this percentage had a three-fold increase [29.3%] in our population.

Middle ear sequelae that are likely to harm hearing, tympanic perforation and cholesteatoma, were seen in 25 of

our 166 children [15%]. Ten [6.0%] children had a perforation at the moment of examination; fifteen had a history of middle ear surgery [nine [5.4%] had a tympanoplasty and six [3.6%] a mastoidectomy]. As our study is a cross-sectional analysis and our youngest patients are still at risk to develop these complications in the future, the actual proportion of C[LP] children that will develop middle ear sequels is expected to be even higher. Compared to the general paediatric population, where the prevalence is respectively 0.4% for a tympanic membrane perforation and 0.2% for a mastoidectomy [13,27], this is a significantly increased risk in this subset of patients. Finally, we aimed to determine the risk factors of developing middle ear complications in C[LP] patients. Patient characteristics are often described as a predictor in examining the risk of middle ear complications. Studies have been able to establish a link between the severity of the cleft, type of ventilation tube placed, placement of ventilation tubes during the palatoplasty and the incidence of middle ear problems. As the male gender is linked to both a higher incidence of otitis media and to more severe forms of palatal clefting, it has also been described as a significant factor [4,28-30]. The results of our study, however, could not confirm these previous findings, but could only point out that a higher age was an independent risk factor for middle ear complications. The still relatively low number of children that had developed complications at the time of inclusion may be a major cause of the absence of significant risk factors, apart from the age, as well as the cross-sectional design. However, it should also carefully be considered that current surgical techniques for palatoplasty – for example the Sommerlad techniques – reduce the impact on middle ear status. As previously mentioned, there are limitations to this study, mainly that this is a cross-sectional analysis and not a longitudinal cohort study and children of different age categories are included, with the evolution of the otologic status in youngest ones still unknown. Secondly, some data – as example the surgical history – were retrieved retrospectively so there can be information bias. There is also the possibility of prevalence-incidence bias: children without middle ear problems may be underrepresented in the study population due to lack of recent middle ear information. Finally, no audiological data were analyzed in this study.

Conclusion

Middle ear problems are common in children with cleft palate. The susceptibility of developing OME is substantially increased in young children, where the impact of temporary hearing loss should not be underestimated considering the associated difficulty in speech and language development in this population. As middle ear complications can persist even in patients with a corrected palate, a significant proportion of children develops complications type tympanic membrane perforation in nine of our 116 patients aged six years and older and the development of cholesteatoma in 6 patients, mainly aged six years and older in our population.

Close otolaryngologic follow-up of all children with cleft palate is therefore necessary and should be adjusted to the personal needs of the child. Consequently, we suggest providing a standardised follow-up for these patients on an

otological level with a least a yearly otomicroscopic evaluation up to the age of 18 years and preferably lifelong in cases of otological manifestations. Additional research remains necessary to detect risk factors of adverse middle ear outcome in this population. Finally, a longitudinal cohort study that follows cleft patients from birth until adulthood can expand our otological knowledge in cleft patients.

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