B-ENT, 2012, **8**, Suppl. 19, 105-115

Functional consequences of chronic ENT inflammation on the development of hearing and communicative abilities

N. Deggouj, S. Castelein, A. Grégoire, H. Laroche, C. De Graeuwe, C. de Toeuf, G. Desuter, P. Rombaux and C. Hupin

Department of Otorhinolaryngology, Head and Neck Surgery, Cliniques Universitaires Saint Luc, UCL, Brussels, Belgium

Key-words. Otitis media; language development; peripheral hearing; central hearing; speech; adenotonsillar hypertrophy

Abstract. *Functional consequences of chronic ENT inflammation on the development of hearing and communicative abilities.* Hearing processing and communication abilities development may be influenced by chronic inflammation of the airways in children, especially in case of otitis media and/or adenotonsillar hypertrophy. The present review summarizes the influence of adenotonsillar hypertrophy on speech abilities as well as the consequences of otitis media, with a particular focus on peripheral and central hearing, on the development of language, attention, and memory skills.

Introduction

Chronic ENT inflammation in children, and especially otitis media, have a major impact on hearing and consequently on language development. Moreover, speech may be affected by adenotonsillar hypertrophy. In this article, we will review different consequences of chronic ENT inflammation on peripheral and central hearing, and on the development of language, attention, and memory skills, but also on speech abilities.

1. Peripheral and central hearing

Otitis media with effusion is a very common condition in children, particularly in the first three years of life. Hearing loss is the most common complication and sequela of this middle ear disease, with the clinical picture differing from that of permanent conductive or cochlear hearing impairments. Rather than being a stable auditory deficit, the hearing loss associated with OME is temporary, but sometimes persistent or recurrent, and variable in degree and symmetry.[1,2] In theory, a reduced and fluctuating input signal of this kind could affect emerging language, auditory processing, and readiness for school.

Impact on peripheral hearing

The prevalence of hearing loss in children with OME depends on its definition. Although determining prevalence on the basis of published reports is difficult because of limited information about testing conditions, equipment calibration, definition of hearing loss, and diagnosis of disease, estimates of prevalence can be made by selecting data from some of the better controlled studies.

Behavioural pure-tone air-conduction thresholds associated with episodes of otitis media have been documented in several reports. Kokko[3] studied 161 ears with OME. The average degree of air conduction loss through the speech frequency range (PTAs; 500 Hz, 1 kHz, 2 kHz) was 27.6 dB; the bone conduction values averaged 3 dB; the mean air bone gap was therefore 24.6 dB. Audiometric data (n = 627 ears) from several studies reviewed by Bess[4] revealed that 55% of ears had PTAs exceeding 21 dB HL. Within the speech frequency range, 7.7% had an average loss of 10 dB or less, 91.5% had losses between 16 and 40 dB, and only 0.8% had losses of 50 dB or more. Fria *et al.*[1] found that half of their subjects (n = 762) had PTAs in excess of 23 dB HL, whereas 20% had average hearing losses that exceeded 35 dB HL. Their study did not find any short-term effect associated with the duration of OME. Roberts *et al.*[5,6] reported on a group of children whose hearing was assessed regularly using a behavioural method until the age of two. Thresholds of 25 dB HL or greater were indicative of hearing loss. They found that 1-year-old infants had hearing loss during an average of 35% of the test sessions during the first year of life and 44% of the time between the age of 2 years and study entry. The relationship between time spent with bilateral OME and hearing loss was highly significant. A study conducted by Gravel *et al.*[7] examined hearing sensitivity prospectively in young children as a function of OME status in the first 3 years of life. The results revealed that a large percentage (50% to 68%) of children with OME had elevated hearing-loss levels in comparison to the OME-free group in all 3 years.

The profile of air conduction in OME is usually relatively flat, with slight peaking at 2000Hz.[3] Fria *et al.*[1] showed that acuity in children with OME was 7 dB less impaired at 2000 Hz. This observation can be explained by the increase in mass and stiffness secondary to OME, which causes an increase in the resonant frequency of the middle ear system, combined with the changes in the acoustics of the external auditory canal due to more reflection from the tympanic membrane.

It has been a long-standing premise that there is a correlation between the viscosity of the effusion and the degree of hearing loss. This was disproved by Wiederhold *et al.*,[8] who showed that thresholds were related to the volume of the effusion, but not the viscosity.

The question we can ask is whether or not OME and the temporary conductive hearing loss that frequently accompanies the condition can result in auditory sequelae in the long term. Gravel *et al.*[2] looked at whether OME and hearing loss negatively affected peripheral hearing after the disease had resolved. They demonstrated clearly that young children do not experience residual peripheral hearing loss associated with early OME experiences once the condition has resolved in the four frequencies (500, 1000, 2000, 4000 Hz) studied. The data also indicated that the average effect of OME on hearing level is quite similar, irrespective of age, when children experience more frequent episodes. There is evidence, however, that suggests that a history of chronic OME may result in cochlear hearing loss in frequency regions above those conventionally tested during routine audiometry.[7,9,10] Gravel *et al.*[7] conducted a prospective study that showed significantly poorer extended high-frequency hearing thresholds at 12.5 kHz and 14 kHz in second-grade children who had a history of more OME and more HL in early life.

Of course, individual children may also experience residual peripheral hearing loss associated with particularly protracted and severe courses of OME when the tympanic membrane and/or middle-ear structures have been permanently damaged.

As we will see, higher-order auditory sequelae may be a consequence for some children with an early history of hearing loss associated with OME, even when their peripheral hearing is later considered normal. Several reports have documented atypical ABR indices in children with recurrent histories of OME.[11-16] Gunnarson *et al.*[13] followed children prospectively, documenting middle ear status and assessing ABR thresholds regularly during 18 months of life. These authors then recorded ABRs from the same children when they were between 5 and 7 years of age. ABR test findings revealed significantly prolonged absolute latencies for waves III and V, and prolonged interpeak I-III and I-V latencies for two groups of study children: those with intermittent OME, and those with chronic OME in early life compared with an OME-free control group. Gravel et al. found longer ABR Wave V latencies in a group of children of school age who had suffered from OME and hearing loss in early life.[7]

Central auditory processing disorders

Central auditory processing is the activity of the central auditory pathways that allows for the correct discrimination of acoustic stimuli. It includes the correct perception of frequencies, intensities, durations, and the correct detection of variations in these different parameters. It leads to the correct discrimination of complex verbal and non-verbal auditory stimuli, especially when these stimuli are unusual (distorted sounds, unclear articulation, very fast speech flow, speech produced by a foreign speaker or in a foreign language that is not well known) or produced in poor listening conditions (loud background noise, competing voices etc.). Different models have been described for the cerebral circuits involved in speech perception.

Zaehle *et al.*[17] described a model inspired by the known functioning of vision. They described a ventral pathway which makes it possible to determine the object or the face ('what') and a dorsal pathway which allows the analysis of the characteristics, including the spatial ones, of the object or the face ('where' or 'how').[18] Sounds with phonological contents activate more on the left, the primary auditory cortex (gyrus of Heshl), the nearby associative area (temporal planum) and the median part of the superior temporal sulcus and gyrus. From there, two pathways are activated: one ventral and one dorsal. The ventral pathway brings in the anterior part of the superior temporal gyrus. It provides access to lexical information (in other words, the pathway for the 'what'). This region is also activated by changes in the spectral content of complex acoustic stimuli. The dorsal pathway (or phonological pathway, or the pathway for the 'how') uses neuronal circuits distributed in the posterior temporal, parietal and frontal regions. It analyses how sounds are produced and ordered. This pathway is also activated by changes in the temporal content of complex stimulations.

Everyday speech perception is usually audio-visual. Audio-visual integration is a central process allowing for the improvement of speech perception, especially in poor listening conditions: extraneous noise, low-quality oral message, deafness and so on.[19] It involves the intervention of a fronto-parieto-temporo-occipital neuronal network which is comparable to the dorsal pathway mentioned above.[20-23]

Children accumulate memories of patterns of auditory, visual, somaesthetic and motor stimuli created by seeing and hearing others speaking and by their own vocal productions. Infants, and later children, see and hear speech produced around them. At the same time, they start to produce badly differentiated sounds, then vowels, syllables, words, and finally phrases which become more and more complex. They accumulate memories of patterns of auditory, visual, somaesthetic and motor stimuli associated with the production of these sounds. Normal hearing is therefore required during these stages. The patterns in memory need to be activated when the subject detects these stimuli.

An early and sustained hearing deficit associated with chronic otitis persisting for several months can disturb the construction of the neuronal network involved in this speech processing and, in particular, in phonological coding. This network starts to specialise early in the mother tongue.[24]

At the outset, infants are receptive to all the phonemes of all different languages. In the early months of life, they lose this faculty to detect all the phonological contrasts and specialise in detecting the contrasts used in the native language. Their perception of phonemes becomes category-specific: for example, in French, the sound 'a' is categorised as an 'a' even when it is produced with different intonations, a higher or lower pitch of the spectral content, and shorter or longer duration; by contrast, a change in duration in Flemish or a tonal variation in Chinese would be associated with the perception of two different phonemes. Normal hearing is fundamental during the development of this specialised phonemic perception. Problems with this network affect the perception of speech in quiet or in poor listening conditions, the development of the oral language and also reading and writing acquisition. Indeed, reading problems are associated with a deficit in speech perception,[25] and particularly in phonological representation.[26]

Persistent otitis media leads to a significant reduction in the auditory input. If it persists during the early months of life, which are crucial for central auditory network development, it may adversely influence its architecture and functioning.[27] The risk of enduring central auditory impairments is particularly high for children presenting with persistent and severe otits media with degraded auditory input.[28,29]

Children between 6 and 8 years old with an early history of OM tend to have lower scores than non-OM children for phonological awareness skills, semantic skills with expressive vocabulary and word definitions and reading.[30,31] Other studies have failed to find a negative impact on language skills in children with an early history of OM and tested at 6 years or older.[32,33]

Free-recall and directed-attention tasks with dichotic listening to CV syllables were compared in children with OM history and control children. The expected right-ear bias was found in the control children during free recall and the directed right condition, but there was a shift towards a left-ear bias in the directed left condition. A predominantly right-ear bias was found in the children with a history of OME in all three tasks. The left-ear neglect may affect hearing performance in real life in quiet (the left-hand speech information may be ignored) and in noise.[34]

An early OM history (before the age of two years) was also found to have a negative impact on speech discrimination in noise in children tested at the age of 7 years.[35] Childhood OM with an associated hearing loss in the low and high frequencies is correlated with a greater probability of tinnitus in adulthood.[36] Animal models have showed that persistent conductive hearing loss may be associated with hyperacousis.[37]

2. Consequences for the development of language, attention, and memory skills

Otitis media or infection in the middle ear is a frequent illness in infants and in particular during the first three years of life, a crucial period for the development of language. Indeed, 70% of infants present with at least one episode of otitis media before the age of 3 and, for most infants, otitis media is a recurrent problem.[38,39] According to Menyuk,[40] the incidence of otitis media attains its peak between 6 and 18 months of age. In other words, it occurs when children are encoding the phonological categories of their native language. There is a second prevalence peak at about the age of 6 years.[41]

Otitis media is a term that is used in a generic way in paediatrics to cover a wide range of infections involving the middle ear. Otitis media may lead to a temporary and fluctuating loss of audition due to the presence of liquid in the middle ear.

In addition to otitis media, the most frequently occurring chronic infections include nasal obstruction and tonsillar hypertrophy. Repeated nasal obstructions in children lead to an imbalance in the swallowing and articulation functions, which are based on the same anatomy and therefore interact closely. According to Thibault,[42] there is a similarity in the lingual supports for swallowing and for the articulation of apico-dental consonants [t d n l], as well as those for constrictive consonants [s z ch j]. In this context, nasal obstruction results in mouth breathing and hypotonia, a low position of the tongue at rest, adapted swallowing, and lingual interposition in the production of certain consonants. According to the logopedic dictionary,[43] infantile swallowing may be defined as an oro-facial function limited to infants which is characterised by a spreading of the tongue, that comes into contact with the lips in a sucking motion. This type of swallowing is supported by separated arcades with lingual interposition. Tonsillar hypertrophy, when bilateral, may also lead to oro-pharyngeal obstruction, pronunciation difficulties (oro-pharyngeal voice), and swallowing difficulties which present as large-morsel dysphagia.

Even though the negative effects of a loss of permanent audition on the development of language are well documented, there is no consensus about the impact of otitis media on the development of language and speech in young children. Indeed, a 2004 meta-analysis[44] based on eleven studies concluded that the associations between otitis media occurrences resulting in hearing losses and standardised measures of language development in preschool children were not consistent. For these authors, otitis media associated with a perforation and loss of audition cannot be considered to be an explanatory variable for difficulties with language development.

However, some studies have shown that children with otitis media develop poorer phonological, morphological, and communication skills. In 2001, Miccio *et al*.[45] conducted an in-depth investigation of the results of six children aged 12 to 48 months presenting with a history of otitis media. The analyses were conducted using films of 15-minute language exchanges. The results indicated that chronic otitis media and the resulting loss of audition were associated with a risk of delay in the development of language and speech. Children with a hearing loss of less than 20dB generally go through the same stages of phonological acquisition as children with normal hearing. It is noteworthy that one of the children with a low number of otitis media episodes but a hearing loss greater than 20 dB (26.4 dB) had atypical phonological acquisition and a delay in language development. Transitory hearing loss confronts the child with an unstable signal which may impede phonological acquisition and ultimately lead to a delay in language development. The study from Petinou *et al*.[46] conducted in the same year supports these results. This study aimed to evaluate the consequences of otitis media with discharge and the associated loss of hearing on the phonological and morpho-phonological perception of hissing consonants ([s] and [z]) in young children. Children with a history of otitis media had significantly poorer results for tasks relating to phonological and morpho-phonological perception.

In 2006, in a study involving a group of 86 children with a history of otitis media aged 6 to 8 years and a control group, Winskel[30] attempted to determine the effects of otitis media on language development and on written language skills. This study evaluated the children's phonological awareness, semantic knowledge, and narration and reading skills. The results suggested that children with a history of otitis media performed worse in the areas of phonological awareness (tasks relating to alliteration, rhyme and reading pseudo-words), in tasks evaluating semantic representation (denominations and definitions), and reading acquisition. The largest differences were noted for pseudo-word reading, rapidity of reading, and written comprehension. According to these authors, episodes of recurrent otitis media may lead to long-term effects on the language skills of children aged 6 to 8 years, as well as on learning written language. The reading delay does not, however, improve with age.

By contrast, other studies[47] found no relationship between episodes of otitis media in infancy and language development. A recent study[48] is interesting in this respect, introducing some nuances to the discussion. This study examined the long-term impact on the language skills of school-age children of otitis media with an associated hearing loss in very young children. In this prospective study, the status of the middle ear of 65 children born in good health was investigated every 3 months during the first 2 years of life. Comprehension and language expression were evaluated at 27 months and at 7 years of age. A positive correlation between hearing loss secondary to otitis media and language development was observed at 27 months, but not at school age. As a consequence, the hearing loss seen between the ages of 2 to 7 years did not appear to affect school results. This study found that otitis media had a negative impact on the receptive and expressive language skills in 2-year-olds. However, at the age of 7 years, these skills had returned to normal levels.

To date, most research in this area has centred on the perception of different language features, and very few studies have investigated the comprehension of a discussion in daily life, with or without noise, or the different features in combination. Nevertheless, this measure of language appears to be of paramount importance, as several parents or teachers have noted that children experiencing episodes of otitis media at a young age had difficulties with instruction comprehension or conversation. In 2005, a study carried out by Keogh *et al.* of 480 school-age children found no difference between the experimental and control groups, but did find greater variability in the group with a history of otitis media.[49] Children with a history of otitis media are a heterogeneous group with extremely variable results; some children in this group had significant difficulties with language and comprehension.

Studies evaluating the impact of hearing loss due to otitis media on attention capacity have also generated equivocal results. Mody *et al.*[50] showed that attention associated with linguistic stimuli may be disturbed by a history of persistent otitis media. At nine years of age, the children in the experimental group obtained results that were slightly worse than those of the control group for tasks involving language perception and working memory. The authors observed that the children with a history of otitis media performed worse on tasks involving auditory discrimination, particularly when the stimuli were phonetically close. On the other hand, they did not observe any significant difference for the type of errors, or when the items were dissimilar. The authors concluded that episodes of otitis media could have subtle long-term effects on phonological representation.

The capacity for auditory attention appears to be weakened in children presenting with persistent otitis media requiring drainage. In 2000, Asbjørnsen *et al.*[51] investigated nineteen 9-year-old infants with a history of otitis media and eighteen control infants with a task involving dichotic listening. The precision of the response was the same in the experimental and control groups. However, the children with a history of otitis media had a preference for the right ear which was more pronounced than in the control group. According to the authors, the early auditory deficit could have affected the development of the language centre in the left cerebral hemisphere. In effect, given that a weaker signal necessitates greater processing capacity in order to be interpreted, this could have resulted in an augmentation of the processing capacity for auditory signals, and particularly for verbal signals, resulting in a stronger bias towards the right ear. This team also observed a significant difference at the level of modular attention: children with a history of otitis media experienced difficulties when asked to pay attention uniquely with the left ear. In 2005, this team found matching results for children suffering from non-chronic otitis media. It appears that the two groups of infants with a history of otitis media (chronic and non-chronic) have the same difficulties with concentrating on an information source despite restored audition and normal cognitive and intellectual development.

In 1994, Feagans *et al.*[52] showed that children aged between 12 and 18 months suffering from chronic otitis media had impaired auditory attention during the reading of a book. In addition, they reported that the quality of stimulation (in a day-care centre, for example) also had an impact on the infants. When the quality of stimulation was lower, the infants with disease experienced negative effects on attention that were greater than those suffering from chronic otitis media but receiving adequate stimulation. On the basis of maternal evaluations, this study also reported a relationship at 24 months between distracted behaviour and the number of otitis media episodes, particularly in the group of infants suffering from chronic otitis media. In 2005, these authors confirmed that the quality of the day-care centre interacted with the negative effects of otitis media on the development of the infant, which could explain the variance found in the literature for language development.[53]

By contrast, other authors,[54] when using a questionnaire, found no significant relationship between otitis media in early infancy and attention and behaviour during the 6 first years of life. The questionnaires were completed by the parents, teachers, or clinicians when the children were not able to answer the questionnaire because of their young age. The outcome of this study was in line with the results obtained by Paradise *et al.*,[55] who investigated the potential effects of otitis media on language, cognition, and psychosocial development using a questionnaire method. These researchers also took into account the level of parent-infant stress at the ages of 1, 2, and 3 years, as well as the cumulative duration of the otitis media episodes. The analysis of the questionnaires did not show any link between the cumulative duration of otitis episodes and the level of parent-infant stress or the behavioural problems of the infants. However, these two factors were related to socio-economic status.

There have been very few studies examining working memory in depth. Several studies have been limited to investigating short-term memory using number spans, which is an insensitive method. The studies did not reveal any significant difference between infants with a history of otitis media and the control group.[56] In 2005, Majerus *et al.*[57] attempted an in-depth investigation of short-term memory performance in infants with a history of otitis media. Only one significant difference was observed at the level of phonological processing: weaker performance in the rapid repetition of pseudo-words and rhyme judgment. On the other hand, the results obtained at the level of short-term verbal memory and vocabulary were comparable for the two groups from both the qualitative and quantitative points of view. In addition, capacity for learning new words was also similar.

A history of recurrent otitis media episodes does not appear to have an effect at the level of short-term memory, even with the most difficult tasks. This is consistent with earlier studies.[50,56] It is noteworthy that only Nittrouer and Burton[31] reported a significant difference between the group presenting with otitis media and the control group for short-term memory tasks not requiring verbal production. Majerus *et al.*[57] explain this difference by reference to the young age of the infants (5 years) and the complexity of the task.

There would appear to be no consensus about this issue in the literature, and the studies have produced conflicting results.

At the level of language, it would seem that phonological development could follow an atypical trajectory when hearing loss due to the infection is greater than 20 dB. The different studies appear to suggest that the development of semantic representation may be affected by a history of otitis media. Subsequent repercussions may be seen at the level of phonological conscience and learning written language. However, some studies note that the observed delay essentially corresponds to the age at which the children became infected. Usually, at the age of 7 years, the linguistic competence of infants with a history of chronic otitis media infections has returned to normal. For other authors, the difficulties are more subtle and relate essentially to daily comprehension with noise, with more variability being seen in infants with a history of otitis media.

Furthermore, the studies investigating the impact of otitis media on attention and behaviour using questionnaires found no significant results. On the other hand, when dichotic listening tasks were used, impairment of the modulation of attention could be observed. Infants with a history of otitis media (chronic or not) had difficulties with focusing their attention on information transmitted via the left ear. In addition, the studies presented evidence that environmental factors may interact with the negative effects of otitis media on attention capacity. Attention to language stimuli is not as strong, resulting in long-term effects on phonological representation.

Finally, the different studies did not find any effect of otitis media episodes on short-term verbal memory. However, confirming this observation would require the replication of these results since very few in-depth studies have examined the link between short-term memory and otitis media in young infants.

3. Impact on speech

Adenoid and tonsillar hypertrophies are very frequent among children. These two conditions occur in Waldeyer's ring and involve many types of lymphocytes and secreted antibodies.[58] Hypertrophy of these tissues can lead to various obstructive respiratory problems (examples being obstructive sleep apnoea, snoring and oral breathing caused by poor development of the maxillofacial region) as well as the modification of the resonators situated between the glottis and the lips.[59,60] Indeed, hypertrophied tonsils reduce the oropharyngeal space, pushing the tongue forward in a significant way.[58-60] Moreover, they can have an impact on the mobility of the soft palate and the closing of the velopharyngeal isthmus, possibly leading to a muffled 'hot potato' voice as well as hypo- or hypernasality (depending on the anatomical characteristics of the subjects and their origins). These hypertrophied adenoids can also block the nasopharynx; moreover, this tissue assists in velopharyngeal occlusion in children.[61,62] Surgical procedures focusing on these two conditions will therefore have an effect on speech. Although different authors have looked at this topic from similar perspectives, it is not unusual for their conclusions to differ. This could be due to the lack of precision in some studies, which do not distinguish between patients with tonsillar hypertrophy, adenoid hypertrophy, or both. In other studies, pre-existent anatomical anomalies (such as submucosal palatal cleft and forked uvula) were not specifically addressed and therefore tended to distort the results. The following section reviews the information based on actual knowledge on the basis of recent literature in English. The various selected studies describe the voice objectively and subjectively. In objective appraisals, the acoustic evaluation of the voice uses computer software starting with vocal emission, for example of the three vowels /a/, /u/ and /i/.[60] The following parameters are then analysed: fundamental frequency, jitter (variation of the frequency), shimmer (variation of intensity), NHR (noise to harmonic ratio) and the central frequencies of formants 1 through 3. Experienced voice specialists conducted subjective evaluations. In the Lunderborg *et al.*[60] study, the raters used an analogue visual scale to evaluate the following items: raucousness, breath, hyperfunction, roughness, hyponasality, hypernasality, compressed voice and vocal pitch. This subjective analysis uses a standardised list of words. The GRBASI scale may also be used (Grade, Rough, Breathy, Asthenic, Strain, Instability): it determines a score from 0 to 3 (0: normal, 3: severe attack) for these various parameters. The subject samples varied from one study to another: children referred for hypernasality, tonsillar hypertrophy or adenoid hypertrophy and comparison of the vocal characteristics before and after surgery.

Confusion arises from the fact that the distinction between adenoid and tonsillar hypertrophy is not well established in some studies. For the sake of clarity, we will distinguish between these two entities, even though they can be concomitant in practice.

Adenoid hypertrophy is to some degree physiological in the young child. These adenoids play a passive role in the occlusion of the velopharyngeal isthmus and are therefore vitally important in the prepubescent development of speech.[63] Some authors have discussed 'velo-adenoidal closure' in the child.[61,62] The adenoids attain maximum size between 9 and 15 years of age[64] and then gradually shrink during and after puberty.[63] Compensation mechanisms are therefore in place: the lateral and posterior velopharyngeal muscles take over and the soft palate increases in height and length in conjunction with the closing movements of the valve.[65,66] However, overdeveloped adenoids obstructing the nasopharynx and/or the choanae have infectious consequences, and implications for resonance, breathing and olfaction.[67] At the level of speech, there is hyponasality in proportion to the obstruction of the nasopharynx, and therefore counterbalancing of open-mouth appearance. In practice, hyponasality consists of a lack of nasal resonance during the pronunciation of some phonemes.

Many authors have reported that adenoidectomy may lead to velar insufficiency.[65] Actually, in the majority of children, either there is no velopharyngeal leakage post-adenoidectomy, or it disappears quickly due to the compensation mechanisms of the muscles constituting the valve.[65,68,69] Temporary hypernasality may be present during recovery for the time it takes the soft palate to regain suitable function and for the scars located near the anterior and posterior pillars to soften.[66] Speech therapy for a few months accelerates recovery.

On the other hand, adenoidectomy in a patient with a palatine cleft is the leading cause of exacerbation or hypernasality development.[65,70,71] A meticulous clinical examination is therefore essential. Indeed, in the event of an anatomical defect of the palate, the soft palate alone cannot occlude the isthmus completely; the hypertrophied adenoids therefore play a central role. Some authors have stated that it is important to avoid performing adenoidectomy in patients with palatine cleft,[65] while others have found no impairment of isthmus closure.[72] In practice, clinicians need to take into account certain risk factors associated with palatine cleft, such as a family history of palatine or labial cleft, the presence of congenital malformations (in particular cardiovascular), craniofacial malformations, food problems during infancy (nasal regurgitations, weak suction reflex), poor motor skills, etc. During clinical examination, a forked uvula, a pellucid zone and a notch in the hard palate region define the typical scenario for palatine cleft.[65]

The palatine tonsils are two almond-shaped formations located in the oropharynx between the anterior (palatoglossal arch) and posterior (palatopharyngeal arch) pillars of the soft palate.[58] These tonsils can be a source of repeated infection; they can also cause a mechanical obstruction resulting in difficulties with the passage of the food bolus, snoring, articulation problems and voice modifications (muffled 'hot potato' voice).[59,66,73,74] Mora *et al*.[59] also describe raucousness and a breathy (murmured) voice in children presenting with tonsillar hypertrophy and adenoids. Non-pathological tonsils do not have any effect on speech and articulation.[63] With regard to acoustic characteristics, Lunderborg *et al*.[60] have noted that children presenting with hypertrophied tonsils have higher levels of jitter, shimmer and NHR than the control group, resulting in more raucity. The frequency of the third formant is also lower. This is influenced by the position of the tongue, which is pushed forward by the hypertrophied tonsils.[58-60] Some authors have also discussed hypernasality problems[59,63,66,75,76] consequent to velar insufficiency. Velopharyngeal closure is normally obtained by the contraction of the elevator muscles of the velum and the constrictors of the pharynx. If the superior pole of the tonsil is in a very posterior position and extends beyond the palatopharyngeal arch, it will prevent a rise of the soft palate during the closure efforts of the isthmus and will therefore generate an occlusion defect.[58,63] The endo-oral examination is not appropriate for this diagnosis,[58,66] which is made by naso-fibroscopic examination, which highlights the presence of one or two tonsils in the nasopharynx and the presence of a central opening during efforts to close the isthmus. Alternatively, video-fluoroscopic examination, which visualises tonsils and their relationship with the soft palate via frontal and side views of radiographic imaging following barium ingestion, can be used.[58] By contrast, during normal naso-fibroscopic examination, the tonsils are never visualised in the nasopharynx; at most, tonsillar hypertrophy results in a convexity on the nasal side of the soft palate.[58] In the particular case of patients presenting with anatomical defects of the palate, tonsillar hypertrophy can be essential to the closure of the isthmus.[58]

In general, studies looking at tonsillectomy and its effect on speech are fairly unanimous. According to the Lundeborg *et al*. study,[60] tonsillectomy improves values for jitter, shimmer and NHR, which are pathologically higher in patients with tonsillar hypertrophy. Salami *et al*.[77] also found an improvement in hypernasality. A reduction in the values for fundamental frequency, jitter, shimmer, NHR, VTI (voice turbulence index), SPI (soft phonation index), DUV (degree of voiceless), and of DVB (degree of voice breath) were observed in the Mora study.[59] In patients with velopharyngeal abnormalities (open cleft or weak mucous membrane), no worsening was observed in closure of the isthmus after tonsillectomy.[72] However, in the event of tonsillar hypertrophy in patients with a corrective pharyngeal flap for velar insufficiency associated with a palatine cleft that is located too low or that is too narrow, tonsillar hypertrophy is involved in velopharyngeal closure and every tonsillar procedure is associated with the risk of a closure defect.[58] In the case of tonsils with an upper pole in a very posterior position, the approach will always be to remove them; in the event of persistent hypernasality following tonsillectomy, a pharyngeal flap[58] should be considered.

Conclusion

Chronic ENT inflammation in young children modifies the structural and functional development of the auditory and language pathways. It will affect language and learning, as well as central auditory processing, interfering with the perception of speech in non-favourable situations (noise, poor speech articulation) in the very long term.

Research looking at the impact of otitis media on the development of hearing, language, attention and memory in infants must be continued. It would be interesting to study associated variables simultaneously. Indeed, the variability found in the literature could be explained, in part, by different factors such as environmental or medical variables.

Adenotonsillar hypertrophy, which is frequently seen in children, is known to affect speech. Although not all authors agree, the general opinion is that adenoid hypertrophy causes hyponasality, while hypertrophic tonsils can be result in a muffled 'hot potato' voice. If the superior pole of the tonsil is located behind the posterior pillar of the soft palate (velum), the patient will present with a velopharyngeal insufficiency resulting in hypernasality. This is an absolute indication for tonsillectomy. Both adenoidectomies and tonsillectomies improve voice in general. However, clinicians must be attentive to the possible presence of anatomical defects involving the palate. The failure to do so may lead to a velar insufficiency that will be compensated by the hypertrophy of various lymphoid tissues. The closing and opening of the velum both play an active role in two paramount functions: physiological nasal breathing and speech. Any surgery (adenoidectomy, tonsillectomy, surgery of the velum) that simplifies one of these functions is likely to compensate the other. The key is to find the appropriate trade-off.

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Naïma Deggouj
Department of Otorhinolaryngology, Head and Neck Surgery
Cliniques Universitaires Saint Luc
Catholic University of Louvain, Brussels
10 avenue Hippocrate
1200 Brussels, Belgium
Tel.: 32.2.764.19.49
Fax: 32.2.764.89.35
E-mail: naima.deggouj@uclouvain.be