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DIAGNOSIS OF ACUTE MAXILLARY SINUSITIS AND ACUTE OTITIS MEDIA

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To my mother

CONTENTS

LIST OF ABBREVIATIONS

AMS	acute maxillary sinusitis
AOM	acute otitis media
GP	general practitioner
CT	computed tomography
MRI	magnetic resonance imaging
PNEF	peak nasal expiratory flow
PNIF	peak nasal inspiratory flow
SD	standard deviation
TM	tympanic membrane
URI	upper respiratory infection

LIST OF ORIGINAL PUBLICATIONS

This study is based on the following original publications which shall be referred to by their Roman numerals. The publishers kindly gave permission to reprint the articles.

I **Blomgren K, Hytönen M, Pellinen J, Relander M, Pitkäranta A**
Diagnosing acute community-acquired maxillary sinusitis in primary care
Scandinavian Journal of Primary Health Care 2002;20:40–44

II **Blomgren K, Simola M, Hytönen M, Pitkäranta A**
Peak nasal inspiratory and expiratory flow measurements — practical tools in primary care?
Rhinology, in press

III **Blomgren K, Pitkäranta A**
Is it possible to diagnose acute otitis media accurately in primary care?
Family Practice 2003;20(5):524–527

IV **Blomgren K, Pohjavuori S, Poussa T, Hatakka K, Korpela R, Pitkäranta A**
Effect of accurate diagnostic criteria on incidence of acute otitis media on otitis-prone children
Scandinavian Journal of Infectious Diseases, in press

V **Blomgren K, Robinson S, Saxèn H, Pitkäranta A**
Clinical significance of incidental magnetic resonance image abnormalities in mastoid cavity and middle ear in childre
International Journal of Pediatric Otorhinolaryngology 2003;67(7):757–760

ABSTRACT

The number of diagnosed acute otitis media (AOM) and acute maxillary sinusitis (AMS) cases is increasing for no apparent reason. Most diagnoses are made in primary health care, and despite the frequency of these diseases, some diagnoses may be inaccurate. Primary health care has no methods even to evaluate nasal function, whereas new methods at university clinics produce information of unknown clinical relevance.

We conducted five prospective studies: We compared diagnostic equipment, diagnostic criteria, and diagnoses of general practitioners and the otorhinolaryngologist for 50 children with parent-suspected AOM and for 50 adults with self-suspected AMS (III, I). To learn whether the use of strict diagnostic criteria has any influence on incidence of AOM in otitis-prone children, we conducted a 6-month follow-up study in almost 300 children (IV). We tested the properties of two new nasal functioning tests, peak nasal expiratory flow (PNEF) and inspiratory flow, (PNIF) in 100 healthy adults (II). We compared magnetic resonance imaging findings (MRI) in the middle ear and mastoid cavity and AOM history in 50 children scanned for neurological purposes (V).

Our results indicate that AOM and AMS diagnoses in primary care are frequently based merely on symptoms and nonspecific clinical findings. Diagnostic criteria are loose, and diagnostic equipment seldom used. Use of strict diagnostic criteria and of the pneumatic otoscope and tympanometry reduces AOM diagnoses significantly (III, I). PNIF and PNEF measurements are highly variable and poorly repeatable and thus unsuitable as diagnostic methods (II). Incidental high signal intensity mimicking acute infection may occur in scans of the middle ear and mastoid cavity in children with healthy ears (V).

Accurate diagnosis of upper respiratory infections has an impact on both the individual patient and the whole of society. Accurate diagnoses could reduce the number of operations such as tympanostomies, adenotomies, and sinonasal surgery, and thus cut health care costs; limited use of antibiotics could delay the development of antimicrobial-resistant bacteria. When limitations in diagnostics are recognized, it is possible to develop new diagnostic equipment and ensure that medical education for students and primary practitioners is focused wisely.

INTRODUCTION

Acute otitis media (AOM) is the most common, and acute maxillary sinusitis (AMS) is the fifth most common indication for antimicrobial treatment, with incidences of both AOM and AMS increasing rapidly (McCaig and Hughes 1995; Joki-Erkkilä et al. 1998; Schappert 1999). Both infections have a substantial impact on the economy of families, of employees, and of health care systems (Kaliner et al. 1997; Niemelä et al. 1999). AOM alters children's hearing at a critical age, which may have long-lasting consequences throughout childhood (Margolis and Hunter 1991). Children with multiple AOM episodes before the age of three may have weaker linguistic skills and poorer classroom concentration and mathematics skills at school than do children with few episodes (Teele et al. 1990; Luotonen et al. 1996; Luotonen et al. 1998).

Despite the huge impact of upper respiratory infections, criteria for diagnoses are often loose, and physicians are often uncertain of their diagnoses (Froom et al. 1990; van Duijn et al. 1992; Hansen et al. 1995; Mäkelä and Leinonen 1996; Lyon et al. 1998). Unwarranted use of antibiotics prescribed for viral infections leads to the worldwide problem of antimicrobial resistance (Neu 1992; Manninen et al. 1997). The reliability of the diagnosis of bacterial infections is frequently questionable (Gonzales 1997; Palmer and Bauchner 1997; Nyquist et al. 1998). Accurate diagnosis is equally essential to avoid the overdiagnosing which results in unnecessary medication and surgery, and the underdiagnosing which causes delays in therapy (Pelton 1998). Acute mastoiditis still exists, and AOM may be overlooked without pneumatic otoscopy (Schwartz et al. 1981b; Ghaffar et al. 2001). At the moment, no truly effective and practical method exists for prevention of either viral upper respiratory infections (URI) or their bacterial complications. Roughly one-fifth of URI cases in children are complicated by AOM, resulting annually in 500 000 episodes of AOM in Finland, alone (Heikkinen et al. 1995; Niemelä et al. 1999). Adults have from two to three common colds annually, and 0.5% to 2% of these end in AMS (Dingle et al. 1964; Berg et al. 1986; Gwaltney 1997).

The clinician must find parameters and diagnostic tools to distinguish bacterial infections from other inflammatory disorders. Radiologic studies of the upper respiratory area performed for reasons not related to ear, nose, and throat diseases also produce information of unknown clinical relevance (Cooke and Hadley 1991; Patel et al. 1996). As long as infections cannot be prevented, diagnoses must be as accurate as possible. The belief that patients with upper respiratory infections are satisfied only when they receive a prescription for antibiotics may actually be a myth. Patients are satisfied with their diagnosis and treatment when they understand their illness and feel that the examination was thorough (Hamm 1996). When the diagnosis is based on a careful examination, it is also more likely that it is correct.

REVIEW OF THE LITERATURE

Definition

Acute maxillary sinusitis

AMS is defined as symptomatic infection of the maxillary sinus mucosa that leaves behind no significant mucosal damage (Kern 1984; Clement 1997). This current definition covers neither the duration of symptoms nor the pathogen. The traditional definition, used also in the present thesis, focuses more on secretion than on mucosal inflammation. When sinusitis is bacterial, there appears a usually purulent effusion in the maxillary sinuses (American Academy of Pediatrics 2001). The common cold, on the other hand, may be called viral rhinosinusitis, since it affects the sinus mucosa (Gwaltney et al. 1994). Some authors point out that since the typical viral URI lasts for 7 days, no sinusitis can be diagnosed unless the patient has been symptomatic for at least one week (Shapiro and Rachelefsky 1992), while others define acute sinusitis as any infectious process in the sinus lasting from one day to 3 weeks (Kern 1984). Some authors set the upper limit for acute sinusitis at 6 to 8 weeks (Clement 1997) while others call sinus infections lasting from 3 weeks to 3 months subacute sinusitis (Kern 1984).

Acute otitis media

AOM can be diagnosed when a rapid and short onset of signs and symptoms of infection in the middle ear and local or systemic signs of an infection like earache, fever, irritability, poor appetite, vomiting or diarrhea are present simultaneously. This definition covers neither the pathogen nor the presence of an effusion in the middle ear, although the tympanic membrane (TM) in AOM is defined as full or bulging, opaque, and poorly mobile, indicating effusion in the middle ear. According to this definition, AOM can also be diagnosed–in cases in which signs and symptoms of acute infection are combined with a purulent discharge–through tympanosomy tube or perforation of the TM (Bluestone 1995; Rosenfeld and Bluestone 1999).

Diagnostics

Acute maxillary sinusitis

SIGNS AND SYMPTOMS

Accurate diagnosis of AMS is impossible if the diagnosis is based solely on clinical examination (Varonen et al. 2000). The main problem is that its signs and symptoms overlap with those of the common cold. No sign or symptom is exclusively specific to AMS (Hansen et al. 1995) although some: purulent rhinorrhoea, pain when bending over, unilateral maxillary pain, pain in the teeth, poor response to decongestants, and long duration of illness increase the probability of AMS (van Duijn et al. 1992; Williams et al. 1992; Lindbaek et al. 1996; Little et al. 1998). In one study, the doctor's overall clinical impression of a patient with suspected AMS was more accurate than was any single finding (Williams et al. 1992). Some researchers have created combinations of symptoms and signs to help in diagnosing: The most accurate predictors of AMS have been a combination of facial pain and purulent rhinorrhea from the same side (Berg and Carenfelt 1988) or a combination of maxillary toothache, poor response to decongestants, and a colored nasal discharge (Williams and Simel 1993; Low et al. 1997). Others have failed in finding a useful combination for differentiating URI from AMS (Varonen et al. 2002).

MAXILLARY PUNCTURE

Maxillary puncture and antral aspiration provide both direct evidence of secretion and the possibility to culture the pathogen (Berg et al. 1981). In addition to its diagnostic advantages, maxillary puncture is time-consuming, and, if not painful, at least more or less uncomfortable to the patient, and thus not recommendable as a routine procedure (Otolaryngologiyhdistys 1999; American Academy of Pediatrics 2001). The fact that maxillary puncture has actually failed to enhance the therapeutic effect of antibiotics has also reduced its popularity (Axelsson et al. 1975; von Sydow et al. 1982). Maxillary puncture is, however, still indicated if a patient does not respond to first-line antibiotics or is extremely ill, or if identification of the causative agent is important (Kern 1984).

LABORATORY TESTS

In AMS diagnosis, laboratory testing is useless. Elevated erythrocyte sedimentation rate with or without high C-reactive protein value has been specific to AMS in adults with URI in some studies (Hansen et al. 1995; Lindbaek et al. 1996) but unspecific in others (Savolainen et al. 1997a). Interestingly, in one study, CRP values were elevated when the causative agent of AMS was an aggressive pathogen like *Streptococcus pneumoniae* or *Streptococcus pyogenes* (Savolainen et al. 1997a). In the future, laboratory testing will probably be more specific and distinguish viral infections from bacterial infections. Preliminary results of nasal lactoferrin measurements in AMS diagnostics are promising (Niehaus et al. 2000).

RADIOLOGIC EXAMINATION

Neither paranasal computed tomography (CT) nor magnetic resonance imaging (MRI) is a useful method when AMS is diagnosed, but both are essential when complications occur. Sinus symptoms do not correlate with findings in CT (Bhattacharyya et al. 1997), and CT has shown incidental sinus abnormalities in over 40% of patients scanned for reasons not even related to the paranasal region (Havas et al. 1988; Flinn et al. 1994). As sinus abnormalities in CT during the common cold have been the rule rather than the exception (Gwaltney et al. 1994; Hansen et al. 1995; Glasier et al. 1989), CT in AMS is indicated only if periorbital or orbital complication is suspected (Younis et al. 2002). MRI detects incidental abnormalities even more frequently than CT, with a frequency from 25% to 49% (Cooke and Hadley 1991; Moser et al. 1991; Patel et al. 1996; Wani et al. 2001; Kristo et al. 2003). MRI is recommended when intracranial complications of AMS are suspected (Younis et al. 2002).

Plain sinus radiographs are available in most primary health care centers and are widely used in diagnosis of AMS. A clear sinus rules out sinusitis, air fluid level and a completely opacified sinus are relatively reliable indicators of AMS, but the significance of mucosal swelling is controversial (Axelsson et al. 1970). Different AMS etiologies induce identical histopatological changes, with mucous membrane thickening and secretion visible in plain radiographs (Axelsson et al. 1975). Plain radiographs, CT, and MRI of the paranasal sinuses present the problem of revealing significant mucosal swelling even during a common cold (Puhakka et al. 1998; Kristo 2002). As almost 40% of adults with common colds have "radiological sinusitis," radiographs should not be taken unless the symptoms are severe and there exists reasonable doubt of AMS (Puhakka et al. 1998). Few clinicians have the luxury of consulting a radiologist, especially during off-duty hours. In plain sinus radiographs, agreement between otorhinolaryngologist and radiologist has, fortunately, been excellent (Krishnan 1992). The physician treating the patient has, moreover, a considerable advantage in knowing the clinical picture.

Ultrasound of the maxillary sinus is quick, painless, inexpensive, and safe, and the examination seems easy to perform. No wonder that ultrasound is the most popular imaging technique in diagnosis of AMS, for example in

Finnish primary health care (Mäkelä and Leinonen 1996; Honkanen et al. 2002). That only scan type is made in Finland may explain the enthusiasm of Finnish doctors also in research (Revonta 1980; Mäkelä and Leinonen 1996; Savolainen et al. 1997b; Laine et al. 1998; Puhakka et al. 2000). Authors of ultrasound articles are usually divided into two parties, believers and non-believers. Wide variation exists in reports of the accuracy of ultrasound, high sensitivity and specificity seldom occurring in the same study. In experienced hands, ultrasound is able to detect even small amount of sinus fluid. Sensitivity in detecting secretion has been over 90% but specificity under 50% (Savolainen et al. 1997b). In another study, specificity was over 90% but sensitivity only 29% (Rohr et al. 1986). In a study involving Finnish primary care, sensitivity was 61% and specificity 53% (Laine et al. 1998). Studies must be compared and evaluated with care. Most are conducted in ENT clinics where the authors of the article perform the examination. It is likely that they are more aware of the technique and of facial anatomy and also are more motivated to perform the examination than are general practitioners (GPs) in their own everyday work. Despite the risk of false positive diagnoses, several studies use plain radiographs or even MRI as a reference method which they compare to ultrasound (Rohr et al. 1986; Shapiro et al. 1986; Puhakka et al. 2000). Education improves ultrasound-examination accuracy. In a recent study done in primary care, GPs participated in a small group tutorial for 1.5 hours, after which, agreement in ultrasound interpretation with an experienced ultrasound specialist was 81% and specificity of ultrasound in detecting fluid in the maxillary sinus was as high as 95% and its sensitivity 92% (Varonen et al. 2002). GPs using ultrasound have not necessarily received any education on the subject, having learned the technique and interpretation solely from the manufacturer's instructions (Laine et al. 1998). Use of ultrasound with or without plain sinus radiographs improves the accuracy of diagnosis (Varonen et al. 2000). When diagnosis is based on symptoms and signs, over 90% of patients who suspect that they have AMS have been diagnosed as having AMS–some, most likely, incorrectly. Availability of ultrasound and radiographs has reduced the percentage of AMS diagnoses to 77% (Mäkelä and Leinonen 1996).

PEAK NASAL INSPIRATORY AND EXPIRATORY FLOW

When bronchi become obstructed, airflow decreases, and its volume is assessed with pulmonary peak flow measurements (Quanjer et al. 1997).When the nose is obstructed for one reason or another, the airflow decreases as well (Pallanch et al. 1998). Nasal modifications of pulmonary peak flow measurement, PNIF and PNEF measurements, correlate with the degree and sensation of nasal blockage (Åhman 1992; Fairley et al. 1993). PNIF has served in evaluation of the efficacy of medication (Benson 1971), in domiciliary measurement of allergic rhinitis (Wilson et al. 2000), and in assessing nasal airway patency during challenge (Wilson et al. 2003); PNEF in evaluation of response to immunotherapy (Frostad 1980) and in allergen challenges (Munch et al. 1982). As peak flow measurements are routinely used in diagnostics and follow-up of asthma it is tempting to assume that PNIF or PNEF could be useful in assessing the degree of mucosal inflammation in URI and thus perhaps even in diagnosing AMS. A commercial PNIF meter is already on the market (In-check, Clement Clarke Int. Ltd, Essex, UK) and a PNEF meter is simply a combination of a basic PEF meter (Wright Peak Flow Mini-meter, Clement Clarke) and a flexible anesthesia mask. Measuring PNIF and PNEF is painless, noninvasive, and rapid. In PNIF measurement the patient exhales calmly, puts on the mask, and inspires forcefully through the nose with the mouth shut (Wilson et al. 2000). In PNEF measurement, the patient exhales sharply through the nose (Viani et al. 1990). Although the properties of PNIF and PNEF have eagerly been compared with rhinomanometry (Frölund et al. 1987; Jones et al. 1987; Wihl and Malm 1988; Holmström et al. 1990), what remains unknown is when an individual flow value is pathologic. In other words, is there a normal range for PNFI and PNEF?

PEDIATRIC POPULATION

Diagnosis of acute pediatric sinusitis must be made on the basis of signs, symptoms, and clinical examination. Laboratory tests may be normal even in complicated sinusitis (Pitkäranta et al. 1999; Hytönen et al. 2000), and radiological findings do not necessarily correlate with a child's clinical condition. Pathological findings are frequently found in plain radiographs, CT, and MRI of children with common colds, and also in children without symptoms of a respiratory infection (Kronemer and McAlister 1997; American Academy of Pediatrics 2001; Schwartz et al. 2001; Kristo 2002). Nor is ultrasound reliable (Kronemer and McAlister 1997). Because avoiding radiation exposure is especially preferable in children, imaging techniques, mainly CT, are recommended only in cases of suspected complications (American Academy of Pediatrics 2001).

Diagnosis of AMS in children can be made when symptoms of upper respiratory infection, i.e., stuffiness, purulent rhinorrhoea, cough, and mild fever, lasts at least 10 days without improvement (American Academy of Pediatrics 2001). Although a common cold may last for over 10 days, symptoms usually become milder, or at least do not become worse after the first 5 to 7 days (Ueda and Yoto 1996).

Acute otitis media

SIGNS AND SYMPTOMS

The definition of AOM includes a long list of symptoms which may be related to AOM (Bluestone 1995). This has proven of only moderate help to the clinician, since most of these signs and symptoms overlap with those of the common cold and almost any other acute infection, and small children express almost any discomfort with crying (Niemelä et al. 1994). In order to ease diagnosis, several studies have focused on finding signs and symptoms predicting AOM more reliably. Though some signs and symptoms do predict AOM more accurately than others, all authors emphasize that diagnosing AOM always requires a clinical examination.

Earache has had the highest predictive value for AOM (Hayden and Schwartz 1985; Niemelä et al. 1994; Heikkinen and Ruuskanen 1995; Uhari et al. 1995; Kontiokari et al. 1998), but AOM may occur without earache; vice versa, absence of earache does not exclude AOM (Hayden and Schwartz 1985; Heikkinen and Ruuskanen 1995; Kontiokari et al. 1998). Especially in younger children, ear symptoms may be absent, or parents just do not recognize them (Hayden and Schwartz 1985; Niemelä et al. 1994; Heikkinen and Ruuskanen 1995; Uhari et al. 1995). Researchers disagree on the value of signs other than earache: Signs found to be both related and unrelated to AOM are cough (Niemelä et al. 1994; Uhari et al. 1995), restless sleep (Heikkinen and Ruuskanen 1995; Kontiokari et al. 1998), and fever (Schwartz et al. 1981b; Niemelä et al. 1994; Heikkinen and Ruuskanen 1995; Kontiokari et al. 1998). In one study, fever predicted even the implicated pathogen, *Streptococcus pneumoniae* (Rodriguez and Schwartz 1999). Duration of symptoms is not a clear sign, either, as AOM can develop any time during URI (Heikkinen 1994; Koivunen et al. 1999). For this reason, physicians should encourage parents to re-visit in a few days if the child's symptoms continue after diagnosis of URI. Parents' suspicion of AOM has been a more reliable predictor of AOM than have most signs and symptoms, with a sensitivity of 71% and specificity of 80% (Kontiokari et al. 1998).

CLINICAL EXAMINATION AND PNEUMATIC OTOSCOPY

Diagnosis of AOM is based on careful evaluation of TM with a pneumatic otoscope. Other methods are only supportive and never replace ear examination. The cooperation of patients and their parents is essential. Many children are afraid of doctors, and one should always have the time to create a calm and relaxed atmosphere for both patient and parents. A parent or nurse should hold the child's head gently but firmly, because head movements during otoscopy may painfully press the edge of the ear speculum into the sensitive auditory canal. Calming a screaming child, unfortunately, is sometimes impossible. In such cases, immobilizing the child is even more essential in order to avoid damage and thus a more traumatic experience (Hoberman and Paradise 2000).

Adequate illumination of the TM requires proper lighting and an open ear canal, but circumstances are seldom optimal. As many as one-third of physicians treating AOM have reported changing otoscope bulbs less often than recommended, and in one-third of otoscopes the light output has been inadequate (Barriga et al. 1986). Children's narrow ear canals are easily obstructed by cerumen, which compromises visualization. Cerumen removal is necessary in about 30% of children with AOM, and even more often in infants (Schwartz et al. 1983). Even despite an insufficient view, cleaning of the ear canal is frequently ignored (Jensen and Lous 1999).

In myringotomy-confirmed studies, a cloudy, bulging, poorly mobile TM has been the best predictor of AOM in children, and a red TM a poor predictor of middle ear effusion (Karma et al. 1989; Schwartz et al. 1981a). Degree of translucency of the TM is an important sign, because a purulent effusion in the middle ear makes the TM opaque (Schwartz et al. 1981a). Since evaluation of the TM is based on a subjective impression of color, position, and movement of the TM, often under suboptimal circumstances, interobserver variability occurs (Thibodeau and Berwick 1980; Hemlin et al. 1998).

Adequately performed pneumatic otosopy is quite an accurate method in diagnosing AOM, with a sensitivity over 90% and a specificity of nearly 80% (Cantekin et al. 1980; Mains and Toner 1989), but as with any other skill, it requires education and training. Convincing improvement in diagnostic accuracy has been reported after just a few months' experience (Mains and Toner 1989; Kaleida and Stool 1992). Studies on otoscopic accuracy and interrater agreement have, however, sometimes been performed by enthusiastic experts in pneumatic otoscopy, and the patients may even be under general anesthesia. Results of such studies are thus not directly applicable to clinical work. In the future, physicians will probably have more sophisticated and accurate methods. With fluorescence-emission spectrophotometry it was possible in an animal model to determine even the AOM pathogen noninvasively as long as ten years ago (Werkhaven 1994).

TYMPANOCENTESIS AND MYRINGOTOMY

Tympanocentesis (needle aspiration through the TM) and myringotomy (incision in the TM to provide fluid) are the only methods directly demonstrating the presence or absence of middle ear effusion (Rosenfeld 1999). These methods also have an immediate and positive effect on conductive hearing loss, which in AOM may be as significant as 50 dB (Margolis and Hunter 1991; Hunter et al. 1994). Their role as diagnostic methods and treatment modalities has changed completely during recent decades. In 1991, Finnish medical students and GPs were advised to perform myringotomy on every patient with AOM (Palva 1991) and as late as 1999 on patients with severe symptoms (Karma 1999). Yet neither tympanocentesis nor myringotomy enhances recovery, and they are no longer recommended as diagnostic or therapeutic methods for AOM in non-complicated cases (van Buchem et al. 1981; Kaleida et al. 1991). Nowadays, tympanocentesis and myringotomy are recommended only for complicated

AOM and when the etiologic agent needs to be identified (Dowell et al. 1999; Hoberman and Paradise 2000; Pichichero 2000). Myringotomy still plays an important role in training practitioners in diagnostic skills. This may be replaced in the future by simulation techniques (Kaleida and Stool 1992). There are already promising results from teaching myringotomy by use of an infant mannequin model with an artificial TM (Pichichero and Poole 2001).

TYMPANOMETRY

Tympanometry is a non-invasive, quick, safe, and painless method to measure relative middle-ear pressure (Terkildren 1959). It answers the key question of diagnosis: Is it likely that the middle ear contains fluid? And it even shows how much fluid it contains (Finitzo et al. 1992; Koivunen et al. 1997). Measurement is quite simple: A tone probe is set in place to seal the ear canal, the probe sends low sound energy, pressure in the ear canal is changed, and the sound energy reflected back from the TM is measured (Rosenfeld 1999). When pressure in the ear canal equals pressure in the middle ear, the TM vibrates loosely, which allows sound energy to enter the middle ear freely. This point of maximal admittance forms the peak of the tympanogram and corresponds to the pressure in the middle ear. If the middle ear contains fluid, the TM is not mobile at any pressure, and sound admittance to the middle ear is constant and poor, producing a flat curve (Palmu 2001). Because tympanometry is unable to a distinguish a serous from a purulent effusion, pathologic results must be combined with patient history and clinical examination. In AOM, symptoms of an acute infection must be present (Johansen et al. 2000).

Tympanograms can be classified in numerous ways (Marchant et al. 1986; Finitzo et al. 1992; Palmu et al. 1999). The simple and practical classification by Jerger divides tympanograms into classes A, B, and C. In type A, the middle ear pressure is more than -100 daPa, in type B, the curve is flat, and in type C, the middle ear pressure is less than -100daPa. Type A represents the normal middle ear, B, fluid in the middle ear or perforation of the TM, and type C, negative pressure in the middle ear (Jerger 1970). Type C tympanograms are frequently found during non-complicated common colds and are no longer considered pathological (Koivunen et al. 1997; Winther et al. 2002). Interpretation of tympanograms is easy, and interrater agreement has been excellent, even for infants' ears (Johansen et al. 2000; Palmu et al. 2000). Since the ear canal has to be sealed, some cooperation with the child is required. If the child is crying and struggling, the sensitivity of tympanometry is poor, and the examination thus useless. Type A tympanograms are reliable under all circumstances, but a incorrect position for the probe can produce a B curve mimicking pathology even in a dry middle ear (Koivunen et al. 1997).

Tympanometry is a valuable supplement to diagnosis but is seldom used (Honkanen et al. 2002; MacClements et al. 2002). In only 1% of AOM diagnoses in Finland has tympanometry been used. (Honkanen et al. 2002). Comparison of otoscopy and tympanometry has shown agreement in diagnoses for nearly 90% of children (Gimsing and Bergholtz 1983; Toner and Mains 1990). In some studies, sensitivity and specificity for tympanometry have been as high as 90% and 86% (Finitzo et al. 1992), whereas in others, figures have been 70% and 98% (Palmu et al. 2000) and 90% and 54% (Babonis et al. 1991). Pneumatic otoscopy and tympanometry have been equally accurate in detecting middle ear fluid with a predictive value of nearly 90%. To a validated and experienced otoscopist, tympanometry provides no additional benefit (Toner and Mains 1990).

When reading these studies, one must remember, however, that in most of them, physicians performing tympanometry and pneumatic otosscopy are real experts in diagnostics. Nowadays, hardly anyone has the daily possibility, not to mention desire, to compare the results of pneumatic otosopy to those of myringotomy in an acutely ill child. Surveys undertaken in primary health care are perhaps more serviceable to those still developing their diagnostic skills. To them, tympanometry provides a chance to gain experience in the relation of middle ear pressure to differing otoscopic views. In one study from general practice, more than one in every four initial diagnosis was changed after tympanometry (Johansen et al. 2000) and in another, 74% of GP's classified tympanometries correctly (Van Balen et al. 1999).

ACOUSTIC REFLECTOMETRY

Another objective method to detect middle ear effusion is acoustic reflectometry. This is even less frequently used than tympanometry, although measurement is easier to perform (Barnett et al. 1998; MacClements et al. 2002). Again, a probe including a sound generator and a microphone is inserted into the ear canal, but unlike in tympanometry, no seal is required. The probe transmits sound from 1800 Hz to 7000Hz, and sounds reflect back from the TM. Sounds reflected from the TM meet and partially cancel the sounds still approaching it. The probe analyzes the difference between reflected and transmitted sound waves. Any increase in sound cancellation between transmitted and reflected sounds increases the probability of middle ear effusion. Results are presented as a spectral gradient angle and are easy to interpret: a narrow angle for fluid, a wide angle for dry middle ear (Teele and Teele 1984; Lampe et al. 1985; Barnett et al. 1998).

In detecting middle ear effusion, acoustic reflectometry is as accurate as tympanometry or pneumatic otoscopy, with a sensitivity ranging from 67% to 94% and a specificity from 70% to 95% (Lampe et al. 1985; Schwartz and Schwartz 1987; Jehle and Cottington 1989; Lampe and Schwartz 1989; Block et al. 1998). Models are portable, and measurement takes only about 5 seconds per ear (Jehle and Cottington 1989). A small amount of cerumen does not interfere with measurement, but if more than one-third of the ear canal becomes obstructed, cleaning is needed (Schwartz and Schwartz 1987; Block et al. 1998). Some models are even designed and marketed for parents. As long as the child's general condition is good, parents can follow the symptoms of URI at home until acoustic reflectometry gives a positive finding. These consumer models are as accurate as professional instruments, and results have been well reproducible (Block et al. 1998).

RADIOLOGIC EXAMINATION

The characteristics of AOM make numerous demands upon diagnostics methods. Most importantly, due to the relatively benign nature of the disease, no risk or harm to the patient is acceptable. Examination should be painless and quick, and require no major degree of cooperation. Examination should also be inexpensive, easy to perform and interpret, and as in any method, be reproducible. Thus far, no radiologic modality fulfills these criteria. The plain radiograph and CT transmit ionizing radiation, MRI is expensive and time-consuming, and ultrasound requires cooperation and has unknown reliability and reproducibility in middle-ear studies.

Today radiology plays no role in the diagnostics of AOM. In the beginning of the 20th century, several authors conducted large series regarding radiologic findings in the mastoid cavity during acute and chronic otitis media (Eisinger 1932; Runström 1933). As CT is superior in imaging the complex bony structure of the middle ear and temporal bone, plain radiographs are now history. Thus far, MRI has not replaced CT but instead supports it by providing information also about the inner ear (Maroldi et al. 2001). Imaging is necessary, however, only for suspected complications. When complications are limited to the mastoid region, CT is the technique of choice (Maroldi et al. 2001), but intracranial complications require MRI (Dobben et al. 2000).

Theoretically, one method for diagnosing AOM, even in primary health care, may be ultrasound. It transmits no ionizing radiation, it is quick to perform, and due to the popularity of maxillary sinus ultrasound, most clinicians are already familiar with the method. Although the tympanic cavity is not ideally situated for any type of technique, it can be evaluated non-invasively through the tympanic membrane. A preliminary report on detecting middle ear fluid with ultrasound was published back in the early 1970's. In this technique, the ear canal is filled with conducting gel, and a transducer is placed in the canal a few millimeters from the TM. Ultrasound first reflects back from the TM, and in the case of middle ear fluid, also from the bony wall of the middle ear. Because ultrasound is unable to advance in the air, if the middle ear is dry, no reflection echo is received from the back wall (Abramson et al. 1972). Use of ultrasound in middle-ear study has remained experimental, even though new small-caliber and high frequency transducers have offered the potential to develop more practical solutions. Initial experiments with more advanced technology have been promising (Wu et al. 1998). In addition to theoretical advantages, ultrasound has, unfortunately, serious practical shortages that will probably prevent it from ever being an everyday tool in middle-ear study. Firstly, the ear canal should be filled with liquid or gel, as it is impossible to visualize the middle ear unless fluid or soft tissue lies adjacent to the TM. Secondly, standardization of the procedure would be almost impossible, and the examination would be highly dependent on the performer's skill. Thirdly, the examination requires much cooperation from the patient, and manipulation of the TM, especially in cases of AOM, is painful, which makes ultrasound unsuitable for children.

DIAGNOSTIC ACCURACY

The rapid increase in incidence of AOM has raised worldwide concern as to the diagnostic accuracy and adequate training of medical students and residents. As myringotomies and tympanocentesis are no longer clinically routine, physicians cannot verify the results of otoscopy. In Texas, pediatricians and otolaryngologists have evaluated videotapes of pneumatic otoscopic examinations. In these ideal circumstances without insufficient views, struggling toddlers or demanding parents, the pediatricians managed to diagnose AOM correctly in only 50% of cases and the otolaryngologists in 73% (Pichichero and Poole 2001). In North Carolina, results with tympanograms were evaluated against diagnoses made by pediatric residents and pediatric otolaryngologists, with only a moderate correlation (Steinbach et al. 2002). In Utah, agreement between physicians diagnosing AOM and URI was poor, as well (Lyon et al. 1998). In Texas, more than half the family-practice residents have insufficient criteria in diagnosing AOM, and only 15% used pneumatic otoscopy regularly (MacClements et al. 2002). In Denmark, only 11% of GPs used the pneumatic otoscope, and only 36% even had access to one (Jensen and Lous 1999). Sadly enough, doctors have been most uncertain of AOM diagnosis in those at highest risk, i.e., children younger than one year (Lyon et al. 1998; Froom et al. 1990).

Shortages in medical education and resident training explain relaxed criteria in diagnostics at least in part. In the US and Canada only slightly more than half of the medical faculties had formalized education concerning AOM during pediatrics courses (Steinbach and Sectish 2002). The reason family-practice residents gave for not using adequate diagnostic tools was their lack of training (MacClements et al. 2002). Formal training programs have improved the diagnostic accuracy and increased the likelihood of using the equipment required (Kaleida and Stool 1992; MacClements et al. 2002)

AIM OF THE STUDY

The aim of this study was to characterize the reliability of diagnosis of upper respiratory infections. The specific questions asked were:

1. **What diagnostic criteria and equipment in primary care do GPs use for suspected AMS in adults and suspected AOM in children?**

2. **Can PNIF and PNEF be suitable methods in primary care for the diagnostics and follow-up of nasal diseases?**

3. **What is the interrater agreement between otorhinolaryngologists and GPs in diagnosing adult AMS and child AOM?**

4. **Can the use of strict diagnostic criteria, the pneumatic otoscope, and tympanometry affect the rate of AOM diagnoses in children with a history of recurrent AOM?**

5. **Does MRI reveal mastoid cavity pathology in an asymptomatic children, and if so, is this related to the child's history of middle-ear disease?**

PATIENTS AND METHODS

All studies were prospective. Methods are described in detail in the original papers (I-V). All study protocols were approved by the ethics committees of Helsinki Health Center (I, III) and Helsinki University Central Hospital (II, IV, V), and informed written consent was obtained from each of the patients or guardians. Since patients and circumstances in secondary and tertiary centers differ from those of primary health care, we paid special attention to the selection of patients and volunteers: Studies concerning primary health care (I, III, IV) were conducted in primary health care clinics, and the study concerning mainly secondary or tertiary centers (V) was conducted at a university clinic. In primary care clinics, the equipment used was the equipment already available to every GP in that clinic (I, III, IV), and no special projections were required for findings in head MRI (V). Because standard values for several tests (Obi 1984; Cox and Walker 1997; Mäntyjärvi and Laitinen 2001; Mohidin et al. 2002) are determined from hospital staff, and having volunteers among them is convenient, we collected the study group for Study II from the hospital staff.

Patients and volunteers

For Studies I and III we recruited 50 patients to both studies at walk-in clinics, children at the Hospital for Children and Adolescents (III), and adults at Maria Hospital (I). In Study I, the inclusion criterion was self-suspected AMS and in Study III self- or parent-suspected AOM. Study II comprised 100 nonsmoking volunteers, 50 women and 50 men, from among the staff and students of the Helsinki University Otorhinolaryngology clinic. For Study IV we recruited 309 otherwise healthy children with a history a recurrent otitis media. Study V included scans and records of 50 children undergoing MRI for suspected noninflammatory intracranial pathology at the Department of Pediatric Neurology at Helsinki University Hospital.

Study designs

STUDIES I AND III

These study designs were, to some extent, identical. The patients were first examined by the GP on duty. Immediately after this GP's examination, the investigator, a senior resident in otorhinolaryngology, examined the same patient. She was responsible for the final diagnosis and treatment and was not informed of the GP's examination or diagnosis. Study I included ultrasound examination of the maxillary sinuses, PNEF, three-view sinus radiographs, and measurement of C-reactive protein as well. In Study III, the same otorhinolaryngologist photographed patients' TMs through an endoscopic camera. Afterwards, two experienced clinicians analyzed the photographs independently with and without tympanograms.

In Study I, the otorhinolaryngologist performed a maxillary sinus puncture if she suspected AMS. Later, a radiologist interpreted the radiographs. We collected a reference group by using the same inclusion criterion, i.e., patient with self-suspected AMS, from among patients at another primary care clinic, the Malmi Hospital. The charts from the same study days as when the otorhinolaryngologist was at the study clinic were collected. The diagnoses and treatment by a GP were analyzed and compared with diagnoses in the study clinic.

STUDY II

The same three experienced laboratory technologists performed all measurements on 100 healthy volunteers in a standardized setting of a research laboratory. PNEF and PNIF were measured and the best of three results recorded. To test diurnal variation, a subgroup was drawn of 20 of 100, 10 women and 10 men. They recorded expiratory and inspiratory flows every morning and evening at home for 7 days. To test repeatability we chose 20 women to perform PNIF and PNEF in two series of three consecutive measurements with a 2-minute pause between the series.

STUDY IV

Children were followed up for 24 weeks at our study clinic. The study protocol included three visits to the clinic: the baseline visit, intermediate visit after 12 weeks, and final visit after 24 weeks.

At each visit, the study physician examined the child's ears with a pneumatic otoscope and performed tympanometry. In addition to the scheduled visits, parents were instructed to bring the child to the study clinic every time they suspected AOM. AOM was diagnosed when middle ear effusion and signs and symptoms of an acute infection were apparent simultaneously (Bluestone 1995). If a child fulfilled the diagnostic criteria and had been at least one day without any symptom of acute infection since the previous episode of AOM, the diagnosis was a new episode of AOM. The number of AOM diagnoses during the study was compared to that during the preceding 6 months.

STUDY V

A pediatric nurse performed tympanometry on all children prior to an MRI scan. While children were having this MRI, their parents completed a questionnaire regarding the child's medical history and recent symptoms related to otitis media. Retrospectively, an otoradiologist evaluated the images for mastoid, paranasal, and nasopharyngeal findings. Results were compared between the questionnaire, radiological findings, and tympanometry.

Methods

CLINICAL EXAMINATION (I, III, IV)

Clinical examination of adults included anterior and posterior rhinoscopy, pneumatic otoscopy, examination of the mouth and pharynx, indirect laryngoscopy, palpation of cervical lymph nodes, and auscultation of breath sounds (I). In children the examination was similar to that of adults except that no posterior rhinoscopy and indirect laryngoscopy were performed (III, IV).

PLAIN SINUS RADIOGRAPHS (I)

Plain sinus radiographs were performed for all patients with self-suspected AMS. Radiographs included three standard projections: an occipitomental view (Waters) to evaluate the maxillary and frontal sinuses, an occipitofrontal view (Calwell) to evaluate the ethmoid and frontal sinuses, and a lateral view to evaluate the sphenoid sinuses. Radiologic criteria for maxillary sinusitis were defined as more than 6 mm of mucoperiosteal thickening or an air-fluid level or total opacification of the maxillary sinus (Axelsson et al. 1970).

ULTRASOUND (I)

Ultrasonography of the maxillary sinuses was performed with the ultrasound device Sinuscan 102 (Oriola, Finland) at a frequency of 3 MHz and a transducer diameter of 8 mm. The result was classified as normal when there was no back-wall echo and abnormal when the back-wall echo was seen at a distance of 3.5 cm or more (Rohr et al. 1986).

PEAK NASAL EXPIRATORY FLOW (I, II)

PNEF was measured with the participant in a sitting position with the mini-Wright Peak Flow Meter (Clement Clarke). Each participant was instructed to take a deep breath, then to put on a rubber mask and to exhale sharply through the nose, making a maximal nasal expiratory effort with the mouth closed. The best blow of three was recorded. In Study I, the peak flow rate between 250 l/min and 300 l/min was recorded as normal, values lower than 250 l/min as low, and higher than 300 l/min as high (Viani et al. 1990).

PEAK NASAL INSPIRATORY FLOW (II)

PNIF was measured (In-check, Clement Clarke Int. Ltd, Harlow, UK) in a sitting position as well. Each participant exhaled fully, put the mask on, and inhaled forcibly through the nose. Again, the best result of three was recorded. If the participant had problems with the technique, more than three attempts were permitted.

MAGNETIC RESONANCE IMAGE (V)

All children were scanned on 1.5T unit MRI (Vision Siemens, Erlangen, Germany). Both maxillary sinuses, the ethmoid sinuses, and mastoid cavity and middle ears were evaluated separately. Signal intensity on T_2-weighted images was classified as low, intermediate, or high. Nasopharyngeal mass was categorized as absent, not prominent, moderately prominent, or prominent. When a contrast agent was applied, mucosal enhancement was recorded as positive or negative.

TYMPANOMETRY (I, III, IV, V)

Tympanometries were performed with the Danplex Handtymp (Copenhagen, Denmark) (V), the GSI 37 Auto-Tymp (IV), or GSI 38 Auto-Tymp (the latter two from Grason-Stadler Inc. Milford, NH, USA) I, III. As the classification system, we used Jerger's, in which in the A-type curve, middle-ear pressure is more than -100 daPa, in the C-type, less than -100 daPa, and in the B-type flat (Jerger 1970).

STATISTICAL ANALYSIS (I-V)

Statistical analysis was done with SPSS 9.0 for Win dows. A p-value of 0.05 was considered significant.

In Study I, Fisher's exact test was used and continuous variables categorized. The cut-point for C-reactive protein was ten.

In Study II, association of age and height with PNIF and PNEF measurements was calculated by stepwise multiple linear regression analysis. The coefficient of repeatability was determined by first calculating the differences between the first and second measurements. Then the mean and SD of the differences were plotted against the average of the two measurements (Bland and Altman 1986).

In Study III, the sign-test served to compare changes in diagnostic rates. Agreement between clinicians was measured with Cohen's κ, which has the value 1 if agreement is perfect and 0 if agreement equals that by chance. If $\kappa \geq 0.75$, the agreement is considered excellent (Woodward 1999).

In Study IV, the number of AOM diagnoses during the 6-month follow-up was compared to that during the preceding 6 months. Their change was tested by the paired samples t-test, with the result expressed as the mean with a 95% confidence interval.

In Study V, the χ^2 test served to compare between radiological findings and AOM history.

RESULTS

Diagnosing acute maxillary sinusitis and acute otitis media in primary care (I, III)

Interrater agreement between the otorhino-laryngologist and GPs in adults with self-suspected AMS was 58%. GPs paid most attention to non-specific symptoms and signs like tenderness of the maxillary sinus during percussion (Table 1). More disease-specific examinations: anterior and posterior rhinoscopy, were performed in 54% and 12% of the patients, respectively, and sinus ultrasound in 50%. Agreement with the otorhinolaryngologist in interpretation of ultrasound was 64%. An otorhinolaryngologist diagnosed AOM in 44% and the GP on-call in 64% of the children brought to the walk-in clinic for suspected AOM.

The clinicians agreed on the diagnosis of AOM in 64% of children. GPs paid the most attention to TM color, whereas TM movement was the most important sign for the otorhinolaryngologist. For color, mobility, and position of the TM, the otorhinolaryngologist recorded 100%, but the GP 87%, 69%, and 47%, respectively. Photographs of every child's TM with and without tympanograms were shown to two experts experienced in AOM diagnoses. Tympanometries reduced the number of AOM diagnoses and raised the amount of diagnostic agreement between the otorhinolaryngologist and both experts and also between the experts. Use of the pneumatic otoscope and tympanometry reduced the number of AOM diagnoses over 30%.

Table 1.
Classification of examination results by otorhinolaryngologist and general practitioner in 50 patients with self-suspected acute maxillary sinusitis

Examination	Examinor	Not performed N (%)	Normal (%)	Abnormal N (%)
Tenderness of the maxillary sinus during percussion	Orl	1 (2)	12 (24)	37 (74)
	GP	8 (16)	5 (10)	37 (74)
Anterior rhinoscopy	Orl	2 (4)	15 (30)	33 (66)
	GP	23 (46)	15 (30)	12 (24)
Posterior rhinoscopy	Orl	9 (18)	24 (48)	17 (34)
	GP	44 (88)	2 (4)	4 (8)
Otoscopy	Orl	0 (0)	48 (96)	2 (4)
	GP	18 (36)	30 (60)	2 (4)
Ultrasound of the maxillary sinus	Orl	1 (2)	43 (86)	6 (12)
	GP	25 (50)	19 (38)	6 (12)

Peak nasal inspiratory and expiratory flow measurement (III)

Distribution of individual values for both PNIF and PNEF was large and repeatability poor (See Study II, Figure 2). Diurnal variation in both PNIF and PNEF was substantial, with results varying over 50% in measurements performed on consecutive days for several volunteers. Age and height showed no logical association with either PNIF or PNEF.

Effect of accurate diagnostic criteria on incidence of acute otitis media in otitis-prone children (IV)

During the 6-month study period, AOM diagnoses decreased 56%, and 77% of children had fewer episodes of AOM discovered than during the preceding 6 months (See Study IV, Figure 2). None of the children developed any AOM complications.

Prevalence and significance of incidental MRI abnormalities in children's mastoid cavity and middle ear (V)

MRI abnormalities mimicking inflammation in the mastoid cavity and middle ear occurred in 12% of children scanned for neurological indications (See Study V, Table 1). Changes correlated neither with neurological diagnoses, inflammatory changes in paranasal sinuses, nor with season in which imaging too place.

Tympanometries performed by pediatric nurses after one training session were found to be unreliable.

DISCUSSION

Past

Diagnosis of AOM and AMS has changed in conjunction with changes in medicine and in society. Social factors in part explain the rapid increase in incidence of diagnosed of AOM and AMS. Although the diseases and the equipment used in diagnosis are mostly the same as 50 years ago, the world is different (Morrison 1955). Today we have almost 20 000 physicians in Finland, one for every 263 inhabitants. In 1900 there was only one physician for every 7143 inhabitants, in 1950 for 2018 inhabitants, and in 1970 for 958 (Lääkäriliitto 2002). Distances to receive medical care were long, and highly respected doctors were not to be bothered with the so-called minor diseases. The elderly often say that in the old days they held warm cabbage leaves to their cheeks during bad colds; and tobacco smoke was blown into aching ears. After a few days they got better. Myringotomy and maxillary puncture were the only treatment modalities before antibiotics, and although this truth is easily forgotten, AOM and AMS do have a high rate of spontaneous recovery (van Buchem et al. 1981; van Buchem et al. 1997). Penicillin brought a revolution in treatment of all infectious diseases in the 1940s and has remained the most important drug for AMS and AOM ever since (Chain et al. 1940; Otolaryngologiyhdistys 1999; Puhakka et al. 1999).

In the agricultural world most people lived and worked on farms. They had fewer contacts than do people in crowded urban environments where infection-carriers are constantly nearby. Before migration from country to town, small children were at home whether healthy or ill, and farm work had to be done, regardless of circumstances. A medical certificate for absence from work offered no social benefit in other industries, either. In Finland, a general workman's sickness benefit was suggested as early as 1911, but a law requiring it was not passed until 1963, long after Sweden's, Norway's, and Denmark's (Häggman 1997).

The present

People in Finland are highly educated, the media reports health issues eagerly, and medical information via the Internet is available to all (Havén 1998). There are more physicians than ever (Lääkäriliitto 2002), the law requires occupational health service for every worker, short sick leaves have no effect on employees' income, and primary health care for children is free of charge (Eduskunta 1972, 2001). Although the significant improvements and changes have solved many problems in the health care service, supply and demand are still unbalanced, and new challenges arise.

Rapid development in medicine produces not only much of the information desired but also information for which no one asks. How to react when a child with no infectious symptoms is scanned for migraine or hydrocephalus, and head MRI reveals acute mastoiditis, a potentially fatal condition? Should antibiotics be prescribed, just to be sure, or can the unsought information simply be ignored? Should the unexpected changes be followed up and if so, when? In 2002 almost 750 head MRI scans were performed at the Helsinki University Hospital for Children and Adolescents alone, and over 100 children were scanned in private hospitals in Helsinki, so these questions are of more than of academic interest (Puputti 2003). We recommend that if the child has no symptoms related to the ears, increased signal intensity in the mastoid cavity and the middle ear in T_2-weighted images does not require treatment. If otitis is suspected, a physician must always examine the child's ears (V).

While physicians at the university clinics are surrounded with modern machinery and overwhelmed with the information it produces, their colleagues in primary health care base their diagnoses mainly on patient history and clinical examination with limited equipment. Despite the fascinating visions of growing new organs from stem cells, transplanting brains, and preventing fetal diseases in utero, today's patients tend to have banal plagues like common colds, and children still cry all night with pain in their ears. To see how these diseases are diagnosed and treated and whether we would do anything differently in the same circumstances with the same patients, we conducted Study I and Study III and found that GPs seldom followed the recommended diagnostic criteria (Otolaryngologiyhdistys 1999; Puhakka et al. 1999). When GPs examined children, tympanometry was not even available. This should not be even a financial issue, because one light and portable instrument can serve several clinicians at a polyclinic or primary care center. It is not realistic to assume that every primary health care centre provide its GPs with all existing equipment, but it is reasonable to expect GPs to use the equipment already available and to have up-to-date knowledge of the most common diseases they diagnose and treat. Those designing medical education should also carefully consider the emphasis of the curriculum, and remember that the most relevant diseases for medical students are those they face as GPs and not those which are the focus of their own research work.

Expectations in diagnosis and treatment of URI differ between patients' and physicians' : Physicians recognize the diagnostic problems-in one study almost 90% of Finnish GPs thought that too many antibiotics are prescribed for AMS (Varonen and Sainio 2003). Physicians prescribe antibiotics in part because they want to fulfill patients' or parents' expectations (Hamm 1996; Palmer and Bauchner 1997), whereas the patients, in fact, realize the importance of careful examination and properly explained diagnoses (Hamm 1996; Varonen and Sainio 2003). Patients' beliefs about the best treatment for their illnesses have borne little resemblance to the GP's diagnosis, while 35% of pediatricians have admitted they occasionally prescribe antibiotics to a child on the parents' request, though believing these were unnecessary (Hamm 1996; Palmer and Bauchner 1997). People are either more demanding when their children are ill, pediatricians are more sensitive to others' expectations than are GPs, or pediatricians are just more honest in surveys. In our studies, patients and parents seldom had an opinion about the best treatment for the illness, or they were unwilling to share it. In Studies I and III, only 22% of patients thought antibiotics were the best treatment for the disease, whereas 62% (I) and 38% (III) actually received a prescription.

No doubt, the incidence of AOM and of AMS has risen (Joki-Erkkilä et al. 1998; Schappert 1999), but the health care system itself may to some extent be responsible. In order for one to stay home when sick or to care for a sick child, employers demand some kind of medical certificate. Mothers working outside the home are more likely take their children to the doctor than are nonworking mothers simply because legally they must (Horwitz et al. 1993). Some decades ago, people had no financial reason to seek medical care for URI symptoms, and AOM and AMS, in most cases, do not actually require any treatment at all (van Buchem et al. 1985; van Buchem et al. 1997; Damoiseaux et al. 2000). Both AOM and AMS can, however, develop even fatal complications (Pitkäranta et al. 1999; Hytönen et al. 2000; Ghaffar et al. 2001). Since GPs in Finland seldom have the luxury of offering close follow-up to their patients with symptoms of URI, nor even the circumstances to examine them adequately in the first place, overdiagnosis and unnecessary antimicrobial treatment are, if not acceptable, at least understandable. We believe that not only medical equipment and clinical skill but also these circumstances affect parents, children, physicians, and thus diagnoses. Our study clinic in Study IV offered nearly ideal circumstances: The clinic physician was always the same, appointment length was 30 minutes, parents were encouraged to make contact even for the slightest suspicion of AOM, and the clinic was especially designed and decorated for children under school age. In spite of their history of recurrent AOM, the children, with few loud exceptions, were usually surprisingly calm and cooperative. Parents had the opportunity for questions, and the physician had time to answer them. Visits to the clinic could always be arranged on that very day or the following day. The service was free of charge. Because we had the possibility for close follow-up, there was no need for antibiotics if the diagnoses was unclear, and parents never ones requested antibiotics. We had the impression that they trusted the physician's decision, because it was based on careful examination, and the reasons for the chosen treatment were explained. Since no myringotomy or paracentesis was performed, one can argue that our decrease in AOM incidence was due to underdiagnosis. This is, of course, possible, although both tympanometry and the pneumatic otoscopy are reliable in detecting middle ear fluid (Karma et al. 1989; Watters et al. 1997), and we know that none of our patients developed any AOM-related complication.

A new treatment strategy for AOM– observation was introduced and found safe almost 20 years ago, and since then, several trials have confirmed the safety of symptomatic treatment and close follow-up (van Buchem et al. 1985; Damoiseaux et al. 2000; Rosenfeld 2001). Although this is officially recommended in the Netherlands, GPs have not fully adopted the policy even there (Damoiseaux et al. 1999). This observation strategy would inevitably reduce, not only the number of antibiotic prescriptions, but also the number of AOM diagnoses, because it includes clear diagnostic criteria. Unlike most recommendations, it also admits the uncertainty in AOM diagnoses (Rosenfeld 2001). Observational treatment would lead to statistical error only in the case of overdiagnosing. In a case with an incorrect AOM diagnosis at the first visit, no acute infectious symptoms would probably be present, and the ears would still be healthy at the follow-up visit, thus requiring no antimicrobial treatment. This strategy is not, at least not yet, recommended in Finland (Puhakka et al. 1999). As Dr Rosenfeld rhymes in his lovely observation-option poem: "But the observation option is best ignored, when timely follow-up cannot be assured" (Rosenfeld 2001).

Since resources in health care are limited, they must be targeted wisely. As the World Health Report 2000 summarizes the issue: the emphasis is not on more money for health but more health for the money (Murray and Frenk 2001). This is, in other words, evidence-based medicine, a combination of a physician's clinical skills and knowledge plus the best available evidence from systematic research (Sackett et al. 1996). Accurate and relevant diagnostic tests are important tools that help the physician make the right diagnosis and choose the best treatment (Sackett et al. 1996). It is impossible to evaluate the efficacy of treatment afterwards if the diagnosis is not reliable in the first place. Thus far, nasal diagnoses in primary health care have been based on the patient's and physician's subjective impressions of nasal airflow, which for various reasons, may be restricted . Our colleagues in primary care have been ill-equipped to diagnose objectively even the most common nasal diseases, certainly not those allergic or infectious. We thought that PNIF and PNEF could suit primary care use and were hoping to construct a standardized normal range, perhaps dependent on patient's gender, age, or height, like the peak expiratory flow from the lungs. PNIF and PNEF seemed, unfortunately, to be more or less useless in characterizing the complex nasal function reliably. Their valuable characteristics: economy, portability, non-invasiveness, and speed could not balance the cold statistical evidence showing large variability and poor repeatability. So the nose will challenge researchers after us, and a practical nasal functioning test remains to be found.

Future

Today the challenge in AOM and AMS lies in accurate diagnosis and correct treatment. In the future, when the pathogenesis and mechanisms of upper respiratory infections are truly known, infections can, we hope, be prevented with precision strikes at key points in the infectious process. We need to comprehend, for example, the role of the Eustachian tube and how inflammatory mediators affect it (Doyle et al. 1990), and why some of those exposed do not become infected (Gwaltney et al. 1980). Despite several ambitious trials, no truly effective vaccine or other method preventive of AOM has yet been introduced. It is, of course, impossible to eliminate risk factors such as gender, and age, and genetics, but modification of some: i.e., bottle-feeding, imperfect hygiene in day-care centers, parental smoking, and use of pacifiers, is possible and to some extent effective (Uhari and Möttönen 1999; Niemelä et al. 2000). The efficacy of pneumococcal vaccine in overall reduction of AOM has been only 6% (Eskola et al. 2001), whereas intranasally administered influenza vaccine has reduced AOM episodes by 30% (Belshe et al. 1998). Intranasal fluticasone propionate and xylitol have failed in prevention when administered after the onset of upper respiratory infection (Ruohola et al. 2000; Tapiainen et al. 2002), even though regularly administered xylitol has been effective in preventing AOM in healthy children (Uhari et al. 2000). Rhinoviruses are the most common pathogens of common colds (Arruda et al. 1997; Nicholson et al. 1997; Mäkelä et al. 1998) and start their replication in the nasopharynx (Winther et al. 1986). A nasally administered agent affecting the nasopharyngeal mucosal surface and its protective system could, in theory, be effective in preventing URI and thus AOM and AMS. Attempts have been made but reduction in AOM cases by modification of nasopharyngeal pathogen carriage with an antiadhesive oligosaccharide has been ineffective (Ukkonen et al. 2000). Tasty prevention may come from eagerly studied functional food: At least probiotic milk and red wine show protective effect against URI (Hatakka et al. 2001; Takkouche et al. 2002).

As long as infections are inevitable, some kind of reliable, rapid, bedside tests for URI diagnoses are badly needed. It is impossible to distinguish between pathogens clinically, even distinguish bacterial from viral ones, and yet we know that some pathogens cause more morbidity than do others, and early treatment is essential, especially for the elderly (Nicholson et al. 1997; Walsh et al. 1999). Treating viral diseases with antibiotics exposes patients to unnecessary adverse effects and wastes money. Treatment failures in AOM are common when the pathogens are viruses, especially rhinoviruses (Chonmaitree et al. 1992; Sung et al. 1993; Patel et al. 1995). In patients with AMS, rhinoviruses can also be detected in 40% of sinus aspirates and in 50% of sinus epithelium (Pitkäranta et al. 1997; Pitkäranta et al. 2001). When infections are unresponsive to first-line treatment, physicians are tempted to prescribe wide-spectrum antibiotics, even though resistant bacteria cause treatment failure only rarely (Arola et al. 1990). Early diagnosis and treatment of viral diseases could reduce the use of antibiotics and also have an impact on risk for developing bacterial complications like AMS and AOM (Pitkäranta et al. 1997). Practical and safe medication for viral URI is no longer science fiction but rather a matter of time. Neuraminidase inhibitors and pleconaril have shown that development of efficient medication is possible (Whitley et al. 2001; Hayden et al. 2002). When challenges concerning adverse effects, administration, and price are solved, we will enter a new era in treatment of URI. Identification and treatment modalities for viruses would not mean medication for every infection: most viral URIs resolve spontaneously, and treatment could be focused more on infections causing significant morbidity (Walsh et al. 1999), and on patients at high risk for complications (Sung et al. 1993). Developing tests and medication also for the so-called benign viruses is nevertheless equally essential, as the epidemic of severe acute respiratory syndrome (SARS) in spring 2003 demonstrated (Tsang et al. 2003).

For the scientist, a modern aspect of the follow-up of URI and other diseases is evaluation of quality of life. Patients, on the other hand, have never cared about nasal volumes nor the presence of middle ear effusion; they just want to breathe normally, hear properly, and feel healthy. Quality of life is part of evidence-based medicine and will be routine in all clinical research in the future. Sensitive and standardized disease-specific questionnaires for evaluation of quality of life will be developed for each disease. Improvement in objective measurements even of patients' symptoms is of no interest if quality of life is not improved, as well. We already know that severity of nasal symptoms does not necessarily correlate with quality of life (Radenne et al. 1999).

In the near future, patients and parents will have non-invasive and easy-to use diagnostic equipment at home and can consult health care professionals if specific treatment is needed. Acoustic reflectometry is already marketed for domestic use (Barnett et al. 2000). There will also probably exist computer programs to calculate the most likely diagnosis based on symptoms, signs, and patient history. Such programs already exist for other diseases such as vertigo (Kentala et al. 1996).

Just as today, tomorrow's physicians will be surrounded by new information, part of which is of unknown clinical relevance. No doubt, also functional MRI and PET images will produce unexpected findings for the middle ear and paranasal sinuses, and clinicians and radiologists will be as puzzled as we are today with our conventional MRI findings. Developing new medication and equipment from idea to clinical practice takes decades, and every step produces fresh information, both relevant and irrelevant. During that process, scientists have to choose those paths they believe are worth following–without any guarantee of the value of the final product. Those who have approached the tree of knowledge are also aware of the adder living there and thus know that medical knowledge is neither solid nor permanent. The scientist must have vision and gaze toward the future, but a clinician meets, diagnoses, and treats patients today, in the here and now. While awaiting new vaccines, diagnostic equipment, medication, or other help for children and adults under the burden of recurrent antimicrobial treatment and surgical interventions, clinicians can use the equipment and knowledge available, make a real difference in diagnostic rates, and most importantly, ensure correct diagnoses for their patients.

CONCLUSIONS

1. GPs based their AMS diagnoses mostly on the patient's suspicion of AMS and on tenderness of the maxillary sinus during percussion. The child's symptoms and the color of the tympanic membrane were the diagnostic criteria most commonly used in AOM diagnoses.

2. PNIF and PNEF measurements showed large variability and poor repeatability which made them unsuitable both for diagnoses and for follow-up of nasal diseases.

3. Interrater agreement between otorhinolaryngologist and GP for adults with self-suspected AMS was 58% and for children with parent-suspected AMS, 64%.

4. Use of proper diagnostic criteria, and the pneumatic otoscope and tympanometry in children with history of recurrent AOM reduced AOM diagnoses by 56%.

5. Incidental high signal intensity in MRI from the mastoid cavity and middle ear may occur in asymptomatic children without apparent AOM or history of middle-ear disease.

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