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Cover picture

AMERICA'S FIRST HOSPITAL PHARMACY
(About 1755)

Colonial America's first Hospital Pharmacy began operations in 1752, one year after Pennsylvania Hospital was established in a Philadelphia house. John Morgan, first as hospital pharmacist, later as a physician, championed independent practice of the two professions.

One of a series: *A History of Pharmacy in Pictures*, presented by Parke, Davis & Company.

George A. Bender, Director Robert A. Thom, Artist

Management of ear discharge

Introduction

Ear discharge is the commonest ear symptom presenting to general medical practitioners. The cause may be in the external or middle ear. The external auditory meatus has an outer cartilaginous and inner bony part. Sebaceous glands, ceruminous glands and hair follicles are present only in the outer part. The tympanic membrane lies obliquely at the inner end of the meatus. The middle ear is a cleft in the temporal bone, lined by mucosa. It communicates anteriorly with the nasopharynx via the Eustachian tube and posteriorly with the mastoid air cells through aditus and antrum.

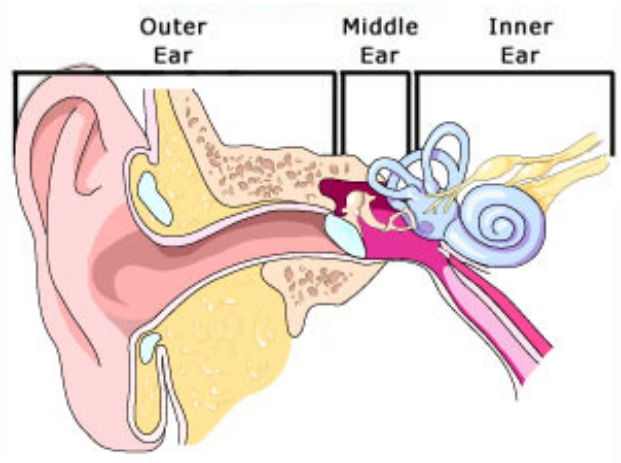

Figure 1. *Anatomy of the ear canal.*

Panel 1. Common differential diagnoses of ear discharge

External ear	Generalised otitis externa - bacteria/ virus/fungus focal otitis externa - furuncle
Middle ear	Acute otitis media Chronic suppurative otitis media Cholesteatoma

Diseases of the external ear

Intact skin is a barrier for fungi and bacteria; self inflicted trauma to skin by cleaning the ear canal with various tools (cotton buds, safety pins, keys, hairclips) is the commonest cause of external ear infection. When the external ear canal is infected, there is pain and swelling. Itching and irritation are also common. However, the hearing is not impaired. Outer ear infection is commonly caused by bacteria or fungi.

Fungal infection Fungal infection is common, mainly from *Candida albicans* and *Aspergillus flavus*. *Candida* infection produces a white curd like discharge. *Aspergillus* produces a thick mycelium that adheres to the skin and blocks the ear canal. The discharge appears as wet blotting paper with black spores.

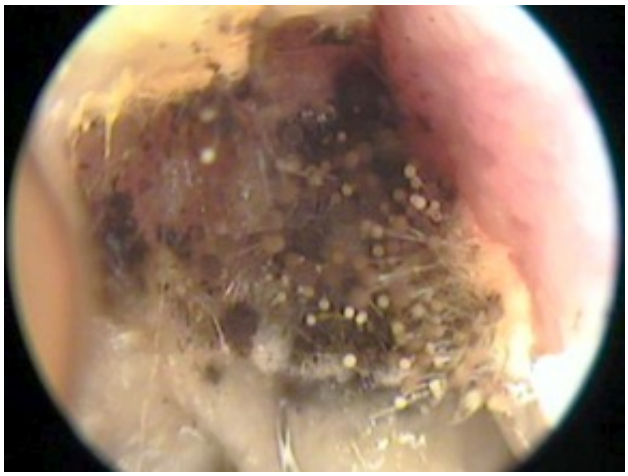

Figure 2. *Fungal infection of the external ear canal as seen by otoscope.*

Treatment Clean debris and prescribe antifungal ear drops and cream for 1 month. Antifungals from the azole class (clotrimazole, fluconazole, ketoconazole and miconazole) seem to be the most effective, followed by nystatin and tolnaftate [1]. Fungal infection affects all cell layers of the stratified squamous epithelium, the cell cycle is 1 month, hence for complete eradication the duration of one month of antifungals is recommended. In addition to topical therapy, aural hygiene is important in the treatment of otomycosis, as ototopical medications work best after cleaning of secretions and debris. The patient should keep the ear dry by using ear plugs during bathing.

Furuncle

Furuncle (infection of hair follicle) is due to self-inflicted injury of the ear canal. There is severe pain due to stimulation of nerve endings. The causative organism is *Staphylococcus aureus*.

Treatment Cloxacillin capsules 500mg 6 hourly for 7 days and local application of fusidic acid or muporocin. Treatment with intravenous antibiotics may be required if there is perichondritis, fever or regional lymphadenopathy.

Incision and drainage are not usually indicated.

Insertion of a small pope wick even if the canal is swollen may be recommended. Steroid antibiotic drops can be inserted on the wick to reduce oedema.

Prevention The patient has to stop cleaning the ear canal with various objects and use ear plugs during bathing. 0.5% Acetic acid solution (3 drops twice a day) can be applied on a long term basis to the ear to maintain a low pH environment which inhibits bacterial and fungal infection in people who have recurrent outer ear infection.

It is important that diabetes mellitus is excluded in all cases of outer ear canal infection.

Diseases of the middle ear

Acute otitis media (AOM) Infants and toddlers are more commonly affected. It is the second most common disease of childhood, after upper respiratory infection (URI). The eustachian tube and the middle ear are parts of the respiratory tract and each time a child gets a cold (viral infection) the middle ear is inflamed. Secondary bacterial infection with *Haemophilus influenzae*, *Streptococus pneumoniae* and *Morexella catarrhalis* may supervene. The child gets severe earache due to exudate causing increased pressure within the middle ear. The child may have diarrhoea, vomiting and refusal of feeds. Ear examination is a must in any crying baby to visualise the inflamed drum.

Treatment AOM can be a self-limiting infection. Many guidelines suggest deferring the antibiotics in acute bacterial otitis media for one to three days if pain is manageable. No adverse effect on long term outcomes have been found when antibiotic treatment is withheld. A recent trial has found increased rates of recurrence of otitis media in children who were treated with antibiotics.

If pain does not subside antibiotics have to be given for 7 days. The first line antibiotic treatment, if warranted, is amoxicillin. If the organism is resistant, then amoxicillin-clavulanate, or another penicillin derivative plus a beta lactamase inhibitor is indicated.

If the ear is discharging, an ear swab has to be sent for culture and ABST. Empirical antibiotics can be started before the report is available. Review the patient in 2 weeks to assess the state of the ear drum. If the perforation persists, the ear canal has to be protected during bathing with an ear plug. Perforation will heal gradually if the ear is kept dry. If the perforation does not heal, surgical closure (myringoplasty) may be required later.

Recurrent AOM Some children get recurrent AOM. If they get more than 3 attacks in one year, insertion of a ventilation tube (grommet) is recommended to correct the eustachian tube dysfunction.

Chornic suppurative otitis media with central perforation

When there is a persistent perforation of the ear drum, the middle ear cleft can get infected via two routes ie. outer ear canal and eustachian tube. Persistent perforation could be secondary to acute otitis media or trauma.

When the middle ear cleft is infected by bacteria *(Eschevichia coli, Proteus sp, Pseudomonas)*, there is copious mucoid discharge with no associated pain. A superadded fungal infection may be present.

Treatment Ear swab should be taken for culture and ABST. Aural toilet, oral and topical antibiotics for one week and antifungal cream (optional), are effective.

The ear should be covered during bathing. Immersion in water during bathing is prohibited. Whenever there is an infection, a course of antibiotics will help to settle the infection. When the ear is dry, perforation can be closed (myringoplasty) by using patient's own tissue ie. temporalis fascia or tragal perichondrium.

When there is persistent infection in the mastoid air cells, it is necessary to clear them by cortical mastoidectomy in addition to myringoplasty.

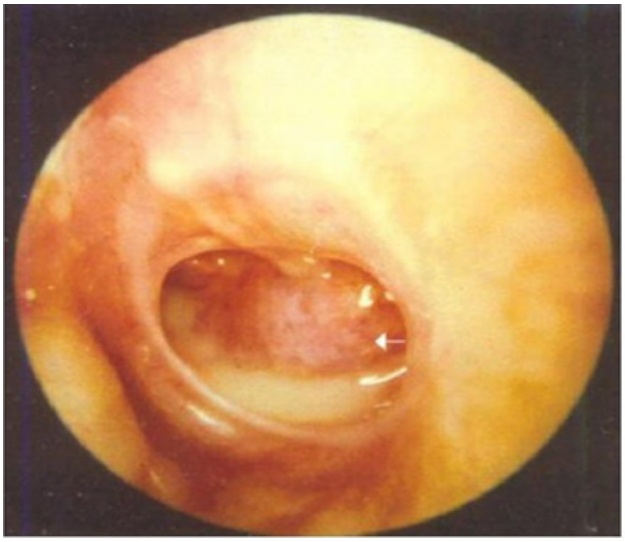

Figure 3. *Central perforation with discharge in the middle ear.*

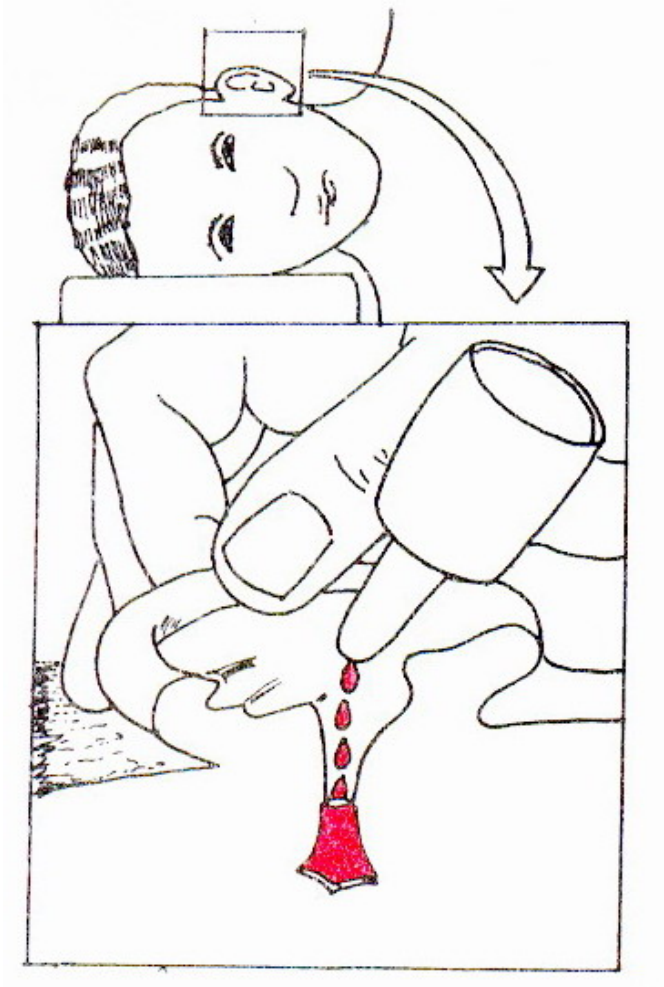

Figure 4. *Method of insertion of ear drops.*

Chronic suppurative otitis media presents with attic or marginal perforation with or without cholesteatoma. The outer ear canal and the outer part of the ear drum is lined by skin (stratified squamous epithelium). Due to various reasons the skin can migrate into the middle ear forming a retraction pocket with drawn-in ear drum at the pars flaccida or in the posterior superior quadrant of the pars tensa. Keratin collects within the pocket. Gradually the pocket grows into the mastoid region. When the pocket is too big for self-cleaning, there is a foul smell due to growth of anaerobic bacteria. Basal layer of squamous epithelium grows into surrounding structures eroding the bone. An offensive scanty discharge is present without pain. There is hearing impairment with or without vertigo. Infection can spread to meninges, brain, facial nerve or inner ear. Patients usually present with scanty, smelly ear discharge, deafness, facial palsy, mastoid abscess, ear canal polyp or intracranial complications. It is mandatory to examine the ear thoroughly with otoscope and microscope.

Treatment High definition CT has been advocated for the evaluation of the temporal bone and the cranial cavity to exclude complications. Management is usually surgical ie. mastoidectomy. There is no place for medical management other than aural toilet and topical antibiotics.

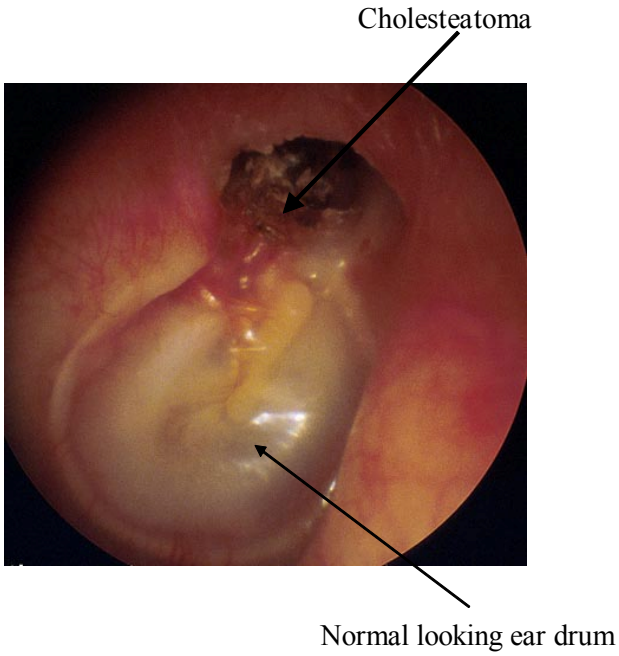

Figure 5. *Cholesteatoma.*

Summary

Ear discharge arises from infections in the middle or external ear. Outer ear infection is commonly due to bacteria or fungi. Exclusion of diabetes mellitus is an important step in the management of external ear canal infections.

Otitis media is most commonly caused by infection with viral and bacterial pathogens. It may be acute or chronic. Acute otitis media is self-limiting and the patient should be observed before starting antibiotic treatment. Cholesteatoma is a destructive and expanding growth consisting of keratinising squamous epithelium in the middle ear and is a common cause for recurrent ear discharge. Mastoidectomy to remove the cholesteatoma is the preferred management.

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Cough and cold remedies for children

Summary

Over-the-counter cough and cold remedies for children under two years of age have recently been rescheduled to prescription-only. This will mean that doctors and pharmacists will encounter more consultations for such medicines. These drugs are no longer recommended in children because of the lack of efficacy and reports of serious adverse events.

Key words: children, over-the-counter medicines.

(Aust Prescr 2009;32:122-4)

Introduction

Upper respiratory tract infections are common in children and it is not surprising that cough and cold symptoms can be a major burden to many families. Until recently, over-the-counter (OTC) cough and cold remedies were widely available in Australia, and extensively used in young children.They include antitussives, antihistamines, expectorants and decongestants (Table 1). However, since September 2008 cough and cold medicines for children under two years have been rescheduled to S4 to become prescription-only. The USA and the UK introduced similar restrictions in response to reports of adverse effects, accidental overdoses and lack of evidence of their efficacy for acute and chronic cough in children.

This change in the scheduling of these medicines will result in more consultations, and doctors and pharmacists should be aware of the potentially serious adverse effects of these medicines. It is important to have a sound approach to providing symptomatic relief to children with cough and colds.

Cough in children

Cough is a reflex response to mechanical, inflammatory and chemical irritation of the tracheobronchial tree. It is a normal mechanism for the maintenance of a healthy respiratory system.

Diagnosis

When a child presents with cough or cold symptoms, the most important first step is to make the correct diagnosis and exclude serious pathology. Most causes of cough are self-limiting and do not require investigations. A detailed history and physical examination are most important, followed by specific investigations only when clinically indicated.

Causes of cough

Management of a cough should be directed at the underlying cause. Cough that is accompanied by other upper respiratory tract infection symptoms, such as rhinorrhoea and sore throat, is usually due to viral infections and is rarely bacterial. If such a cough lingers, it may be a postinfective cough. A barking or brassy cough may suggest croup or tracheomalacia. Cough accompanied by respiratory distress suggests pneumonia or bronchiolitis. Asthma may present as nocturnal cough, while cough that disappears when the child is asleep may suggest a psychogenic cause.

A coughing infant or child with paroxysms of cough may have pertussis. Suppurative lung disease should be considered if the cough is most vigorous in the morning. If there is a temporal association with feeding or with positioning, gastrooesophageal reflux should be considered.

The presence of a foreign body should be suspected after an acute episode of choking, while aspiration may occur in children with hypotonia or pharyngeal incoordination. Chlamydia trachomatis is an uncommon but serious cause of cough that should be considered especially if the infant has conjunctivitis or whose mother has evidence of chlamydial infection. Structural anomalies causing cough are usually associated with other symptoms such as stridor or cyanosis.

Symptomatic treatments for colds and cough

Cough and cold symptoms can cause significant distress to children and their families, and this is reflected in the vast array of OTC medications marketed over the years. Most cough and cold remedies are a combination of antitussives, antihistamines, expectorants and decongestants. Table 1 lists their reported actions, common adverse effects and more serious adverse reactions.

Table 1

Common cough and cold remedies *

Drug type	Reported actions	Common adverse effects	Serious adverse reactions
Antitussives			
Pholcodine	Centrally acting opioid derivative; directly suppresses medullary cough centre	Dizziness, sedation, nausea	Opioid dependence, potential abuse, serotonin syndrome, lethargy, stupor, aspiration
Dextromethorphan	Narcotic analogue; directly suppresses medullary cough centre		
Antihistamines			
Diphenhydramine Brompheniramine Chlorpheniramine	Histamine H_1-receptor antagonists; prevent histamine-induced reactions in cells of the respiratory tract, gastrointestinal tract and blood vessels	Sedation, headache, dizziness, nervousness, restlessness, irritability, palpitations	Hallucinations, seizures, central nervous system depression, cardiovascular collapse, apnoea, death, anticholinergic effects

(Contd.)

Drug type	Reported actions	Common adverse effects	Serious adverse reactions
Decongestants			
Pseudoephedrine Phenylephrine	Sympathomimetic drugs, adrenergic receptor agonists; produce vasoconstriction within the respiratory tract mucosa, and cause increased heart rate and cardiac contractility	Nervousness, restlessness insomnia, trembling, headache, anxiety	Tachycardia, palpitations, dysrhythmias, hypertension, hallucinations, agitation, central nervous system depression, seizures
Expectorants			
Guaifenesin Ipecacuanha	Expectorants; promote the expulsion of mucus and other materials from the respiratory tract	Drowsiness, dizziness, headache, rash - these rarely occur at therapeutic doses	Nausea/vomiting, abdominal pain, nephrolithiasis
Mucolytics			
Bromhexine	Oral mucolytics; loosen and thin bronchial secretions by reducing surface tension and viscosity of mucus	Dizziness, headache, rash - these rarely occur at therapeutic doses	Nausea/vomiting, abdominal pain, diarrhoea

* information modified from references 14 and 15

Note: these drugs are commonly sold as combination products

Efficacy in children under two years

Data on the efficacy of cough and cold medicines in children under two years old are extremely limited. There is no reliable evidence to recommend their use in this age group.

Efficacy in children over two years

There have been numerous trials of cough and cold drugs in older children. A Cochrane review in 2008 found that treatments were no more effective than placebo for acute cough in children. The review included two trials with antitussives, two with antihistamines, two with antihistamine-decongestants and one trial with antitussive/bronchodilator combinations. One trial favoured active treatment with mucolytics over placebo.[1]

Another Cochrane review of three randomised controlled trials found that antihistamines had uncertain efficacy for prolonged non-specific cough (more than four weeks) in children compared to placebo.[2] The two larger trials showed no significant difference in symptom improvement. The smaller study indicated that cetirizine, a second generation antihistamine, was significantly more efficacious than placebo in reducing chronic cough in children with seasonal allergic rhinitis.[2]

In another Cochrane review, there was insufficient evidence to determine whether OTC medicines were beneficial for cough when given as an adjunct to antibiotics for acute pneumonia in children and adults.[3] Similar results were found in a review of nasal decongestants for the common cold in children.[4]

Non-drug treatments

There are limited data on the use of non-pharmacological therapies for cough and colds. Nasal saline drops are effective in chronic rhinosinusitis[5], but there is limited evidence on their efficacy in the common cold. Steam and vapour are not recommended due to lack of efficacy data and the potentially serious adverse effect of burns. There is no evidence to show that physiotherapy is effective for cough other than when secondary to suppurative lung diseases. Cochrane reviews do not support the use of complementary medicines such as echinacea, vitamin C or zinc in the treatment of cough and colds.[6] A randomised controlled trial showed that honey was effective in children with

cough[7], however there were many limitations to this study. In addition, ingestion of honey has been associated with infantile botulism and should not be used in children under one year.

Why not prescribe cough and cold medicines?

Although the majority of trials analysed in the Cochrane reviews did not report adverse events, it is well known that cough and cold products in children are a major cause of unintentional drug overdoses[8], and are associated with sudden infant deaths. A recent report estimated that 7091 children under 12 years of age have been treated for adverse drug events in 63 emergency departments in the USA over two years.[10] Adverse reactions to drugs contained in cough and cold medicines have also been reported in Australia (www.tga.gov.au/ndpsc/record/rr200706.pdf).

The potential for adverse effects is high, firstly because until recently there was no regulation for dosing of such drugs in young children, and secondly because these medicines are often administered by multiple caregivers. In October 2008, the US Food and Drug Administration advised against the use of OTC cough and cold products in infants and children under two years of age, and recommended caution in children aged 2-11 years due to the risk of potentially life-threatening adverse effects.[11] These were described in the context of overdose or the use of multiple similar preparations. The Therapeutic Goods Administration made the same announcements in April 2008.[12] A recent recommendation in the UK advises that cough and cold medicines should not be used in children under six years.[13]

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Management of infections of eyelids

The eyelids play a major role in protecting the eye. The lids help to lubricate the eyes by producing lubricant secretions, and in the distribution and drainage of tears.

Anatomically lids comprise skin, orbicularis oculi muscle, tarsal plates and conjunctiva, arranged in layers. The delicate layer of skin has loose connective tissue but no fat. It contains eccrine sweat glands and sebaceous glands. The lashes, arranged along the lid margin have apocrine sweat glands (of Moll) and modified sebaceous glands (of Zeis). Meibomian glands are vertically oriented sebaceous glands in the tarsal plate, with small central canals opening at the lid margin.

Given the number of glands present it is no wonder that the eyelid is a common site of infection. Hordeolum is the term used to describe a common inflammation of the lid. Presenting as a red, painful swelling of acute onset, hordeola tend to occur more in young people. The aetiology is usually a staphylococcal infection.

Infection occurring on the outer aspect of the lid is known as an external hordeolum or a stye. It is an abscess of the eyelash follicle affecting the glands of Zeis or Moll.

The infection can occur on the inner aspect of the lid as an internal hordeolum affecting the meibomian glands. If unresolved an acute internal hordeolum can end up as a chronic inflammatory reaction (lipogranulomatous inflammation) of a blocked meibomian gland (chalazion).

The occurrence of a hordeolum is related to lid hygiene, local conditions or systemic infections. Studies have shown that patients with internal hordeola tend to be nasal carriers for staphylococci.

Stye (external hordeolum)

It will begin as a red painful localised area near the lid margin. Sometimes an abscess pointing to the base of the lash follicle may be visible.

Treatment

In the early stages hot compresses alone will resolve the condition. Removing the eyelash will help in draining the abscess to quicken the healing. Topical antibiotic ointments such as fusidic acid will be useful in limiting the infection. Broad spectrum systemic antibiotics are important if the inflammation is not localised.

Internal hordeolum

It is an acute infection occurring in the meibomian gland. Starting as a tender painful swelling within the tarsal plate it may enlarge to discharge either posteriorly through the conjunctiva or anteriorly through the skin.

Treatment

Warm compresses and topical antibiotics are included in the initial management. Incision and curettage may be required if a residual nodule remains.

Chalazion

Starting as a visible or palpable well-defined subcutaneous nodule, about 25% of chalazions have no symptoms and will disappear without any treatment.

However, sometimes a chalazion may become red, swollen and tender. A larger chalazion may also cause blurred vision by distorting the shape of the eye. Occasionally, a chalazion can cause the entire eyelid to swell suddenly. Rarely, a chronic chalazion can cause a ptosis to the extent of inducing amblopia in a child.

Treatment

Symptoms are treated with one or more of the following methods.

Warm compresses will help clear the obstructed tarsal glands. Applying hot compression with a clean washcloth soaked in hot water and applying to the lid for 10 to 15 minutes, three or four times a day until the chalazion resolves is recommended. The cloth should be repeatedly soaked in hot water to maintain adequate heat. As the clogged gland opens, discharge from the eye can increase. But this should eventually improve.

Antibiotic ointments may be prescribed if there is infection. Topical treatment with fusidic acid is recommended as a twice or three times a day application. However, before application of topical medication warm compresses are recommended for a better outcome.

Steroid injection is sometimes used to reduce the inflammation of a chalazion.

Surgical treatment is performed if a large chalazion does not respond to other treatments or affects vision. This is usually performed under local anesthesia as an out-patient procedure. A small vertical incision is placed on the inner aspect of the eye lid on the conjunctiva and the wall of the chalazion is scraped off.

A chalazion usually responds well to treatment, although some people are prone to recurrences. If a chalazion recurs in the same place, it may be necessary to refer to an ophthalmologist to perform a biopsy to rule out more serious problems such as a rare lid neoplasm.

Table 1. Lid infections and inflammations

	External hordeolum	*Internal hordeolum*	*Chalazion*	*Blepharitis*
Onset	Acute	Acute	Chronic	Chronic
Site	Glands of Zeis or Moll	Meibomian gland	Meibomian gland	Lid margin skin
Type of inflammation	Acute	Acute	Chronic lipogranulomatous inflammation	Chronic
Signs and symptoms	Acute pain and swelling near lid margin	Acute painful swelling away from lid margin	Painless firm nodule	Itching,redness,soreness, irritation, photophobia foreign body sensation
Treatment	Hot compressions, removal of eyelash	Hot compressions Topical antibiotic ointment Systemic antibiotics	Hot compressions Topical antibiotic ointment Vertical incision	Cleaning lid with diluted baby shampoo or sodium bicarbonate (3%). Topical antibiotic /weak steroids. Tear substitutes Systemic tetracycline

Blepharitis

This is another common condition that affects the lids. Although the word literally means inflammation of the eyelid due to any cause, this term is often used for chronic lid margin disease. Blepharitis is associated with tear film instability (dry eye), and recurrent chalazions leading to anterior blepharitis. It usually occurs due to lid commensals such as Staphylococci, Streptococci, *Propionibacterium acne* and *Moraxella.* Symptoms include burning sensation of eyes, crusted lid margin with scales at lash bases.

The main method of treatment is regular lid cleaning with cotton buds dipped in dilute baby shampoo twice a day for two weeks. Ocular lubricants (tear substitutes) are prescribed for symptomatic relief of tear film instability. Acute exacerbations require topical antibiotics and weak steroids if corneal involvement is present.

According to the site of involvement there are two types of blepharitis.

Anterior blepharitis

Pathogenesis of anterior blepharitis is unclear, but both staphylococcal infection and seborrhoea are known to contribute.

Burning sensation, irritation, mild photophobia, crusting and redness of the lid margin (usually more in the morning) are common symptoms. Symptoms characteristically occur as exacerbations and remissions. Signs include lid hyperemia and scales on eyelashes. In staphylococcal blepharitis the scales are hard and are located around the base of the lashes whereas in the seborrhoeic type the scales are soft and can be found anywhere on the lid margin and the lashes. In addition the lid margin is greasy and the lashes tend to stick together due to the presence of excess fatty material.

Tear film instability, recurrent hordeola, hypertrophy and scarring of the lid margin and chronic papillary conjunctivitis due to hypersensitivity to staphylococcal toxins are some of the complications.

Treatment

The patient needs to be convinced about the nature of the disease. Treatment is tedious but despite the lack of permanent cure, control of symptoms is usually possible. Lid hygiene is the mainstay of treatment. A cotton bud dipped in a weak solution of baby shampoo or sodium bicarbonate (3%) should be used to gently scrub the lid margin twice a day for two weeks.

Antibiotic ointment containing fucidic acid or chloramphenicol is used to treat acute folliculitis. Weak topical steroids are used as a short term treatment for marginal keratitis and secondary papillary conjunctivitis. Tear substitutes are required for associated tear film instability which is important in relief of symptoms.

Posterior blepharitis

This is characterised by excessive meibomian gland secretions. Additional signs include oily or foamy tear film and capping of gland orifices by small oil globules. Complications include chalazion formation, tear film instability and papillary conjunctivitis.

Treatment

In addition to lid hygiene, warm compresses and gentle lid massaging to help in expression of secretions is useful. Systemic therapy with tetracycline 250 mg q.i.d. for one week and then b.d. for 6 to 12 weeks or doxycycline 100 mg b.d. for one week and then daily for 6 to 12 weeks is recommended for moderate to severe cases. In children, and pregnant or breast feeding women tetracyclines should not be used because of possible deposition in growing bone and teeth, and erythromycin may be used instead.

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Oxygen delivery systems

Oxygen is a drug. Oxygen delivery systems can be confusing and one needs to know which delivery system should be used in a given patient. This article explains the types of commonly used oxygen delivery systems and the mechanics of their function.

Oxygen source

Depending on where one works the oxygen source may be a concentrator, a wall unit or a cylinder, which is the commonest in most wards.

Delivery systems

Oxygen delivery systems are classified according to the volume of oxygen that flows through them for delivery to the patient. The systems can be broadly classified into low flow and high flow systems.

Low flow system

A low flow system provides a variable oxygen concentration which is insufficient to meet the patients peak inspiratory flow [1]. Let's consider a patient who takes a tidal volume of 500 ml, breathing at a rate of 20 breaths /min with a normal I:E of 1:2. A person breathing at a rate of 20/min will take 3 seconds for each breath. As each breath consist of an inspiration and an expiration and as the I:E is 1:2 the time for each inspiration is 1 second. The tidal volume of 500 ml has to enter the lungs during this second; hence the flow should be 500 ml/s or 30 l/min. It is this flow that is referred to as the peak inspiratory flow. Wall units or cylinders cannot provide this flow as their maximum flow is about 10-15 l/min. As the system cannot provide the peak flow the patient entrains air from the environment. This dilutes the oxygen and the final oxygen concentration reaching the patient is reduced.

Minute ventilation in this example is 10 l (tidal volume x rate). This flow can be provided by the low flow system. It is important to appreciate the calculated peak flow of 30 l/min was an extrapolation of the required flow during inspiration which was only one second. Patients do not breathe continuously during the respiratory cycle. Each inspiration is interrupted by expiration. In another inspiration is intermittent. During the time of inspiration a very high flow is taken in which cannot be provided. However the sum of the inspiratory flows in a minute which is the minute ventilation can be provided. This explains the main drawback of the low flow system. During inspiration, as the peak flow is insufficient, the patient entrains air from the environment diluting the oxygen and during expiration as the oxygen still flows in the system, it gets wasted.

Types of low flow systems

Nasal cannula

It is the most popular low flow oxygen delivery system and the least expensive. Most nasal cannulae are tubes with two prongs each about 1cm long. The prongs fit into the nostrils and the tubing is secured around the face. Usual flow rate is 1-4 l/min. Higher flows can be uncomfortable to the patient. Cannulae can usually deliver 24-40% of oxygen. Advantages of this system are ability of the patient to eat and drink without removing it, and the ability of mouth breathing without interference with oxygen delivery. However, the use of nasal cannulae may have some adverse effects such as nasal stiffness, dryness and rhinitis.

Face mask

Low flow oxygen may also be delivered through various types of masks. The simple face mask covers the patient's nose and the mouth. This light weight transparent mask has numerous holes in its side that allows room air to enter and exit. This system provides approximately 35- 50% oxygen concentration. The flow rate has to be at least 5 l/min to wash out the dead space of the mask and prevent re-breathing exhaled air.

Partial re-breathing mask

This is a form of low flow oxygen delivery that can deliver higher concentrations of oxygen[2]. A partial re-breather mask looks like a simple face mask with a reservoir bag. Oxygen flows through the supply tubing into the reservoir bag allowing the patient to breath oxygen rich air from the bag and a small amount of room air from the side holes. A flow rate of 6-10 l/min can provide an oxygen concentration of 40-70%. The reservoir bag should be at least partially inflated at all

times. The main advantage of the reservoir bag is that it can collect the oxygen during expiration and also act as an oxygen reservoir during peak inspiration where the flow becomes inadequate.

Non re-breather mask

This is the low flow system that can deliver the highest concentration of oxygen. These masks are most commonly used in anaesthetic practice. It allows for a tight seal around the nose and mouth that prevents the patient from breathing room air. The oxygen is delivered to the mask by a circuit which has a reservoir bag which is non-self-inflating. During expiration the oxygen rich gas get collected in the bag. This provides the additional flow required during inspiration. These masks can provide an oxygen concentration up to 60-80%. The bag has to be non-self-inflating to prevent it entraining room air that will dilute the oxygen.

High flow system

High flow systems deliver a flow that is more than the patient's peak inspiratory flow, and as such the patient need not entrain air from the environment. As there is no entrainment the oxygen is not further diluted [3].

Venturi mask

A venturi mask (also known as the ventimask) is one of the best methods of delivering a specific and constant percentage of oxygen. In this mask the oxygen enters a normal face mask through an adapter in which the gas flows through a constricted opening (Figure 1). As the gas passes through this opening it accelerates entraining air from a side port in the adapter. The amount of air entrained depends on the flow rate and the size of the opening. Since the size of the opening is fixed, if a specific rate of oxygen is allowed to flow through it, a specific amount of air is entrained. This allows one to predict the dilution of oxygen and its final concentration. The oxygen flow together with the entrained environmental air exceeds the peek inspiratory flow. Flow rates of 4-10 l/min provide oxygen concentrations of 24-55%.

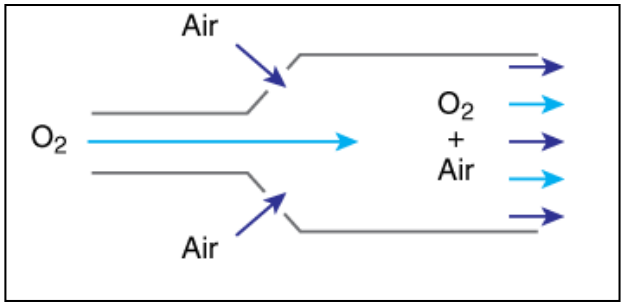

Figure 1

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