

**MELBOURNE Handbook for the Management
of Children with Cystic Fibrosis**

Acknowledgements:

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Special thanks go to:

John Massie, Lysette Curnow, Angela Burge, Mark Oliver, Danielle Deidun, Alex Robinson, Rachel McAleer, Philip Robinson

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1. INTRODUCTION – THE CYSTIC FIBROSIS SERVICE

1.1 UNIT PERSONNEL – LIST OF CONTACT PERSONS AND THEIR ROLE

1.2 NEWLY DIAGNOSED PATIENT

1.2.1 Initial family discussion and education.

The parents of the newly diagnosed infant with CF (who may be accompanied by other supporting relatives) are called in to the hospital to discuss the implications of the diagnosis of CF. This discussion is usually conducted by the Respiratory Physician-on-call (who will subsequently remain that child's primary physician) and the CF Coordinator and Counsellor, with possibly the respiratory fellow/registrar in attendance.

1.2.2 Educational issues

CF is a complex multisystem disorder and the diagnosis is devastating for families of children newly diagnosed with this condition. The period of education may take several months but is initiated as soon as possible after diagnosis. Due to the emotional impact of the diagnosis parents may not be able to process a lot of new information. Repetition and divulging of small amounts of information at any one time are usually required. It is important that the topics are discussed in simple layman's terms and as sensitively as possible. Emphasis should be placed on being positive without underplaying the seriousness of the disease. Unless the child is unwell, admission to the ward is not required. The initial education period usually lasts five days. Families should be encouraged to stay in the hospital's medi-hotel (Supported Care Unit) during this time. There is no cost incurred by the family for staying in the medi-hotel. On arrival to the hospital, the infant will be admitted by the Respiratory registrar/resident as per an in-patient admission. Symptomatic patients usually require admission. Families who choose to stay at home overnight during the education week are encouraged to use the Family Resource Centre in between sessions.

The following essential areas should be covered at the first meeting with the parents although the content and order may vary depending on circumstances and the parents' questions. Education is provided regarding:

1.2.2.1 Disease and treatment.

- Most patients will be asymptomatic at the time of diagnosis. Symptoms usually start to appear in the first year or two although in mild cases, they may only be seen in mid childhood or even later.
- The lungs and/or the bowel are usually the first organs to show symptoms.
- Most symptoms are caused because patients with CF produce abnormal thickened mucous.
- The thickened mucous can lead to problems in the lungs with poor clearance and infection, and in the bowel with blockage of glandular ducts (particularly the pancreas) resulting in malabsorption. Therefore from the outset, treatment is directed primarily towards preventing and dealing with these two major problem areas.
- Treatment for the lungs is mainly physiotherapy (to help clear the thickened mucous) and antibiotics (to control infection).
- Treatment for the bowels consists mainly of enzyme supplements (which replace the missing pancreatic enzymes), dietary advice and dietary supplements.
- Treatment is usually required every day.
- Other organs such as the liver and reproductive organs can be affected in CF although not usually early on, and therefore will be discussed in more detail later.

- It is difficult to identify most children with CF from their unaffected peers. CF does not affect intellectual development.
- Treatment, and hence the outlook, for CF patients is improving all the time with current median life expectancy up to mid-adulthood..
- Children who receive their treatment and regularly attend the hospital for outpatient assessment by the multidisciplinary team usually do well. Most children with CF can lead essentially normal active lives well into their teenage and adult years.

1.2.2.2 Genetic mode of inheritance.

- CF is a genetic disease inherited equally from **both sides** of the family.
- Parents are asymptomatic heterozygote 'carriers'.
- There is a 1 in 4 chance of the subsequent children having CF and 1 in 2 of being a carrier.
- Formal genetic counselling will be arranged.
- Sweat tests are routinely arranged for siblings.

1.2.3 Multidisciplinary team

During the initial period of education, parents are introduced to the multidisciplinary team and learn about the role of these disciplines in the care of their child.

- Physician – 2 to 3 sessions
- Dietitian – 2 to 3 sessions
- Physiotherapist – 3 to 4 sessions
- CF Coordinator – usually sees the family each day
- Community nurse and physiotherapist (Melbourne metropolitan families only) – 1 session
- Genetic counselling - genetic counselling will be offered to the family to allow the parents to make an informed decision regarding future pregnancies and to provide carrier testing to family members.
- CF Pharmacist – 1 session

1.2.3.1 Investigations at diagnosis

- Full clinical history and examination of nutritional, respiratory and general status
 - Stool for fat globules and tryptic activity – is the child pancreatic sufficient?
 - FBE
 - U&E – assess sodium levels
 - LFT
 - Vitamins ADE
 - Genotype - bloods taken from both parents and the infant
 - Sweat test even if homozygous Delta F508
 - Oropharyngeal suction specimen for culture
 - Sweat test for full siblings
-
- Bronchoscopy and broncho-alveolar lavage – assess pulmonary infection and inflammation. (Can be delayed for a few weeks and organised as a day-case on formal bronchoscopy list under general anaesthesia but usually performed before 3 months of age)
 - Limited slice high-resolution CT scan of chest – performed at same time as bronchoscopy under a general anaesthetic in radiology.

1.2.3.2 Research Investigations (performed with written, informed consent only)

- Infant lung function testing – arranged for end of initial period of education or any time prior to bronchoscopy and BAL and CT
- BAL sample stored for subsequent assessment of pulmonary inflammation
- Urine for urinary desmosines
- Utilise or store samples as appropriate to other ongoing research

1.2.3.3 Treatment initiated at first evaluation

- Physiotherapy
- Nutrition
- Salt supplements – 1/4 teaspoon BD if formula fed and ½ teaspoon BD if breast fed
- Pancreatic enzymes – if pancreatic insufficient
- Fat-soluble vitamins – Bioglan A&E and infant Pentavite
- Prophylactic antibiotics (commenced immediately after BAL or after treatment of organisms identified in BAL)
 - **Augmentin Duo** is preferred antibiotic and is given once daily for one year, increasing to twice daily for episodes of cough.
 - Antibiotics stopped if second BAL at one year of age is negative for lower respiratory tract infection

1.2.3.4 Discharge

Once the child is stable and well, and the family is comfortable and familiar with ongoing home management, they will be discharged with advice regarding follow-up arrangements. Contact numbers and a plan will be provided in case the parents need to speak with a doctor after hours.

1.2.3.5 Follow-up arrangements/schedule

- Initial follow-up: 1-2 weeks after discharge
- Then monthly for 3-6 months, depending on progress
- Then 2 monthly provided all is well

1.2.3.6 Educational materials

- Multiple copies of “An Introduction to Cystic Fibrosis” booklet, produced by Department of Respiratory Medicine, RCH
- “An Introduction to Cystic Fibrosis For Patients and Families” book, 5th edition, written by Cunningham and Taussig
- Copies of “Understanding CF” video and “Cystic Fibrosis Newly Diagnosed – Personal Perspectives on Medical and Social Issues” video
- Further references and internet website addresses as requested by families

1.2.3.7 Support services

- Cystic Fibrosis Victoria
- PASS (Geelong families)
- Very Special Kids

1.2.3.8 Communication

Once patients have had their initial assessment and treatment has been commenced, families have had their counselling and have been provided with a plan of management arranged by the Respiratory Department, a summary letter containing all the relevant information is sent to the referring doctor/midwife/GP and any other medical and/or allied health professionals likely to be involved in their care.

1.3 THE CF OUT-PATIENTS

1.4 ANNUAL REVIEW

1.5 THE ROYAL DISTRICT NURSING CF HOMECARE SERVICE

1.5.1 Staffing

The RDNS CF Home Support Team consists of 2 Clinical Nurse Consultants and a Senior Clinician Physiotherapist. RDNS visits are limited to metropolitan Melbourne and the Mornington Peninsula, however support and education to regional areas is provided electronically and via telephone consults. Imperative to provision of this program is close liaison and communication with the hospital based CF team.

The team are introduced at diagnosis, at which time community support is commenced. Subsequent visits to those children attending the clinic are on an as needs basis, including specialist review assessment, education, support, guidance and motivation for both patients and families regarding diagnosis, physiotherapy, diet, enzymes, medications, new treatments, transition to adult services, and psychosocial issues.

1.5.2 The aims of the service

- To provide an opportunity for clinical and at times non-clinical assessment, these include acute assessment, (dietary intake, GI issues, respiratory, medication management, cross infection, teaching baseline symptoms) and supporting of other health professionals in the community.
- To care for those patients with implantable devices (port-a-cath and gastrostomies).
- To provide physiotherapy including all aspects of individualised respiratory care.
- To provide education to other agencies such as staff at schools, kindergartens, and extended family as necessary.

1.5.3 Referral

- Any member of the CF team, RCH ward and medical staff, community agencies or families, can refer patients to the service. The team attend the Respiratory medicine/CF team meeting on the 5th floor on Thursday mornings.
- The service operates Monday to Friday, 8am to 5 pm
- Appointments can be made with the Clinical Nurse Consultant and Physiotherapist on 9417 1361.

2 PULMONARY MANAGEMENT

2.1 *PHYSIOTHERAPY*

2.1.1 Glossary of terms

Chest clapping/patting

Frog

Huff

Manual techniques

PEG

Port

Shaking/shakes

Tune up

2.1.2 Abbreviations

AAD assisted autogenic drainage

ACT airway clearance technique

AD autogenic drainage

ACBT active cycle of breathing technique

CF cystic fibrosis

CXR chest x-ray

FET forced expiratory technique

GAD gravity assisted drainage

GOR gastro-oesophageal reflux

MPD modified postural drainage

NICU neonatal intensive care unit

NIV non-invasive ventilation

P&V percussion and vibrations

PEP positive expiratory pressure

RDNS Royal District Nursing Service

SPD standard postural drainage

2.1.3 Newly diagnosed infant

The patient and family are seen 3-4 times by a senior physiotherapist from the respiratory medicine team for education and training. The following topics are covered during the education sessions:

- Basic anatomy of the lungs.
- The role of physiotherapy in relation to the respiratory changes associated with cystic fibrosis.
- Signs and symptoms of respiratory exacerbation.
- Demonstrate and establish initial home physiotherapy program with relevant caregiver(s).
- Home program issues: e.g. timing with feeds, gastro-oesophageal reflux (GOR), daily habit, on lap vs. bed or arms, back care for carers, quiet time best suited to infant and caregivers, involvement of siblings.
- Future options for physiotherapy airways clearance techniques (briefly) and development of individually tailored program.
- Encouragement of an active lifestyle and future role of 'exercise'.
- Infant neurodevelopmental input as required e.g. 'tummy time,' gentle stretches, baby massage.
- Inhalation therapy: briefly mention and future equipment purchase as required.
- Provide written handouts and contact details.
- Royal District Nursing Service (RDNS) role and physiotherapist introduction if metropolitan address.
- Follow up arrangements e.g. clinic
- Completion of physiotherapy related paperwork
- Liaise with cystic fibrosis (CF) Team.

Commencement of physiotherapy depends on the method of diagnosis. For infants presenting in neonatal intensive care unit (NICU) with meconium ileus, education is provided to the family at time of diagnosis of CF, however treatment may not commence immediately as these infants are often small (< 3kg) and clinically asymptomatic with regard to respiratory symptoms. In these infants, medical, surgical and nutritional concerns are the primary focus of care. In consultation with the infant's appointed respiratory physician, physiotherapy treatment usually commences between 4-6 weeks of age.

For infants diagnosed on newborn screening or children with late diagnosis, physiotherapy treatment commences at time of diagnosis, consisting of a daily regime of modified postural drainage with percussion (vibrations may be introduced at a later stage) undertaken by a parent or guardian. This is carried out in a series of 5 positions; supine, prone, left side lying, right side lying and an upright position. The sequence is left to the caregiver, but must always finish in the upright position, based on the idea that this is the easiest position in which infants can cough effectively. Advice is given regarding frequency of treatment (normally once each day, increase frequency with increase in symptoms), duration of treatment (20-25 minutes), timing of treatment (preferably AM, at least 1-1.5 hours after a feed) and other problem solving and practical considerations.

The rationale for this approach is based on the concept that early intervention may prevent the onset of complications. There is clear evidence from studies of bronchoalveolar lavage, infant lung function and radiological imaging that manifestations of lung disease occur at a very early stage in the disease process. Although daily treatment continues to be recommended even in this usually

asymptomatic group of patients, there is as yet no evidence to suggest that routine physiotherapy has an impact on the course of the pulmonary changes. However, it is argued that introducing a routine of chest physiotherapy from an early stage so that it becomes part of the child's daily routine may improve compliance with treatment. Another consideration is the process of training parents and caregivers in treatment techniques to ensure that adequate treatment can be regularly provided at home, especially at the onset of respiratory symptoms.

In the case of a late diagnosis in an older child, include above issues as applicable and introduce suitable techniques and further education of the child as well as caregivers.

2.1.4 Chest Physiotherapy

Chest physiotherapy is an integral part of the management of patients with CF. It is thought to prevent and reduce pulmonary complications such as atelectasis and hyperinflation by the removal of bronchopulmonary secretions. Removal of these secretions reduces the overall proteolytic activity in the lungs, which could reduce the progression of elastase-mediated damage to the airways and the mucociliary transport system. The role of the physiotherapist is not limited to airway clearance but also includes encouragement and advice on exercise, posture, mobility and inhalation therapy.

Patients with CF require regular assessment by a physiotherapist. Recommendations for treatment and education, encompassing inhalation therapy, airway clearance and exercise, are tailored to their individual needs, age, clinical status and social circumstances.

2.1.4.1 Treatment Techniques

In order to maximise therapeutic value and reduce the treatment related burden on adolescents and older children, a number of independently performed chest physiotherapy or airway clearance techniques (ACT) have been developed. The choice of treatment is made by the physiotherapist in conjunction with the patient (where age appropriate) and their carer. The physiotherapy treatment modalities include:

- Modified Postural Drainage (MPD) and Manual Techniques
 - Position change
- Active Cycle of Breathing Techniques (ACBT)
 - Blowing games
 - Forced expiration technique (FET) or 'huff'
- Autogenic Drainage (AD)
 - Assisted autogenic drainage (AAD)
- Positive Expiratory Pressure (PEP)
 - PEP mask
 - Baby PEP
 - Mouthpiece PEP
 - High Pressure PEP
 - Bubble PEP
- Oscillatory PEP
 - Flutter
 - Acapella

- Cornet
- Exercise
- Noninvasive ventilation (NIV) as an adjunct to physiotherapy

Considerations for selection and implementation of appropriate ACT

- age
- presenting illness and symptoms
- behavioural characteristics
- GOR – symptoms may include nausea, abdominal or retrosternal discomfort, gag, vomit, coughing copious saliva with sputum
- Sinus problems – headache, sinus pressure, nasal obstruction

Treatment options for different age groups might include;

INFANTS (0-1 YEARS)

MPD with manual techniques

Baby PEP

Positioning, active play, laughing

AAD and other facilitated breathing techniques

TODDLERS (1-3 YEARS)

MPD with manual techniques

Active lifestyle

Blowing and huffing games

Baby PEP

MoPEP

Bubble PEP

AAD and facilitated breathing techniques

SMALL CHILDREN (3-6 YEARS)

Active play and family exercise

Specific activities to target respiratory muscles and postural control

Bubble PEP

MoPEP

PEP mask

MPD with manual techniques

Blowing games and breathing awareness/control games

Components of FET and/or ACBT

AAD and facilitated deep breathing techniques

CHILDREN (6-12 YEARS)

Sports and exercise (team commitment assists adherence, regular participation at school)

MoPEP

PEP mask

MPD with manual techniques

ACBT

Oscillating PEP

AAD transitioning to AD

ADOLESCENTS (12+ YEARS)

Sports and exercise program

PEP

Oscillating PEP

MPD with manual techniques
ACBT
AD

2.1.4.2 Gravity Assisted Drainage and Manual Techniques

Postural or gravity assisted drainage was the cornerstone of therapy until the 1980s. It consists of placing the patient in a range of positions that theoretically facilitate the drainage of peripheral airway secretions to the central part of the lungs. There is some debate over the relative roles of gravity or regional lung ventilation that primarily affects airway clearance. When treating infants and small children, consideration to the different distribution pattern of perfusion and ventilation needs to be given.

Historically a series of 12 positions are described, based on the anatomical divisions of the lungs, with the identified lobe to be cleared placed superior to the carina. This necessitates a 'head down tip' position in some cases. However, contraindications for the use of a 'head down tip' position include;

- cardiac failure
- severe hypertension
- cerebral oedema
- aortic or cerebral aneurysms
- severe haemoptysis
- abdominal distention
- GOR
- Recent surgery or trauma to the head or neck
- Patient at risk of aspiration (e.g. recent meal, nasogastric or gastrostomy feed, coexisting condition)

Studies have shown gravity assisted drainage as an effective means of clearing excessive bronchial secretions in patients with cystic fibrosis. However, some patients may experience adverse events, including oxygen desaturation in patients with moderate or severe lung disease.

It has also been documented that infants with CF have a higher incidence of GOR but there is conflicting evidence as to whether this is exacerbated by the head down tipped position. In the presence of suspected or proven gastro-oesophageal reflux it may be necessary to modify the postural drainage regimen to avoid a head down tip or to use an alternative airway clearance technique.

Together with concerns about GOR in susceptible populations, discomfort, poor tolerance and poor adherence, no patients at RCH are routinely treated with a head-down position. MODIFIED gravity assisted drainage consists of;

- supine with a slight head-up position (e.g. on a pillow)
- side lying (left and right) and prone in a flat position
- in infants, the sitting position is included to drain the apical segments of the upper lobes.

These positions may be further modified if indicated (e.g. increase in work of breathing, sensation of dyspnoea, signs or symptoms of GOR).

Position selection is determined by which lobes or segments of the lungs are to be drained. If there is evidence of a focal area of collapse more specific gravity assisted positioning may be used. However, the most commonly used positions are supine, prone, left side lying, right side lying and sitting/upright. Total treatment time is usually a maximum of 20-25 minutes, with around 5-10 minutes in each position, depending on the aim of treatment.

For infants it may be taught on the caregiver's lap or on a cot, and as children get older, modifications may be required to the method in which it is being performed (if it still the preferred treatment).

Manual techniques, involving percussion and vibrations, are used as an adjunct to gravity assisted drainage, as may be blowing games or the ACBT, depending on the age of the child.

Percussion (or chest clapping or patting) is applied with 1 or 2 cupped hands in a rhythmical manner over the thoracic wall covering the designated lobe. It should never be carried out over bare skin, and the amount of contact will be determined by the size of the child and the designated lobe.

Vibrations (or shaking) is usually interspersed with percussion, or may be performed without percussion. They involve a vibratory compressive manoeuvre as the patient exhales. Vibrations are often more difficult to teach to caregivers.

Care with manual techniques is of primary importance with patients who have portacath devices on their chest wall.

Contraindications to manual techniques include;

- subcutaneous emphysema
- recent epidural spinal infusion or spinal anaesthesia
- recent skin grafts or flaps in the thoracic area
- recently placed pacemaker
- suspected pulmonary tuberculosis
- lung contusion
- bronchospasm
- osteoporosis
- coagulopathy
- chest wall pain
- haematological abnormalities e.g. in oncology patients with neutropenia, reduced platelet counts

Figure 2-1. Five modified postural drainage positions for infants





2.1.4.3 Active Cycle of Breathing Techniques (ACBT)

The active cycle of breathing technique (ACBT) is used to mobilise and clear excess secretions. The regimen is flexible, adapted to suit the individual and can be used in a range of patients. It is a breathing regimen consisting of breathing control, thoracic expansion exercises and the forced expiration technique:

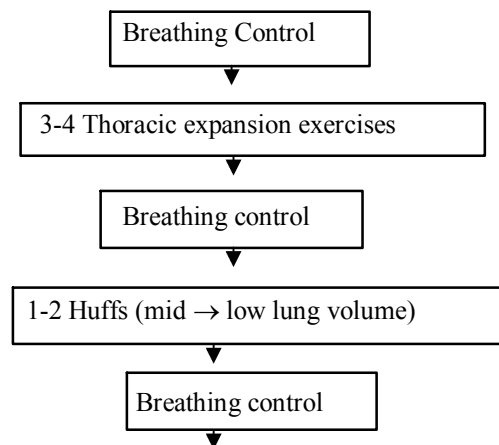
- *Breathing control* is normal gentle breathing at tidal volume, using the lower chest with relaxation of the upper chest and shoulders. It is an essential part

of the cycle to allow pauses for rest and to prevent any increase in airflow obstruction. The length of the pause is dependent on the patient's sign of airflow obstruction.

- *Thoracic expansion exercises* are deep breathing exercises emphasizing inspiration with a quiet unforced expiration. With an increase in lung volume, the resistance to airflow via the collateral channels is reduced. Mobilization of secretions can be facilitated by air passing along these channels and behind secretions. In some patients, an inspiratory hold at the end of inspiration will augment this effect. Thoracic expansion exercises may be combined with manual techniques, and are followed by breathing control.
- *Forced expiration technique* is one or two huffs combined with breathing control. Huffing down to a low lung volume will help to mobilise and clear the more peripherally situated secretions. When secretions reach the larger, more proximal airways, they are cleared by a huff or a cough at a high lung volume. The length of the huff and force of contraction of the muscles of expiration should be altered to maximize clearance of secretions. The concept of the equal pressure point, with collapse and compression downstream (towards the mouth) of the equal pressure point, explains the mechanism of the effectiveness of the forced expiratory manoeuvre of a huff or cough in airway clearance.

The ACBT can be carried out in gravity assisted positions or in sitting. If there are localised chest x-ray (CXR) changes, specific positioning will be implemented. The cycle is repeated until the huff becomes dry and non-productive or it is time for a rest.

Figure 2-2. The active cycle of breathing techniques.



2.1.4.4 Cough & expectoration

The ACBT can be introduced as blowing games from about the age of 2 years (e.g. whistles, bubble wand, musical toys), with increasing independence over time. Huffs can be introduced from about 4 years, with the aid of a small huff tube and mirror, tissue butterflies or feathers. It should never be uncomfortable or exhausting, and the huff should never be violent. It can be used in any position according to the needs of the individual patient. The sitting position may be indicated if secretions are minimal or when it is inconvenient, unnecessary or contraindicated to use gravity assisted positions.

2.1.4.5 Autogenic Drainage (AD)

Autogenic drainage is a breathing regimen performed in postural drainage or sitting position that can be individually adapted to suit each patient's pathology and respiratory function. Mucus clearance is facilitated by the adjustment of tidal volume breathing during which the highest possible expiratory airflow is reached without causing airway closure. AD should only be taught by an experienced therapist, skilled in the technique.

AD is commonly described as having 3 phases, consisting of a period of breathing at low lung volume when secretions are mobilised from the peripheral areas. This is followed by breathing at mid lung volume both to "collect" the mobilised secretions and finally with high lung volume breaths to clear and expectorate. Irrespective of which phase the patient is carrying out, each breath should be taken in slowly through the nose followed by a 2-4 second breath hold. The upper airway/glottis is kept open at all times including expiration. Expiration is variably described as having a high but not forced flow rate, as a sigh or as a gently huff. Expiration may be through the nose, but if a greater sense of mucous shift is desired, then it is better to breathe out through the mouth.

Unproductive coughing should not occur at any stage. The ideal is to suppress any coughing and use strong high volume expiration at the point where mucous is in the upper airways and easily expectorated.

The 3 phases of AD are usually described as follows;

- *Unsticking phase*; this phase involves movement of mucous from the peripheries of the lung by breathing at low lung volumes. The breath should go into expiratory reserve, or even into the residual volume. Each breath out should go down into the residual volume. Each breath in should be relatively small (to a maximum of normal mid tidal volume range) remembering the 2-4 second breath hold. There should be no wheeze or indication of bronchospasm or compressed airways. The patient does a series of breaths at this level as appropriate before going into the next phase.
- *Collecting phase*; this phase involves breathing with inspiratory holds around tidal volume levels. This allows time to collect secretions moved from the peripheral segments. The patient is searching for a sensation of mucous shift at this point to allow them to determine whether they should gradually stage their breathing up towards maximum inspiration (phase 3) or whether they have not really shifted much mucous and may therefore go back and repeat phase 1.
- *Evacuation phase* - occurs once the patient feels that they have collected sufficient mucous to then shift it up into the upper airways ready to expectorate, 5 or so deep breaths are built up towards the point of maximum inspiration (don't forget the breath holds!). Exhalation should remain within the range of normal tidal volume. At the point where mucous reaches the upper airways, a strong high volume exhalation should be used to clear secretions. If a cough occurs, it should be short and effective.

Implementation

1. Choose a breath stimulating position
2. Clear the upper airway
3. Breathing in

- i. Slowly breathe in the necessary volume of air through the nose, keep the upper airways open to avoid severe ventilation asynchronism. Use the diaphragm and/or lower chest if possible
 - ii. Hold the breath for approximately 3-4 seconds during which all the upper airways are kept open. This is to improve the even filling of all lung parts. during this particular phase so that enough air gets behind the obstructions
 - iii. Depending on where the mucous is, in peripheral, middle-large or large airways, the tidal volume needed is ventilated at low, mid or high lung volume level.
4. Breathing out
- i. Preferably breathe out through the nose if the flow is not slowed down by it. If a drop in velocity does occur, or if one wants to hear the bronchial noises in a better way, breathe out through the mouth. In this case, always keep the upper airways open (glottis, throat, mouth).
 - ii. The expiratory force is so balanced that the expiratory flow reaches the highest possible rate without causing airway compression
 - iii. Breathing out in the proper way, the mucous can be heard distinctively. Putting a hand on the upper chest, one can also feel the mucous vibrating. The frequency of these vibrations gives an idea where the mucous is. This feedback makes it possible and easy to adjust the technique.
5. Repeat the cycle by breathing in. Inhale slowly to avoid the mucous going back. Continue to breathe until the mucous starts to collect by moving upwards. If this occurs the level of the ventilated tidal volume is gradually raised. Thus, the breathing evolves from a lower to a higher lung volume breathing level. Finally, the collected mucous plug arrives in the trachea from where it can be evacuated by a strong expiration or a high lung volume huff. Coughing must be avoided as much as possible.

The patients should be in a relaxed position either sitting or lying down. There should be minimal distraction as concentration is required to feel and hear the sensation of mucous movement and to adjust lung volumes accordingly. The patient may have their own hand on their anterior chest to feel for palpable fremitus. If a physiotherapist is teaching AD they should be in a position where they can easily place one hand on the anterior chest to feel for mucous shift and have the other hand over the diaphragm or upper abdomen to feel the activity of these muscles.

AD should be carried out until there can be no more mucous collected. This may be from 20-60 minutes. It is mentally fatiguing, so shorter, more frequent sessions may be required.

2.1.4.6 ASSISTED AD

Assisted autogenic drainage (AAD) is a technique using gentle hands on facilitation in such a way as to mimic the effects of AD. This technique can be used with both patients who are able to cooperate but need some extra assistance, as well as those who are unable to actively participate in airway clearance techniques such as AD (e.g. infants, physical disability). AAD works on the same principles as AD. Different lung volumes are facilitated, aiming for a high expiratory flow rate without any collapse or increased restriction of the airways.

This technique should not be overly vigorous, uncomfortable or distressing to the patient. As with any technique involving infants or those unable to communicate effectively, close observation is necessary. Changes in objective measures such as respiratory effort are important in evaluating the efficacy and appropriateness of continuing the technique with the patient.

This technique takes simple stretch facilitation a few steps further. When treating a baby or toddler, hands are placed and gentle pressure applied in such a way as to affect the lung volume at which the baby is breathing. As with AD, the physiotherapist should be thinking about how to help the patient breathe at lower, mid and higher lung volumes. Thus by changing the pattern and velocity of airflow, mobilization of secretions is facilitated.

Lower lung volume breathing (unsticking phase)

Inhalation should occur at the lower and mid range of normal tidal volume. Exhalation should be encouraged down into expiratory reserve using a steady gentle pressure with the hands with a breath out. Only 2 or so breaths at this level may be required, but if the patient responds well then, 5 or so breaths may be attempted. The older toddler or child who is able to mimic/cooperate may be able to be coached in 'blowing all the way out' with some facilitation by the therapist. They may even be able to briefly hold their breath after inspiration to better copy the original AD technique.

Mid lung volume breathing (collecting phase)

Let the baby/child take a number of breaths at normal tidal volume. Once they have taken several breaths at this level, the therapist can decide whether to facilitate some more breathing down at lower lung volumes, or whether to facilitate breathing at higher lung volumes. Once again, the older toddler/child may be able to add in a few brief inspiratory holds.

Higher lung volume breathing (evacuation phase)

The physiotherapist should use some quick but gentle stretch facilitation at the end of expiration to encourage the baby to take a bigger breath in. Once again, a small series of bigger breaths (aiming to move into inspiratory reserve) are carried out. If there is mucous sitting in the upper airways, there may be a spontaneous cough or a cough can be stimulated if required.

Exercise is another way of stimulating bigger breaths, so this may be used to achieve the desired response. Rhythmic bouncing on an exercise ball in conjunction with AAD to aid in stimulating greater inhalation and flow rates has been described. Physiotherapists should recognize that there are a number of activities and games that could be used to facilitate deeper breaths. Physiotherapists who have some experience using AD would most likely use AAD in a situation where the older toddler or child could be coached whilst the therapist provided hands on guidance and facilitation.

2.1.4.7 Positive Expiratory Pressure (PEP)

Theoretically, PEP allows air movement through pathways of collateral ventilation, enabling better access to peripheral airways, improving regional lung ventilation and increasing resting lung volumes. PEP is reported to improve functional residual capacity, reduce trapped gas volumes and improve secretion clearance.

Treatment using PEP requires careful patient assessment, education, technique selection and monitoring to enable maximal effectiveness and safety. Its application theoretically applies to several different groups of patients. Application of these principles primarily indicate its use in chronic suppurative lung diseases (e.g. CF, bronchiectasis, chronic bronchitis, hypersecretory asthma, immune deficiencies) where problems include asynchronous ventilation of obstructed lung, dynamic airway collapse and secretion clearance difficulties occur.

Indications include:

1. Ventilation problems
 - a. Atelectasis due to e.g. post operative collapse, regional underventilation during anesthesia, mucous obstruction of small airways
 - b. Ventilation asynchrony in chronic obstructive disorders, due to partial mucous obstruction
2. Structural problems e.g. tracheomalacia, bronchomalacia – PEP can provide a modest amount of positive pressure support to unstable airways, promoting secretion clearance
3. Safe, effective and independent airway clearance treatment in chronic suppurative lung disease
4. Manage or prevent risk of side effects with other airway clearance techniques
 - a. Organomegaly – enlargement of abdominal organs (e.g. liver disease) interferes with diaphragmatic function and may preclude GAD
 - b. GOR – incidence and impact of GOR is increased in some paediatric populations including CF and may preclude GAD
 - c. Sinus problems – GAD may increase symptoms. PEP may be modified to use with a mouthpiece if required e.g. recent upper airway surgery
 - d. Musculoskeletal disorders – manual techniques may not be tolerated in some conditions e.g. arthritis, joint contractures, recent surgery
 - e. Haemoptysis – discussion with respiratory medicine consultant. In the instance of small haemoptysis, PEP may be the treatment of choice as manual or oscillating techniques may disrupt the healing mucosa. In the instance of large haemoptysis, physiotherapy treatment is usually ceased for approximately 24 hours (requires discussion with consultant).
 - NB pressures generated during coughing are far greater than during PEP, therefore it is thought that there is a greater risk associated with paroxysmal coughing than with low pressure PEP
5. Haematological abnormalities e.g. in oncology patients with neutropenia, reduced platelet counts etc where manual techniques are contraindicated.

Contraindications include;

- acute asthma/severe bronchospasm
- undrained/tension pneumothorax
- clamped ICC
- moderate/large haemoptysis (>20ml)
- large emphysematous bullae
- severe fibrotic changes
- recent gastric surgery
- peritoneal dialysis

- haemodialysis
- recent nasal surgery (PEP with mask)
- severe sinusitis (PEP with mask)

Precautions include:

- reactive airways
- small /moderate haemoptysis (10-20ml)
- small bullae visible on CXR
- recent ear surgery (eg grommet insertion)
- recent lung surgery
- inability to clean equipment regularly and thoroughly

2.1.4.8 PEP mask

The PEP mask consists of a face mask and a one way valve with an inspiratory and expiratory port. A resistor is attached to the expiratory port to achieve PEP. Patients are assessed by the physiotherapist for the appropriate resistance - one which gives a steady PEP of 10-20 cmH₂O during mid-expiration. The system and appropriateness of resistance should be regularly reviewed.

Figure 2-3. Astra PEP mask system



Figure 2-4. Silicone PEP mask set-up



Implementation

To implement, the patient should be seated in a supported position, able to lean forward onto elbows on table for support (not slumped). Feet should be supported (small children may require a stool).

Allow familiarization with breathing through the mask on its own and discuss breathing pattern. The mask should be held firmly over the nose and mouth to create a firm seal. The patient uses diaphragmatic breathing with a slightly active expiration (do not exhale completely).

Allow the patient to feel sensation of low and high resistance to expiration i.e. use 1.5mm and 5 mm resistors. Explain to the patient that PEP is not like strengthening i.e. working harder does not give better results – that what is right for them, is right for them

Choose a possible resistor (usually smaller-mid range) and allow patient to breathe through the mask without instruction for 10-12 breaths. Observe pressure gauge initially as patients will often try to get the highest reading! Aim for mid expiratory pressure 10-20 cmH₂O. The correct resistor allows the patient to carry out the correct technique comfortably – inspiratory:expiratory (I:E) ratio of 1:3 or 1:4, active but not forced expiration, pressures 10-20 cmH₂O.

Observe a whole session of PEP, not just a few cycles to determine correct resistor – observe pressure generated, respiratory muscle effort and I:E ratio, palpate basal expansion. There should be slightly active but not forced expiration. Common problems include;

- excessive effort
- blowing out cheeks
- excessively fast or slow breathing pattern
- discomfort e.g. ears, sinus, dizziness
- over reliance on pressure gauge

A treatment session consists of periods of breathing with PEP (10-20 breaths or 1-2 minutes) followed by forced expiration technique, consisting of breathing control and 1-2 huffs, and/or cough. The frequency and duration of each treatment is adapted to the needs of the individual patient, and may vary over time.

Not all children require a pressure gauge for home as, over time, most children perform the technique correctly without visual feedback. Parents may choose to use a pressure gauge while their child is learning the technique and to check from time to time, but most usually the resistor being used and pressures being achieved can be checked during physiotherapy review appointments.

Cleaning instructions for astra PEP masks

Disassemble

Mask can be washed each time it is used

- Hot soapy water
- Rinse
- Air dry

One way valve can be washed weekly

- Hot soapy water
- Rinse
- Air dry – need to ensure it is able to dry before next use

Cleaning instructions for silicone PEP masks

All equipment MUST be washed after each time it is used

- Disassemble
- Hot soapy water
- Rinse
- Air dry

2.1.4.9 Baby PEP

Application of PEP via a mask to infants has been described. A size 0 astra PEP mask with one-way valve and black resistor may be used. The child is positioned comfortably, and the mask held over their face for a series of breaths. Short treatments will be required initially as the infant gets used to the treatment.

Figure 2-5. Baby PEP

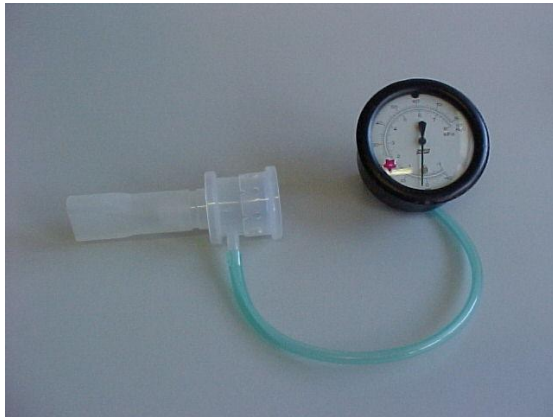


2.1.4.10 Mouthpiece PEP

An alternative is the use of a mouthpiece with a nose clip (MoPEP). This is theoretically supposed to provide the same effect and whilst there are no studies to confirm this, clinical practice indicates reasonable efficacy. Mouthpieces may be preferable in some situations;

- patients who are unable to initially learn the mask PEP technique (due to age, skill level or intellectual disability)
- dyspnoea, and an inability to manage the dead space associated with the mask set up
- patient unable to hold mask in place
- post operative patient
 - sinus surgery – need to avoid/minimize upper airway pressure swings
 - abdominal surgery – less expiratory effort require so may be easier, also less postural stability required to hold mask in place

Figure 2-6. Mouthpiece PEP system with manometer



Cleaning instructions

All equipment MUST be washed after each time it is used

- Disassemble
- Hot soapy water
- Rinse
- Air dry

2.1.4.11 Combination PEP Treatment

It is possible to combine PEP with inhaled therapies such as normal or hypertonic saline (e.g. pari PEP system combined with pari LC plus nebuliser). This can reduce total treatment time for some patients, improving adherence. An interrupter device can be used on a pari system to prevent aerosol waste between sets of PEP. There is no evidence showing any difference with treatment administered in this way, and clinically this can work well for some patients.

Figure 2-7. Combined PEP Treatment



Figure 2-8. Combined PEP Treatment using interruptor (dissembled and assembled)



Cleaning instructions

All equipment MUST be washed after each time it is used

- Disassemble
- Hot soapy water
- Rinse
- Air dry

2.1.4.12 High Pressure PEP

The use of high pressure PEP is reported to reduce airway instability, hyperinflation and airway obstruction, whilst facilitating sputum clearance. It is a modification of the previously described PEP technique and involves adding a full forced expiratory manoeuvre through the mask at the end of each PEP cycle (pressures 40-100 cmH₂O). This usually results in coughing at low lung volume. Coughing is performed through the mask until secretions are high in the respiratory tract. Following expectoration, treatment is continued until maximum clearance is achieved.

Assessment for high pressure PEP requires spirometric lung function equipment which can be attached to the mask. This should be carried out by a senior physiotherapist experienced in the technique and meticulous assessment to choose the appropriate size of resistance, and follow up with full lung function testing is vital to ensure maximal therapeutic value. This technique is not currently used at RCH.

2.1.4.13 Bubble PEP

Bubble PEP has been developed for use with young patients who require assistance with clearance of pulmonary secretions. It uses similar physiological principles to PEP but utilises a bottle filled with a specified level of water and bubble liquid, and

tubing through which the patient blows to create bubbles. This creative technique provides positive feedback which in turn may assist the therapist and parent in gaining the cooperation, interest and increased compliance of the child.

Figure 2-9. Figure: Bubble PEP



Cleaning instructions

All equipment **MUST** be washed after each time it is used

- Disassemble
- Hot soapy water
- Rinse
- Air dry – hang tubing and leave bottle to drain upside down. May need to alternate tubing used for treatment to ensure it dries between uses.

2.1.4.14 Oscillatory PEP

Flutter

The flutter is a pipe shaped hand held device which generates a controlled oscillating positive pressure and interruptions of the expiratory flow when breathing out through it. The device is made of a mouthpiece, plastic cone, steel ball and perforated cover. It aims to improve pulmonary ventilation and to ease expectoration.

The flutter has 2 main characteristics;

1. It generates an automatically controlled oscillating positive pressure. The patient is thus protected against a collapse of the airways, as well as against any prolonged hyperpressure.
2. It enables a modulation of the pressure and airflow oscillation frequency. By turning this frequency to his/her own lung resonance frequency (usually between 6 and 26 Hz) the patient induces maximal vibrations of the bronchial walls where CF infections and airway damage occur.

Therefore, the rationale behind how flutter works as an airway clearance technique is based on the following mechanisms;

- shearing forces produced by the oscillations
- airway stabilization with the PEP
- facilitation of mucous flow
- changes in sputum rheology (decreased mucous viscoelasticity)

During exhalation through the device, the patient's respiratory system undergoes internal vibrations which are triggered by repeated variations of the exhaled airflow and by oscillations of the endobronchial pressure. Altering the inclination of the device from the horizontal can regulate the frequency of oscillation. The resulting vibratory effect combined with intermittent PEP is said to maintain airway patency and enhance mucus clearance. Treatment is carried out in the sitting position or a postural drainage position.

Figure 2-10. Flutter



Indications, Contraindications and Precautions

As per PEP protocol.

Some contraindications (in addition to those already listed) include;

- fragile or healing tissue (e.g. haemoptysis)
- unstable airways

Implementation

The patient should sit comfortably in an upright supported position, with their feet on the floor and elbows supported on a bench or table, particularly when learning the technique.

The patient should hold the flutter horizontally with a slight tip up or down as required to obtain the maximum resonance – the patient should be able to tell when this is achieved, and the therapist will assess via palpation and listening to the expiratory sound.

The patient should take a breath in (a little deeper than normal), place the flutter in their mouth and then exhale a little faster than normal, keeping the cheeks hard and flat. Children may find it difficult to stop their cheeks from 'blowing out' and vibrating. If this occurs, the patient should be encouraged to support their cheeks with the thumb and fingers from the other hand. The patient should not exhale completely at this stage.

A treatment session consists of periods of exhaling through the flutter (anywhere from 4-15 breaths) followed by forced expiration technique, consisting of breathing control, huffs, and/or cough. The frequency and duration of each treatment is adapted to the needs of the individual patient, and may vary over time.

Children may report dizziness during this type of treatment, and this may be avoided by reducing the number of breaths they are taking in sequence.

The frequency and duration of each treatment is adapted to the needs of the individual patient, and may vary over time.

Cleaning instructions

All equipment MUST be washed after each time it is used

- Disassemble
- Hot soapy water
- Rinse
- Air dry

Acapella

The Acapella (or Acapella choice) is another oscillating PEP device. It uses a counterweighted plug and a magnet to direct exhaled air through a pivoting cone to generate the oscillatory effect. The frequency and resistance are adjustable, with the frequency of vibrations ranging between 0-30 Hz.

The basic acapella is available in two colours; blue and green. The green one is used in patients who can maintain an expiratory flow of at least 15 l/min for more than 3 seconds. The blue one is used for patients who can only generate flows of less than 15 l/min. These two devices cannot be disassembled for cleaning, which restricts their application. The aqua acapella choice is the preferred option as it can be easily disassembled for cleaning.

The rationale for using the acapella may be essentially the same as for the flutter, however it is important to note that they are different devices and there has been very little research to date on its effects.

Some of the advantages of the acapella are that it is small and portable, and it is not gravity dependent (i.e. it can be used in a range of positions). Technically, it may also be easier for some patients to manage, if oscillatory PEP is indicated and effective.

Indications

As per flutter

Contraindications and Precautions

- untreated pneumothorax
- active haemoptysis
- inability to tolerate increased work of breathing
- intracranial pressure > 20 mmHg
- recent facial, oral or skull surgery or trauma
- oesophageal surgery
- known or suspected tympanic membrane rupture or other middle ear pathology
- haemodynamic instability
- acute sinusitis
- epistaxis
- nausea

Implementation

A mouthpiece or a mask may be used with this device. The patient should sit with feet supported and elbows resting on a table. It is important that shoulders are relaxed throughout the airway clearance session.

For the first time, the resistance should be initially set at the lowest setting of '1'. Resistance can be adjusted by turning the dial clockwise to increase the resistance or anti-clockwise to decrease the resistance. This will also affect the frequency produced as the amount of airflow is altered. The amount of resistance and force of exhalation should be fine tuned to allow the patient to feel the optimal amount of resonance throughout their chest.

A treatment session consists of periods of exhaling through the acapella (anywhere from 4-15 breaths) followed by forced expiration technique, consisting of breathing control, huffs, and/or cough. The frequency and duration of each treatment is adapted to the needs of the individual patient, and may vary over time.

These steps can be repeated so that a number of sets on the acapella can be carried out. Duration of treatment could be between 5-20 minutes, and would usually be adjunctive to other airway clearance techniques.

Figure 2-11. Acapella



Cleaning instructions

All equipment **MUST** be washed after each time it is used

- Disassemble
- Hot soapy water
- Rinse
- Air dry

2.1.4.15 Activity and Exercise

Regular participation in physical activity and exercise is of great importance for reasons including increased cardio-respiratory fitness, increased ventilatory muscle endurance, decreased breathlessness, enhanced sputum clearance, increased muscle mass and strength (resulting in improved body image) and an enhanced quality of life. It is part of a healthy lifestyle for people of all ages, but particularly for

patients with chronic respiratory disease as it may also promote secretion clearance. The positive effects of exercise and its contribution to maintaining a healthy lifestyle should be emphasised to the whole family from the time of diagnosis. It should be considered as part of the regular care of patients with chronic respiratory conditions from the onset of physiotherapy management, and recommendations tailored to the individual patient's age, interests and abilities. 'Huff and puff' play is encouraged as soon as children are able to perform motor skills sufficiently well to 'get puffed' eg trampoline, running games.

As children grow, exercise recommendations or programmes should be individually tailored and combine endurance and strength training exercises for the upper and lower body. Aerobic exercise such as swimming, cycling, skipping and trampolining aim to improve endurance, allowing longer periods of physical activity without discomfort. Such weight bearing exercises may also be beneficial in terms of preventing or delaying the loss of bone mineral density. Strength training aims to increase muscle strength and mass. While not discouraged it should be undertaken with care, avoiding repetitive stress on joints, particularly in children where repetitive strain on the epiphysial plates can cause injury.

Postural deformities, particularly of the thoracic spine, are common in chronic respiratory disease and careful attention should also be paid to posture. Participation in activities to address core stability is also advised.

Some patients may require consideration of timing of treatments such as bronchodilator therapy or airway clearance to ensure maximal participation in exercise programs. Patients with severe lung disease may be at risk of desaturating during exercise, and should be monitored accordingly. Supplemental oxygen may be necessary and this should improve performance and reduce breathlessness during exercise.

Generally those with mild to moderate disease ($FEV_1 > 55\%$) are likely to be able to exercise to the same level as their healthy peers. Following careful assessment with exercise testing, those with more severe disease should also be encouraged to undertake some form of regular exercise.

2.1.4.16 Non-invasive ventilation as an adjunct to physiotherapy

Non-invasive ventilation (NIV) has an expanding role in the management of acute and chronic respiratory failure in CF, as well providing assistance with airway clearance and exercise.

Physiotherapy can be tiring, particularly when a patient is unwell, due to increased ventilatory demand, adverse effects on respiratory muscle performance, alterations in gas exchange and increase in dyspnoea. NIV has been reported to unload the respiratory muscles during airway clearance in patients with CF resulting in decreased dyspnoea and preventing oxygen desaturation during treatment. It is therefore particularly useful in patients in whom dyspnoea limits treatment effectiveness.

Pressure levels should be titrated to the individual patient, aiming for maximal tolerable IPAP to maximise pressure support and therefore provide respiratory muscle unloading. It is thought that EPAP levels should be kept relatively low to

minimise interference with coughing. The type of mask should also be fitted to the individual patient, with many patients preferring a nasal mask for ease of expectoration.

Use of BiPAP during exercise has also been demonstrated to be effective, and may be applicable in certain circumstances.

2.1.5 Inpatient Physiotherapy

The Physiotherapy Department offers a 7 day service to patients with cystic fibrosis. Weekday hours are 0830 until 1700, and weekend service is from 0900 until 1530 (or 1630 if necessary).

The Senior Physiotherapist to Respiratory Medicine (pg 5404) is notified of patient admission to ward, according to clinical path. Physiotherapy assessment will be made as soon as possible and treatment commenced. Treatment frequency may vary from 1-4 times a day depending on the severity of the respiratory symptoms or other influencing factors.

Treatment usually takes place in the physiotherapy department, according to cohort, twice each day unless influenced by other factors. Each treatment session usually lasts for 1 hour, comprising inhalation therapy, airway clearance and exercise. Treatment times are communicated to the ward each day to enable planning for IV antibiotics times, administration of prescribed inhaled treatments (eg pulmozyme, ventolin) and other daily events. Patients will be seen on the ward post specific procedures until they are able to attend the physiotherapy department.

Parents are encouraged to attend physiotherapy treatment sessions, especially towards the end of admission, for education and updates regarding the physiotherapy home program.

2.1.6 Outpatient Physiotherapy

A senior physiotherapist attends respiratory medicine outpatient clinics, when fully staffed. Their role is to liaise with other team members, review PFT results, obtain sputum specimens if required and review home inhalation therapy, airway clearance and exercise requirements for each individual patient.

Patients are encouraged to phone the physiotherapy department prior to the day of their outpatient appointment to make a time for an annual full review. This enables time for a full treatment session to be completed and observed, alternative treatment techniques trialed and other suggestions made.

In the case of large clinics, patients will be prioritised according to need. Follow up arrangements may be made. Attendance at the outpatient meeting and liaison with the RDNS physiotherapist ensures communication of treatment change or arising issues.

2.1.7 Inhalation Therapy

2.1.7.1 Ward

All prescribed inhaled treatments must be administered on the ward in a well ventilated room and documented in the patient's drug chart. This includes;

Pulmozyme

Patients are to provide their own pari LC plus nebuliser bowl from home. Needs to be administered at least 30 min prior to physiotherapy treatment. These nebuliser bowls required 5-6 litres/min flow, and should be returned to the patient at the end of the admission for use at home.

Ventolin

Needs to be administered at least 10 min prior to physiotherapy treatment. Seretide, flixotide, Qvar and other 'preventers' – administer after physiotherapy treatment.

Inhaled antibiotics ** depends on guidelines currently under review

- Are not for routine administration on the ward
- When indicated, to be administered by nursing staff on the ward
- Indication for administration to be discussed with respiratory medicine consultant
- May be administered bedside on the ward via a tracheostomy connector or mouthpiece using a pari LC plus nebuliser bowl and filter system
- May be administered in the ward treatment room via a mask using a pari LC plus nebuliser bowl and filter system
- See respiratory medicine senior for appropriate equipment

Hypertonic Saline

The decision to trial hypertonic saline may be made by the senior physiotherapist. This may be discussed with the child's consultant. Ventolin needs to be prescribed on the patient's drug chart, and administered prior to the trial. Usually the first administration is 3% hypertonic saline, in the presence of a senior physiotherapist using a pari LC plus nebuliser. The patient is informed to advise staff of any perceived changes with their breathing during administration, are assessed pre and post administration and monitored during treatment. If assessed to be appropriate, 4.5 or 6% hypertonic saline may be used, as may an ultrasonic nebuliser for the duration of the admission.

For patients normally using hypertonic saline at home, administration still takes place in physiotherapy for the purpose of assessing efficacy and enables supervised modifications to take place.

General Guidelines

- for routine administration of nebulised treatments on the ward (e.g. normal saline, ventolin), the disposable single patient use nebuliser bowls (clear/green, Salter) may be used and require 10 litres/min flow from the wall outlet
- mouthpieces (clear T pieces) should be used whenever possible (normally in children >4-5 years)

- the clear/green Salter nebuliser bowls available on the ward are not suitable for long term use and are to be disposed of at end of admission
- For patients seen in the chest room, pari LC plus nebuliser bowls or ultrasonic nebulisers may be used to administer normal or hypertonic saline.

Cleaning instructions

All nebuliser bowls should be washed each time they are used

- Disassemble
- Hot soapy water
- Rinse
- Air dry

Figure 2-12. Pari LC plus nebuliser



2.1.7.2 OUTPATIENTS

Normal Saline

In the past, normal saline was recommended for administration prior to all physiotherapy treatments. This has not been the case in recent years; however, there are some patients who continue with this practice through choice. More routine practice is to now recommend its use for some patients, some of the time.

Bottles of normal saline can be purchased from pharmacies. Patients need to check with pharmacists that preparation is suitable for inhalation and is preservative free. Bottles of normal saline need to be stored in the refrigerator.

Hypertonic saline

The decision to trial hypertonic saline may be made by the senior physiotherapist. This may be discussed with the child's consultant. The majority of patients require ventolin to be administered prior to hypertonic saline administration. Timing of treatment with other therapies and daily routines needs to be discussed. Usually the first administration is 3% hypertonic saline, in the presence of a senior physiotherapist using a pari LC plus nebuliser. The patient is informed to advise staff of any perceived changes with their breathing during administration, are assessed

pre and post administration and monitored during treatment. If assessed to be appropriate, 4.5 or 6% hypertonic saline may be used

Long term use requires a prescription from their consultant. Timing of treatment with other therapies and daily routines needs to be discussed.

Pulmozyme

Patients are referred to the physiotherapist at the commencement of a month trial of pulmozyme for education and provision of equipment and education pack. A pari LC plus nebuliser bowl is provided at the beginning of the trial and replacements are available each 6 months of ongoing treatment (from the physiotherapist). Individual timing issues are discussed, and a recommendation for daily treatment plan made. The primary consideration is that it is administered at least 30 min prior to physiotherapy treatment if it is to be taken prior to treatment (either AM or PM). Pulmozyme needs to be stored in the refrigerator.

Inhaled antibiotics

Prescription of inhaled antibiotics for the first time also requires referral to the physiotherapist for education and discussion regarding equipment and treatment. Information regarding purchase and maintenance of appropriate nebulisation equipment can be provided. Preparation of the treatment and timing with other therapies also requires consideration.

Normal doses of tobramycin are either 4ml or 2 ml – 4ml dose can be administered directly, however, a 2ml dose requires dilution with 2ml of normal saline. Information regarding filter systems can also be provided to families.

Ventolin

Should be administered 10 min prior to physiotherapy treatment, if to be taken at that time to open airways and promote secretion clearance

Corticosteroids

Should be administered after physiotherapy treatment to ensure optimal deposition after airway clearance

General Guidelines

- patients requiring inhalation therapy at home will require individual advice and consideration of specific needs when recommending equipment (both nebuliser bowl and air compressor)
- many different equipment brands, models and prices can be sourced, from local chemists, direct from suppliers and the RCH Equipment Distribution Centre
- features of the nebulisers needs to match the requirements e.g. multiple inhalation therapies each day demands a good quality nebuliser, and therefore we recommend that families discuss intention to purchase with the CF physiotherapists
- CFV are able to loan travel pumps and may be able to assist with the purchase of a nebuliser for patients who are members of CFV
- Beyond warrantee time, nebulisers will need to be serviced to ensure efficiency – please contact the supplier for local service details.
- Use of a mouthpiece (instead of a mask) with inhalation therapy is preferable, due to the improved deposition of particles in the airways, and greater benefit from therapy. Children can generally learn to use a mouthpiece from around 4-5 years of age.

- Separate nebuliser bowls are required for inhaled antibiotics and other inhaled therapies (e.g. pulmozyme, hypertonic saline)
- Nebuliser bowls require regular replacement (each 6 months)
- Patients on pulmozyme are provided with a new pari LC plus nebuliser bowl every 6 months – please see the physiotherapist in clinic
- It is important that all children have their own nebuliser bowl, if more than one child in the family is using inhaled therapies

Cleaning instructions

All nebuliser bowls MUST be washed after each time they are used

- Disassemble
- Hot soapy water
- Rinse
- Air dry

2.1.8 PHYSIOTHERAPY EQUIPMENT

Technipro Marketing Pty Ltd
PO Box 6390
Parramatta Business Centre
NSW 2150

Ph 02 9890 9311
Fax 02 9890 7488
Email technipro@technipro.com.au

Stock: Astra PEP mask set/components
PariPEP system (MoPEP)
Pari LC plus/Pari LC star nebulisers
Pari masks and connectors
Pari filter sets and pads
Interrupter
Manometers and t-connectors
Air Compressors
Flutter

Device Technologies
Locked Bag 521
Frenchs Forest
NSW 1620

Ph 02 9975 5755
Fax 1800 999 323

Stock: TheraPEP
Pressure Gauge
Acapella
Incentive Spirometer

Air Liquide
135 Burnley St
Richmond
VIC 3121

Ph 1300 360 202

Stock: Flutter

Playmaker
54 Princes St
Riverstone
NSW 2764

Ph 02 9627 1011
Fax 02 9627 1049
Email play_maker@msn.com.au

Stock: Postural drainage table

Medical Developments Australia
Factory 7, 56 Smith Rd
Springvale
VIC 3171

Ph 03 9547 1888

Fax **03 9547 0262**
Email mda@bigpond.com

Stock: Silicone face masks (to fit pariPEP)

2.1.8.1 NEBULISERS & COMPRESSORS

Nebulisers

Pulmozyme

- new pari LC plus nebuliser supplied on commencement and every 6 months by Roche. Stock in Physiotherapy Department.

Inhaled antibiotics

- pari LC plus nebuliser available for purchase from EDC, Technipro or Physiotherapy Department

Compressors

Compressors can be purchased from a range of companies including Technipro and Niche Medical. The Senior Physiotherapists can advise families regarding purchase of this equipment.

Compressors for short term use may be loaned from CFV. Compressors available from local pharmacies are generally insufficient for use in CF.

Travel pumps available for loan from CFV (require advance notice).

Technipro:

Pari Turbo Boy

Pari Uni Light – mini, portable, multi-voltage system

Duraneb 3000 – portable, multi-voltage system

Niche Medical:

Portaneb

Annual service recommended.

Lifequip

373a Greensborough Rd

PO Box 116

Watsonia

VIC 3087

Ph 03 9432 2666

Fax 03 9434 3100

2.2 ANTIBIOTIC THERAPY

The use of antibiotics in suitable doses via an appropriate route has contributed significantly to the improvement in both quality and quantity of life for children with CF.

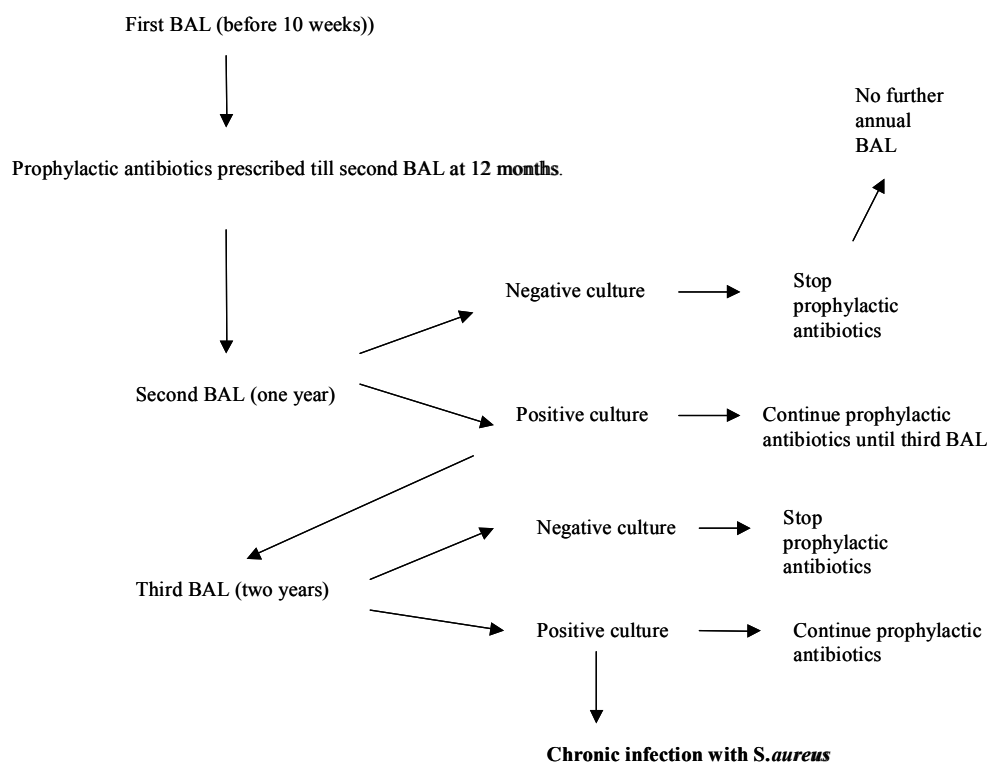
There are a number of long term regimens currently in use for the antimicrobial management and CF centres will individualise their therapies according to local bacterial sensitivities and experience. The guidelines used by the CF unit of the Royal Children's Hospital are summarised below with the dosage details documented in the Pharmacopoeia.

2.2.1 Management of infection with *Staphylococcus aureus*

2.2.1.1 Prophylactic antibiotics

Bronchoalveolar lavage data from our service indicate that occult infection with *Staphylococcus aureus* occurs in approximately 40% of infants. Therefore, we recommend the use of **anti-staphylococcal prophylactic antibiotics from diagnosis until 12 months of age in all CF infants**. Although there have been concerns about the increase in acquisition of *P. aeruginosa* in those on prophylaxis regimens, most studies report patients treated with broad spectrum antibiotics (e.g. cephalexin). We use **Augmentin duo**. After the age of 1 year, **Augmentin duo** can be stopped in those children who have negative BAL culture for *S. aureus*. It should be continued in those children who develop respiratory symptoms after stopping **Augmentin duo** or those whose BAL culture at one year is positive for *S. aureus*. Occasionally infants do not tolerate Augmentin (e.g. vomiting). It is then reasonable to consider alternative anti-staphylococcal treatment (e.g. flucloxacillin) or even no prophylaxis in those without evidence of infection on broncho-alveolar lavage culture.

Figure 2-13. Antibiotic prophylaxis against infection with *S. aureus*



2.2.1.2 Chronic infection

Those children who regularly grow *S. aureus* in their sputum, those whose annual BAL is positive on two consecutive occasions or those whose symptoms return whenever anti-staphylococcal antibiotics are stopped should remain on prophylactic anti-staphylococcal medication (**Augmentin duo**). Any intercurrent respiratory tract infection should be treated by stopping the prophylactic antibiotic and replacing with another anti-staphylococcal agent (e.g. **Flucloxacillin, clindamycin, cephalexin**) for 2 weeks. If the patient fails to respond then intravenous agents for two weeks may be necessary. Aim to include an anti-staphylococcal antibiotic with any subsequent IV course of treatment (**First line IV antibiotics depending on sensitivities: Timentin and gentamicin**). Consider a bronchoscopic lavage in patients not responding to IV treatment. After treatment, prophylactic antibiotics are recommenced.

2.2.2 Management of infection due to *Hemophilus influenzae*

2.2.2.1 Acute infection

Treat with a 2 week course of an oral antibiotic (eg. Augmentin) if *Hemophilus* is isolated in sputum. If sputum is still positive or if symptoms improve but persist after 2 weeks, continue Augmentin for a further 2 weeks but consider alternatives if there is no improvement in symptoms at this stage, including IV antibiotics. If symptoms persist after a total of 4 weeks then consider IV antibiotics. A bronchoscopic lavage is indicated in patients not responding to treatment.

2.2.2.2 Chronic infection

In those patients who repeatedly have *H. influenzae* cultured in their sputum consider long term prophylaxis (e.g. Augmentin). Augmentin is also the antibiotic of choice for acute exacerbations in those with chronic *Hemophilus influenzae* infection.

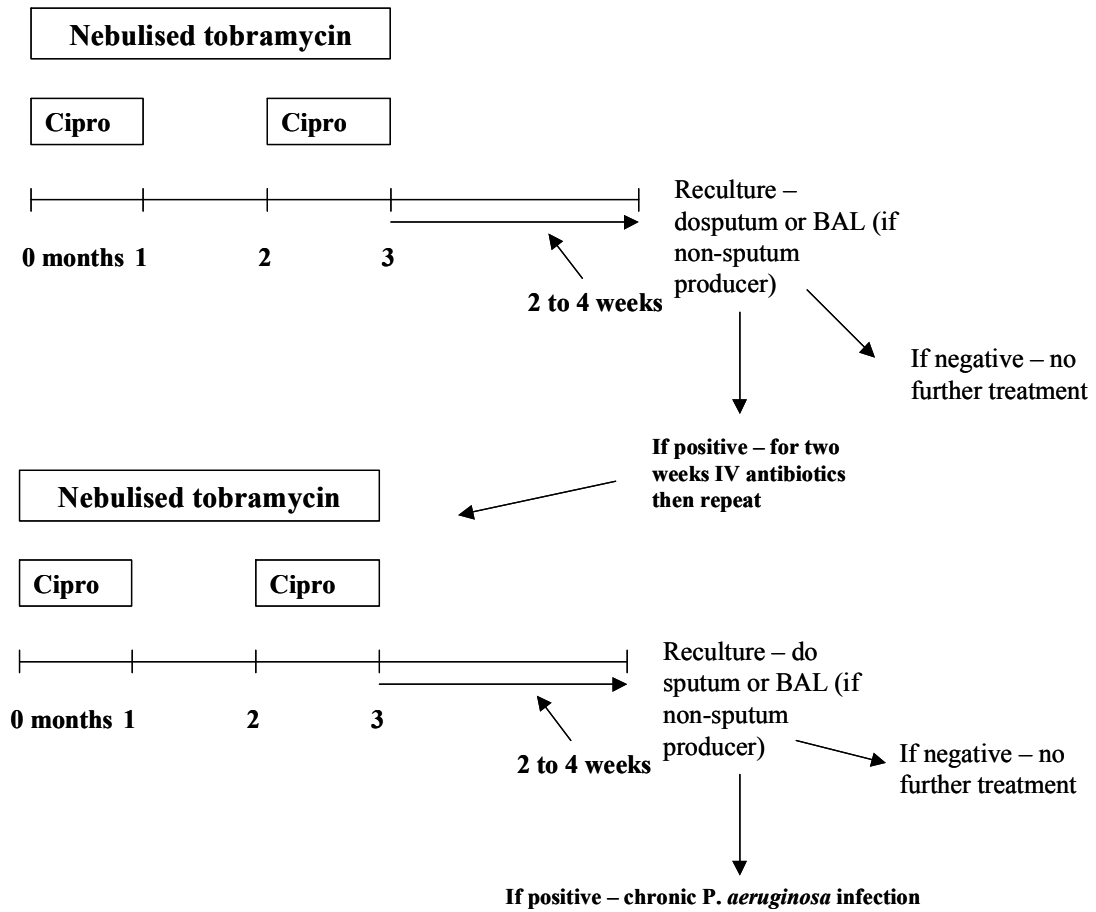
2.2.3 Managing infection due to *Pseudomonas aeruginosa*

The acquisition of chronic *P. aeruginosa* infection is associated with deterioration in lung function and a poorer prognosis. An aggressive antibiotic approach may prevent chronic infection and limit airway disease. **The aim of treating infection early is to eradicate *Pseudomonas aeruginosa* when first identified**

2.2.3.1 Early infection with pseudomonas – if patient is well without signs of exacerbation

Treatment is with three months of nebulised tobramycin (80mg bd under 8 years and 160mg bd over eight years) and oral ciprofloxacin given during the first and last month of tobramycin therapy according to the figure below.

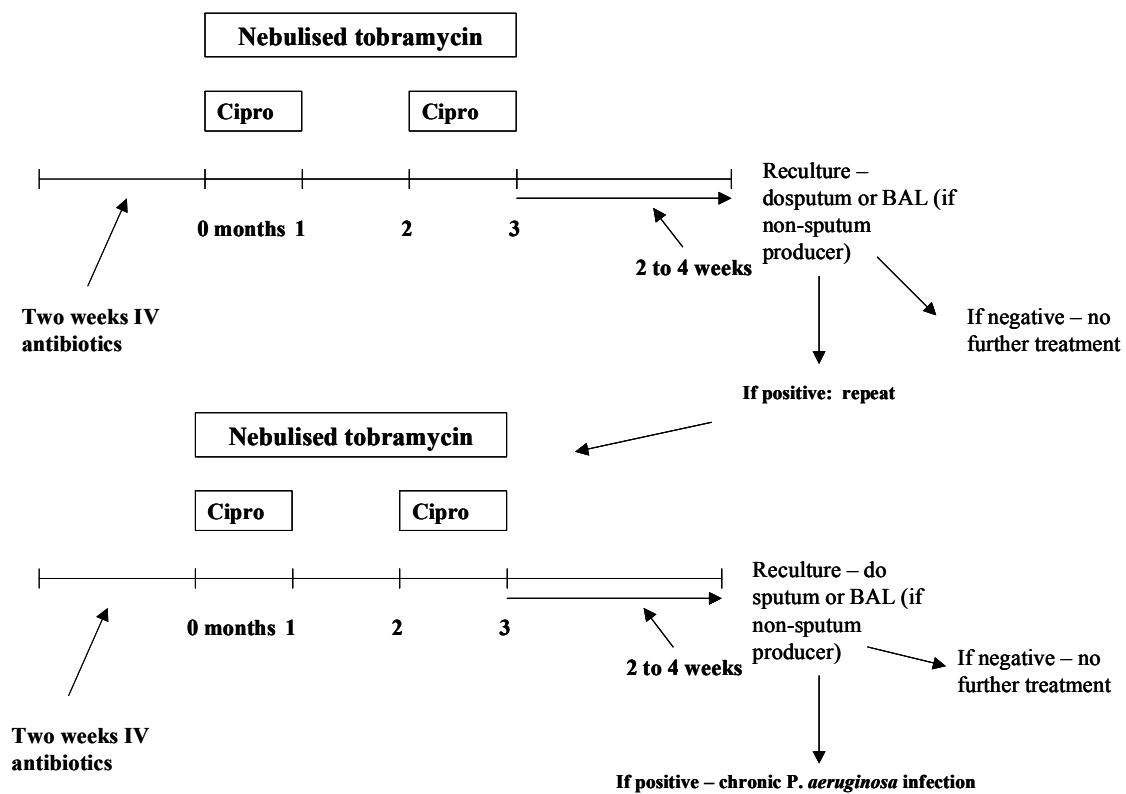
Figure 2-14. Treatment of early infection with pseudomonas if patient is well



2.2.3.2 Early infection with pseudomonas – if patient is unwell with signs of acute exacerbation or treatment adherence in doubt

Treatment commences with two weeks of intravenous antipseudomonal antibiotics (usually **Timentin and tobramycin** but adjusted according to sensitivities) but is then identical to the eradication protocol of those who remain well.

Figure 2-15. Treatment of early infection with pseudomonas if patient is unwell



2.2.3.3 Definition of successful eradication:

At least three negative cultures one month apart

OR

One negative culture from broncho-alveolar lavage AND one other negative culture one month apart

2.2.3.4 Chronic infection

Infection with *P. aeruginosa* is assumed to be chronic after three consecutive positive cultures have been obtained at least one month apart. Long term nebulised tobramycin is then commenced. If patients continue to deteriorate while on nebulised tobramycin then consideration can be given to switching to nebulised colistin, nebulised preservative free tobramycin (TOBI), or ciprofloxacin alternating with nebulised tobramycin on a monthly basis.

If a child chronically infected with *Pseudomonas* develops a cold or an infective acute exacerbation then they should be commenced on 2 weeks of oral ciprofloxacin. An exacerbation is characterised by an increase in cough, sputum production, change in sputum colour, loss of weight, decreased activity and deterioration in lung function. Fever may occur but is not typical. If there is no response to oral antibiotics then admit for IV antibiotics. Some children will require regular courses (2-3 monthly) of IV antibiotics depending on clinical status. IV antibiotics should be for at least 10 days with 2 weeks being the norm. Occasionally patients may benefit from a further 3rd week of IV therapy.

It is accepted practice to give two antibiotics - usually combining an aminoglycoside (gentamicin, tobramycin, amikacin) with a penicillin/beta-lactam combination (Timentin = ticarcillin/clavulanic acid) or third generation cephalosporin (ceftazadime) in order to minimise the development of antimicrobial resistance. Our first line, pending antibiotic sensitivities, is to use **Tobramycin in combination with Timentin**. Nebuliser therapy can be stopped during intravenous therapy.

2.2.4 Other organisms

2.2.4.1 Management of *Burkholderia cepacia* infection

Burkholderia cepacia is a gram negative organism which is ubiquitous in the environment and causes a number of diseases in plants. Infection with *Burkholderia cenocepacia* in those with CF may be asymptomatic, can be associated with a slow decline in lung function or result in the "cepacia syndrome". This is an accelerated and frequently fatal deterioration in lung function with fever, necrotising pneumonia and in some cases septicaemia. It is rare.

Infection with *B. cepacia* often presents a therapeutic problem as it is generally resistant to the beta-lactams, fluoro-quinolones and aminoglycosides. Patients with poorer lung function at the time of infection appear to be at greatest risk of cepacia syndrome but survival cannot be predicted from age, sex, duration of colonisation, or antibody response.

Recent anxiety has been generated with regard to the epidemiology of the organism as direct or indirect transmission appears considerably greater than that observed with *P. aeruginosa* and other CF pathogens. Based on genomovar analysis, however, particular strains of *B. cepacia* (e.g. genomovar three, also named *B. cenocepacia*) appear to be associated with spread in epidemic fashion within individual CF centre patient populations. Thus all *B. cepacia* isolates should be sent for genomovar typing.

Fortunately the prevalence of *Burkholderia cepacia* in the CF clinic at RCH remains very low. Few patients are infected and there is no evidence for cases of clinic-associated transmission. Cross infection is by coughing and contamination with

infected sputum and in keeping with policies elsewhere, children infected with *Burkholderia cepacia* are seen in separate clinics.

The following practical guidelines are in use should an individual, admitted to the ward, be found to be *Burkholderia cepacia* positive on sputum culture:

2.2.4.2 Antibiotic Treatment of Burkholderia infections

Antibiotic therapy should be guided by sensitivities. Infective exacerbations may be treated with oral **chloramphenicol, co-trimoxazole or ciprofloxacin**. Consideration can be given to using nebulised ceftazadime (although the taste is unpleasant).

2.2.4.3 Stenotrophomonas maltophilia

This aerobic gram-negative organism is becoming more prevalent among CF patients. It is an environmental organism present in soil, water, animals and vegetation. It is not part of the normal human flora. There is conflicting evidence as to whether it is associated with a decline in lung function. Current opinion is that it is NOT. Therefore only patients who are chronically infected AND have clinical deterioration should be treated with anti-*Stenotrophomonas* therapy. This is usually with **co-trimoxazole** (depending on sensitivities). There is no evidence for cross infectivity and therefore additional strict isolation protocols are not necessary.

2.2.4.4 Methicillin-resistant Staphylococcus aureus (MRSA)

A small number of patients are colonised with *MRSA*. If sputum is found to be positive for *MRSA* and the child has features of an acute exacerbation, anti-MRSA treatment may be warranted but antibiotics should first be directed against any typical CF pathogens.

If *MRSA* is suspected to be causing symptoms then treat according to sensitivities. For acute exacerbations include either **IV teicoplanin or vancomycin**. For chronic infection, consider nebulised vancomycin (preceded by nebulised salbutamol to prevent bronchoconstriction).

Linezolid, an oral antibiotic treatment for *MRSA*, may become useful in the future but at present experience is limited and its role in acute or chronic infection with *MRSA* is unknown.

The hospital infection control policy on *MRSA* must be followed during in-patient treatment. Patients are usually segregated from other CF patients without *MRSA* and other patients with open wounds or central lines.

2.2.4.5 Non-tuberculous mycobacteria (NTM)

In the US, the overall prevalence of NTM (defined as having at least one positive culture) in those with CF over ten years of age is 13.0%. *Mycobacterium avium* complex (72%) and *M. abscessus* (16%) are the most common species. While over a short, 15-month course of follow-up no significant differences in the rate of decline of lung function is attributable to NTM, recent evidence identifies concerning changes and progression of high-resolution computed tomography findings in patients from whom these organisms are repeatedly recovered. If patients do not respond to

conventional antibiotic therapy targeting typical CF pathogens, then consideration should be given to treating NTM. Treatment duration should be 12 to 18 months. However, even successful eradication of NTM is not always associated with clinical improvement. Suggested first line antibiotics (depending on sensitivities) are **oral ciprofloxacin and clarithromycin**. Rifabutin is less well tolerated but is useful at the beginning of treatment as it is bactericidal with good activity against NTM.

2.2.5 Macrolides

There is emerging evidence for the beneficial use of macrolide antibiotics in children with CF. In addition to their antibacterial properties it is thought that macrolides may work by a variety of anti-inflammatory mechanisms.

2.2.5.1 When should macrolides be prescribed?

Infective exacerbation in chronic *P. aeruginosa* infection

In patients known to be chronically infected with *P. aeruginosa*, in addition to nebulised antibiotics, the drug of choice is ciprofloxacin which is usually prescribed for 2-3 weeks. There is *in vitro* evidence of a synergistic effect with azithromycin. Therefore consideration should be given to prescribing clarithromycin or azithromycin together with ciprofloxacin for children who are slow to respond to a course of ciprofloxacin but who are deemed too well for intravenous antibiotic therapy.

Anti-staphylococcal therapy can be stopped for the duration of azithromycin treatment.

Declining lung function and clinical state

Long-term macrolide therapy should be considered for a 6-month period in the following patient groups:

Over 8 years of age (may be used in younger children but this has not been formally studied) with FEV₁ <80% despite maximum therapy (i.e. RhDNase, nebulised antibiotics, failure to respond to regular antibiotics). In those patients who do not have difficulty in expectorating sputum, it is suggested that a trial of azithromycin be commenced first for 6 months before commencing RhDNase,

Other anti-staphylococcal therapy can be stopped during this period.

After 6 months, treatment should be reevaluated. Indications of successful therapy will include:

- improvement in patient well-being
- respiratory symptomatic improvement
- gain in weight
- gain in lung function
- cessation of lung function decline
- a reduction in number of infective exacerbations

Studies to date have used different dosing regimens and it is unclear at present which dosing interval should be used. Of note, there is no toxicology data for the regular use of macrolides for more than 6 months in patients with CF. It is known that after 4 weeks, levels of azithromycin in sputum plateau but because of the long half-life there is the potential for continued accumulation in tissues.

Important side effects to monitor include hearing and liver function. Liver function tests are performed annually. Formal audiological tests are not routinely performed unless there are specific concerns regarding hearing. Changes caused by macrolides are usually reversible.

2.2.6 Upper respiratory tract infections

The role of viral infections in the progress of lung disease in the young child is still unclear. Several viruses have been implicated including RSV, *Parainfluenza* and *Influenza A*. A viral infection may predispose CF patients to secondary bacterial infection and therefore oral antibiotics are used aggressively in presumed viral infections in CF. For mild upper respiratory tract infections, we recommend anti-*Staphylococcal* and *Haemophilus* cover for two weeks (e.g Augmentin). A 2 week course of ciprofloxacin should be given to patients chronically infected with *P. aeruginosa* who have developed an upper respiratory tract infection pending the results of sputum/cough swab cultures.

2.3 TOTAL IMPLANTED VENOUS ACCESS DEVICES

2.3.1 Long line insertion -- Adolescents

- Background
- Equipment
- Analgesia, anaesthesia and sedation
- Procedure
- Post-procedure care

2.3.2 Background

Long lines are silastic catheters that are commonly used those who require a prolonged course of intravenous medications, for example CF patients requiring 10-14 days of intravenous antibiotics. They have several advantages over alternatives such as intravenous cannulas or PICC lines in that they require less frequent replacement, and can easily be inserted on the ward without recourse to special equipment or general anaesthesia.

2.3.3 Indications

Prolonged or repeated venous access for medications or fluids.

2.3.4 Contraindications:

- Skin sepsis at insertion site.
- Bacteraemia or septicaemia.
- High level of patient anxiety or numerous unsuccessful attempts on previous admissions – consider referring to Anaesthetics for PICC line insertion under ultrasound guidance and general anaesthesia.

2.3.5 Complications:

- Infection
- Thrombosis
- Extravasation
- Unsuccessful placement / need for repeat procedure

- **Informed verbal consent should be obtained.**

2.3.6 Equipment

Have the equipment ready before the child enters the room.

- At least one trained staff member to assist
- Sterile pack including smooth forceps
- Long line set
- Sterile gloves
- Sterile drapes (x2)
- Normal saline ampoule
- Skin preparation: povidone iodine solution (Betadine) or chlorhexidine
- +/- Local anaesthetic
- 5 ml syringe
- If collecting blood: specimen collecting tubes and additional syringe
- IV cannula (20G suggested)

- Steristrips
- Cotton wool balls
- Sterile transparent dressing

2.3.7 Analgesia, Anaesthesia, Sedation

- The more prolonged duration of this procedure, together with the greater need for a cooperative patient, increases the need for adequate analgesia and sedation in these children.
- Apply topical anaesthetic cream (Angel or EMLA) 40-60 minutes prior to the procedure.
- Consider using additional agents, such as nitrous oxide, for younger and anxious patients.

2.3.8 Sites

- Basilic and cephalic veins are preferred sites.
- Use non-dominant arm if possible.

2.3.9 Technique

- Apply tourniquet and select appropriate vein.
- Open sterile pack, long line pack, syringes and sterile towels and gloves.
- Wash hands and put on sterile gloves.
- Draw up normal saline into syringe. Assemble long line: the metal end of the line should be fully inserted into the hub, and then the blue Easy-lock connector should be screwed on. Prime with sterile saline. Make sure there are no leaks indicating line damage.
- Clean the skin and wait until it dries (otherwise skin prep is not effective).
- Create a sterile field with the sterile towels and place the line, syringes and forceps on the sterile field.
- The long line can be fed through either the needle supplied with the long line pack, or through a 20G cannula. Using a 20G cannula has the advantage that if the attempt at feeding the long line in is unsuccessful, there is still a working cannula which can be used for several days before further attempts at long line insertion are made.
- Cannulate vein with either the introducer needle supplied or with 20G cannula. Collect blood samples as required. Release the tourniquet.
- Using smooth forceps or fingers, grasp the long line very close to the tip and feed the long line through the introducer needle/cannula to the desired length (see figure).
- If obstruction is encountered, then try: (i). elevating the arm from shoulder, so that returning venous blood flow aids long line advancement; (ii). flushing the line whilst advancing it.
- Once the long line has been inserted to the desired length (usually 15-20cm), slowly withdraw the needle/cannula keeping it parallel to the skin and leave the long line in position. When the needle clears the skin, secure the catheter by trapping it with a gloved finger at the skin exit site (see figure). Disassemble the long line to allow the needle or cannula to be removed, then reassemble again. Attach the catheter to the appropriate intravenous line.
- Flush the catheter with normal saline.
- Coil any remaining long line next to site and secure the line in place using steristrips. Place cotton wool underneath blue hub to avoid pressure sores and then place a sterile transparent dressing on top.

2.3.10 Post-Procedure Care

- Record in the clinical notes the date, insertion site and length of catheter.
- There is no need for routine dressing changes. The dressing should be changed if it becomes loose, the line is blocked or kinked, or there is suspected inflammation or bleeding.
- The line can be used for blood sampling. However, this increases the risk of thrombosis of the line, and should be weighed very carefully against the risks of blood sampling from alternative sites in children or adolescents who may become distressed by additional procedures.
- The long line should never be used to obtain samples for aminoglycoside levels, as the sample is very likely to be contaminated, thus leading to incorrect dosage changes or need for further sampling and delays.

2.4 OTHER PULMONARY COMPLICATIONS

2.5 DNA'SE THERAPY

2.6 O₂ THERAPY AND ASSISTED VENTILATION

3 GI MANAGEMENT

3.1 NUTRITIONAL MANAGEMENT

3.2 MECONIUM ILEUS.

3.2.1 Background

Ten to fifteen percent of newborn babies with cystic fibrosis present with symptoms of intestinal obstruction within 24 hours of birth. Inspissated meconium, often containing

air bubbles on X-ray, fills a varying length of the intestine particularly the ileum. The bowel is collapsed distal to the obstruction and dilated proximally. The degree of obstruction may vary from delay in the passage of meconium to complete occlusion of the bowel lumen. Additional complicating sequelae can occur in the form of bowel perforation, volvulus or atresia.

The diagnosis of CF should be confirmed by genotyping by a sweat test. Meconium ileus on rare occasions can occur in infants who do not have CF. Serum immunoreactive trypsin is only useful as a screening test and is not diagnostic. A recent blood transfusion is not a contraindication to attempted genotyping on the infant. If in doubt genotyping can also be performed on the parents.

3.2.2 Management of meconium ileus

1. If clinical or radiological evidence of a surgical complication such as a perforation, volvulus or atresia is present:
 - Attend to fluid and electrolyte replacement and acid-base balance.
 - Seek a surgical opinion: the current surgical procedure involves an end-to-end or end-to side anastomosis following resection of the necrotic bowel. Ileostomy is now only undertaken in exceptional circumstances.
 - Physiotherapy, prophylactic antibiotics and enzyme replacement will need consideration immediately post-operatively.
 - Some infants may be troubled by post-operative malnutrition and will require special formulae feeds such as Pregestimil (see Section 3.1) or TPN

2. If there is no evidence of surgical complications consider conservative management under the primary care of a surgical team.
 - Attend to fluid and electrolyte replacement.
 - Consider a diluted Gastrografin enema, preferably under fluoroscopic control. Additional intravenous replacement may be necessary. This procedure may need to be repeated and is best undertaken in a specialised paediatric surgical unit as urgent operative intervention may still be required if it fails.

3.3 DIOS

3.3.1 Management of DIOS

This term describes the accumulation of tenacious, muco-faeculent masses in the distal ileum or caecum which may become adherent and calcify. The cause is unclear but appears to be associated with dehydration, fever, the reduction of enzyme supplementation, liver disease and the use of anti-cholinergic and opiate drugs. Although it occurs most frequently in those over 15 years, it can occur at any age. Other conditions which should be considered in the differential diagnosis include:

- Differential diagnosis of distal intestinal obstruction syndrome
- Constipation
- Intussusception
- Acute appendicitis
- Acute pancreatitis
- Volvulus
- Strictures of colon or ileo-caecal junction
- Obstruction due to adhesions or strictures

DIOS presents acutely with signs of abdominal obstruction or more commonly, sub-acutely with cramping abdominal pain and relative constipation. A palpable mass is often palpable in the right iliac fossa. The management varies accordingly to severity (see table below)

Table 3-1. Management of DIOS

Acute presentations	Investigation	Treatment
Mild Episodes Mild abdominal pain No obstruction May be recurrent (out-patient management)	Nil	Rehydration Lactulose 10 – 20 ml BD Acetylcysteine 100 mg 3 times daily Consider adding oral gastrografin
Severe Episodes Abdominal pain with distension and constipation No obstruction No peritonism (consider admission)	Full blood count Urea & Electrolytes Abdominal X-ray <i>(classically, speckled faecal gas pattern in right lower quadrant with dilated small bowel loops)</i>	Rehydration Lactulose 20ml 3 times a daily Klean-Prep or ColonLyte via NG tube until clear fluid passed PR ¹ Consider gastrografin enema (under radiological guidance)
Obstruction present (admit to ward)	Full blood count Urea& Electrolytes Abdominal X-ray	Rehydration 'Drip and suck' Inform surgeons Consider gastrografin enema (under radiological guidance)

¹Monitor for hypoglycaemia in those with diabetes or liver disease

3.3.2 Other considerations in DIOS

- Check dose of pancreatic enzymes
- Check compliance with medications
- Ensure adequate dietary roughage
- Ensure adequate fluid intake
- Ensure patient has a well-established toilet routine
- Consider adding ranitidine or omeprazole if ongoing malabsorption
- Check timing of enzymes and consider possible mismatch in gastric emptying between food bolus and pancreatic enzymes

3.4 CYSTIC FIBROSIS- HEPATOBILIARY DISEASE

3.4.1 Introduction

A variety of biliary and hepatic disease have been documented in patients with Cystic Fibrosis [CF], as summarised in Table 1. The most common disorders are focal biliary cirrhosis, hepatic steatosis and microgallbladder. Multi-nodular cirrhosis occurs in only 5-15 % of patients. It is this form of liver disease that results in portal hypertension and liver failure. So despite liver and biliary dysfunction being relatively common in the CF population, as a whole this complication of CF is an uncommon cause of mortality. However, it is possible that its existence may add to the morbidity of CF. Studies would suggest that there is a rising incidence of liver disease with age and if clinical disease is not apparent by the second decade of life it is unlikely to be a significant issue. There are gender differences in that cirrhosis is more common in males [2:1 ratio]. The CFTR is expressed only in the biliary tract and this results in defective secretion of chloride by the bile duct epithelium, causing decreased bile flow and hepatic injury which culminates in fibrosis. There is no clear correlation with genotype and the factors that determine the severity of liver fibrosis remain elusive. It has been suggested that there are modifying genes or environmental factors which may affect phenotype and hence outcome.

3.4.2 Important clinical points

- Remember that MOST patients with CF do not show clinical symptoms and signs of liver disease [ie peripheral stigmata of hepatic disease] despite the presence of significant cirrhosis
- The MOST important clinical signs of liver disease are; an enlarged soft liver suggestive of steatosis [suggests malnutrition] or a hard and irregular edge accompanied by a prominence of the left lobe of the liver, which would suggest fibrosis/cirrhosis
- Liver function tests are often only mildly abnormal [GGT and ALT 2X normal], despite presence of cirrhosis- that is hepatic synthetic function is well conserved till late in the course of this disorder. When there is a greater elevation of liver enzymes accompanied by a raised bilirubin and coagulation defect then an urgent consultation with Gastroenterology services is essential
- The presence of an enlarged spleen suggests that the patient has portal hypertension

3.4.3 Outpatient monitoring

- All children should have an abdominal examination on an annual basis and the following should be documented- liver texture, size, presence of splenomegaly and other clinical signs consistent with the diagnosis of liver disease.
- All children should have blood drawn for liver function tests [bilirubin, GGT, ALT ALP, Alb and coagulation screen] on an annual basis
- Children with clinical or biochemical evidence of liver disease should be referred to the CF Gastroenterology service

3.4.4 Further investigations

- Additional blood [see Table 2] and radiological tests should be done *only* after consultation with CF Gastroenterology service. These tests are aimed at

excluding other causes of liver disease and assessing severity of the hepatic dysfunction

- Ultrasound: Is useful for assessing the biliary tract, gallbladder [stones etc], spleen and hepatic vasculature. It is less useful for the detection of hepatic fibrosis as periportal steatosis can appear sonographically similar to focal fibrosis
- Hepatobiliary scintigraphy [iminodiacetic acid (IDA) derivatives]: Can demonstrate two patterns, the first being delayed excretion, which may suggest severe cholestasis or obstruction to bile flow. The second pattern is that of poor uptake and is usually a marker for significant hepatocyte dysfunction. The latter pattern is not usually seen till end-stage disease
- Endoscopic retrograde cholangiopancreatography [ERCP]: Is reserved for patients in whom a stricture is suspected on the basis of scintigraphy and ultrasound findings
- Magnetic resonance imaging: Is a non-invasive method to assess the extra and intra-hepatic biliary system and is usually performed prior to ERCP. It is likely that this test will supersede ERCP
- Liver biopsy: Is not usually indicated unless there is significant clinical suspicion that the hepatic dysfunction is caused by an alternative aetiology

3.4.5 Treatment

3.4.5.1 [A] General principles

- It is important to distinguish between steatosis [malnourished child with an enlarged soft liver] and fibrosis [enlarged or normal liver span with a hard edge and accompanied by splenomegaly]. In the case of the former nutrition would need to be optimised and diabetes mellitus excluded
- All patients should have fat soluble vitamin replacement. Levels of vitamin A, E and D and coagulation profiles checked on a 6 monthly basis. Other tests that need to be done on an annual basis include a full blood examination, liver function tests and iron studies
- All patients should have 3 monthly anthropometric measurements [weight and height] and nutrition should be carefully monitored as the extra load of significant liver disease can be an additional caloric burden
- Adolescent patients should be counselled about the risks of ethanol use and taking potentially hepatotoxic medications and herbal therapies
- All patients need to be immunised against Hepatitis A and B

3.4.5.2 [B] Specific treatments

- Ursodeoxycholate therapy [Urso]: Can be taken orally and is said to enhance fluid secretion from the biliary tract. Initial studies suggest that this treatment can improve liver function tests and hepatobiliary scintigraphy, but this needs to be interpreted with caution as patient numbers were small. A recent Cochrane review confirmed that Urso is an unproven therapy and that further clinical trials are required to justify its longterm use. Nevertheless it is our practice that all children with evidence of liver fibrosis and portal hypertension are treated with this medication

- Portal hypertension: The management is similar to that for non-CF patients. Those with variceal bleeding undergo sclerotherapy or banding and if this fails a shunt or early liver transplant would be considered
- Liver transplant is a viable option for a child with liver failure [very unusual in clinical practice] or uncontrolled portal hypertension. These patients would be referred to the Victorian Liver Transplant Service for further assessment. Survival rates for liver transplantation is between 70 and 80 % and is comparable to the non-CF population. Major contraindications for this therapy are severe pulmonary disease and fungal or *Burkholderia cepacia* colonisation

Table 3-2 Hepatobiliary manifestations of CF

Condition	Frequency
Focal biliary cirrhosis	10-70 %
Hepatic steatosis	20-60%
Multilobular cirrhosis	5-15%
Neonatal cholestasis	2%
Microgallbladder	30%
Gallstones	1-10%
Common bile duct strictures	<2%
Sclerosing cholangitis	<1%

Table 3-3 Differential diagnosis of liver disease in CF

Differential diagnosis	Test
Infectious hepatitis	Serology : Hepatitis A,B,C, CMV and EBV
Autoimmune liver disease	Auto antibodies : anti-smooth muscle, anti-nuclear and anti-liver-kidney-muscle
Metabolic liver disease	Serum copper and caeruloplasmin, iron studies and α -1-anti-trypsin level and phenotype
Drug/toxin induced	History
Hepatic congestion	Abdominal ultrasound assessing for hepatic vein dilatation
Structural abnormalities	Abdominal ultrasound assessing for choledochal cyst

4 **PSYCHOSOCIAL SERVICES**

5 GENETIC SERVICES

5.1 CYSTIC FIBROSIS GENETICS AND GENETIC SERVICES

Cystic fibrosis (CF) is an autosomal recessive condition. The incidence in Australia is 1/2500 with a carrier frequency of 1/25.(1) It is most common in Caucasian people, and extremely rare in Asian, African and indigenous Australian populations.

CF is caused by mutations in the cystic fibrosis transmembrane conductance regulator (CFTR) gene. The CFTR gene encodes for the CFTR protein that when mature is localised in the apical membrane of epithelial cells of the airway, pancreatic ducts, intestinal tract, biliary tree, sweat ducts and vas deferens. CFTR acts principally as an electrolyte transporter, regulating chloride and sodium transport. Other functions of CFTR have been reported and the biology of its role in epithelial cell function is becoming increasingly complicated.

There are over 1200 mutations identified in the CFTR gene.(2) Individuals must have 2 CFTR mutations to have CF. The commonest mutation is $\Delta F508$, which accounts for 70% of mutations. Other mutations are less common, examples being G542X (2.4%), G551D (1.3%), N1303K (1.0%). Mutations are divided into classes (I-VI), depending on the protein produced. Class I-III are considered severe in terms of the complete absence of functioning CFTR, and patients with 2 severe mutations can be expected to have pancreatic insufficiency and usually have the most severe lung disease. Class IV-VI mutations are considered mild in terms of there being some CFTR function. Individuals who have one of these mutations (usually in conjunction with a Class I-III mutation) are usually pancreatic sufficient and may have milder lung disease. However, predicting outcome based purely on CFTR gene mutations is not reliable. There are probably a number of other factors that affect outcome, such as other gene loci, environmental and social factors.

5.2 TESTING FOR CFTR GENE MUTATIONS

At RCH, CFTR gene mutation analysis is performed in the DNA laboratory of Genetic Health Services Victoria. The main scientist responsible for analysis is Sarah-Jane Pantaleo (8341 6275) and Dr Desiree DuSart is the laboratory manager (83416333). Tests are usually arranged by the CF genetic counsellor, Lisette Curnow (8341 6250). We advocate the CF genetic counsellor arranging the tests so that appropriate genetic counselling for the affected family is facilitated (see section on Genetic Counselling).

CFTR gene mutation tests are appropriate in the following situations:

- To confirm the result of a newborn screening test
- To identify the responsible gene mutations in an individual with CF
- To aid the diagnosis of CF
- Carrier testing of parents of affected children
- Cascade family testing after mutations have been identified in a family
- Prenatal testing for known carrier couples

Testing for the following 10 mutations is routinely offered: $\Delta F508$, $\Delta I507$, G551D, G542X, 621+1G \rightarrow T, R553X, N1303K, 1717-1G \rightarrow A, R560T, V520F. Further mutations can be requested in special circumstances (eg R117H, W1282X, R1162X, 3849+10kbC \rightarrow T, R347P/R347H, R334W, R560T, A455E). These are usually patients with borderline sweat tests where confirmation of the responsible gene mutations will aid the diagnosis, or patients with confirmed CF where both mutations are not identified on the initial 10 mutation screen. It is worth pursuing the gene mutations, even if the diagnosis is known, to facilitate cascade family carrier testing. Currently we do not have the facility to sequence the entire CFTR gene.

CFTR mutation testing is usually performed from blood taken in an outpatient pathology collection service. Cheek swabs are technically possible, although the DNA laboratory currently prefers blood samples.

5.3 CARRIER TESTING

Carrier testing should be offered through the CF genetic counsellor (Lisette Curnow 8341 6250). This service is free for individuals with a family history of CF, or who have a partner who is a carrier, funded by Genetic health Services Victoria. Carrier testing is recommended for parents of affected children and their extended family. We do not routinely advocate carrier testing for children under 16 years. For extended family ("cascade") screening we focus on adults of child-bearing age.

Siblings of affected children should have a test to exclude the possibility that they also have CF. Generally this is best done by sweat testing which will answer the question as to whether the sibling has CF or not. Siblings have a 1:4 chance of having CF and for those who do not have CF, a 2:3 chance of being a carrier. Siblings can choose to have carrier testing when they are old enough to understand the implications of being a carrier. In special circumstances it may be easier to use gene mutation analysis to exclude CF in a sibling, eg to avoid a long trip to Melbourne for a sweat test.

Carrier testing is clearly facilitated by knowing the gene mutations responsible for causing CF in the proband. However, 25% of CF subjects in Victoria do not have both mutations identified. In these cases linkage analysis can be used to offer meaningful genetic counselling to families. As yet there is no facility in Australia offering CFTR gene sequencing to identify all possible mutations.

5.4 *PRENATAL TESTING*

Couples in whom both are carriers of CFTR mutations can elect to test the foetus in subsequent pregnancies. This is usually done by chorionic villous sampling (CVS) between 11-14 weeks gestation. Termination of the pregnancy is offered if the foetus has 2 CFTR mutations. Some couples prefer to utilise pre-implantation genetic diagnosis (PGD). This is based on in-vitro fertilisation (IVF) technology. At the 8 cell stage of development (blastomere) one cell is removed and tested for CFTR gene mutations. Only unaffected blastomeres are used for implantation. The PGD service is not government funded so that there are considerable out-of pocket expenses for this option.

5.5 COMMUNITY-WIDE CARRIER SCREENING

A limited pilot study for prenatal or pre-conceptual carrier testing commenced in Victoria in January 2005. This is being offered through private obstetricians only and funded on a fee for service basis. It is hoped that the programme will be expanded, initially in the private sector, then offered universally.

5.6 NEWBORN SCREENING FOR CF

Newborn screening programmes for CF were first introduced in NSW and New Zealand in 1981. The programme in Victoria commenced in 1989. Mr James Pitt (8341-6355) is responsible for CF newborn screening in Victoria.

The primary screen is immunoreactive trypsinogen (IRT) measured from the filter paper card blood spot taken on day 2-4 of life from all babies. Babies with an IRT >99th percentile of values have mutation analysis for $\Delta F508$ using blood from the same filter paper card. Positive results are notified to the CF genetic counsellor who will contact the nominated doctor on the screening card and arrange for the family to be contacted. Babies homozygous for $\Delta F508$ are considered to have CF and are referred to one of the two CF centres in Victoria. $\Delta F508$ heterozygotes are referred for a sweat test to determine whether they are affected or are carriers. Babies with an IRT >99th percentile but no $\Delta F508$ mutation are not recalled as the vast majority do not have CF.

Newborn screening detects 90% of babies with CF.(3) Infants are missed because the IRT is not elevated sufficiently to the 99th percentile or the IRT is elevated >99th percentile but they do not have an identified $\Delta F508$ mutation. In reality, about half the infants missed by screening have meconium ileus or an older sibling with CF and should be referred for a sweat test based on these cardinal clinical features. This means that 95% of babies with CF are diagnosed by 4 weeks of age. Any child with clinical features suggestive of CF should be referred for a sweat test despite screening. Children may have been born in centres around the world that do not screen for CF, some adolescents may have been born before the commencement of CF newborn screening in Victoria, or they could have genuinely been missed by screening.

5.7 THE DIAGNOSIS OF CF AFTER NEWBORN SCREENING

This topic has been thoroughly discussed in a recent consensus statement from the Australasian Paediatric Respiratory Group.(4) The US CF Foundation consensus statement on the diagnosis of CF is also a key document, although limited in the context of newborn screening as most centres on the US do not yet screen.(5)

There are 15-20 new patients with CF each year in Victoria.

The key features to consider when making the diagnosis of CF after newborn screening are:

- Clinical features
- Genotype
- Sweat electrolytes

For babies identified as homozygote $\Delta F508$ after newborn screening we recommend repeating the genotype to ensure there has been no mix-up with the newborn screening card. This is usually done when the infants have baseline blood tests. There are often clinical features of pancreatic insufficiency (confirmed on a stool test for fat globules and faecal elastase) which support the diagnosis. In the absence of any clinical features a sweat test is prudent to confirm the diagnosis.

Babies identified as $\Delta F508$ heterozygotes who have a sweat chloride $>60\text{mmol/L}$ are considered to have CF. An extended CFTR gene mutation analysis will be requested to find the second gene mutation.

5.8 DETECTION OF $\Delta F508$ CARRIERS AFTER NBS

There is an increased risk of carriers being detected by newborn screening, in the order of 1.8 times expected.(6) Currently this equates to about 70 infants per year in Victoria. The parents of carrier infants should be referred for genetic counselling with the CF genetic counsellor and be offered carrier testing.

5.9 SWEAT TESTING AFTER CF NEWBORN SCREENING

This section is complimentary to the section on sweat testing in this handbook. However, there are some differences when considering sweat tests in the newborn period and after babies are identified with an IRT > 99th percentile and have one $\Delta F508$ mutation.

Sweat electrolyte values are high in the first few days of life. After one week these values are reliable with regard to the diagnosis of CF. The main difficulty at this time is the collection of an adequate volume of sweat. For this reason we generally recommend waiting until babies are 2 weeks of age before performing a sweat test, and usually over 3kg in weight. However, in special circumstances a sweat test can be attempted earlier if needed.(7)

Infants with an IRT > 99th percentile and one $\Delta F508$ mutation are at increased risk of having CF (about 1:10 have sweat Cl > 60mmol/L). The traditional range for borderline sweat chloride levels may miss some babies/infants with CF. For this reason the usual sweat electrolyte values are not appropriate and the following are recommended in this special situation:

Chloride	≥60 mmol/L	CF
Chloride	30-59 mmol/L	borderline
Chloride	≤29 mmol/L	normal

5.10 APPROACH TO THE PATIENT WITH A BORDERLINE SWEAT TEST

This is an uncommon, but difficult problem for the treating physician and family. Only 1-2% of infants identified by NBS requiring a sweat test have borderline range values. Borderline sweat tests in older children in whom CF is part of a differential diagnosis occasionally occurs. All children with borderline sweat test results should be seen by a CF physician. These patients require a thorough clinical assessment and repeat sweat testing on two separate occasions. An extended CFTR gene mutation analysis should be requested, although these are often the children in whom mutations may not be identified. Additional investigations might include a review of the NBS result (IRT), stool test (fat globules, faecal elastase), liver function tests, sputum microbiology (or bronchoalveolar lavage), and chest radiology (CXR or CT). Where possible parents need closure on the issue of whether their child has CF or not, but we are increasingly aware that this certainty is hard to achieve. Judicious follow-up and repeat sweat testing is often required.

5.11 REFERENCE LIST

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6. HEART-LUNG TRANSPLANT

5.12 THE VICTORIAN PAEDIATRIC LUNG TRANSPLANT PROGRAM

5.12.1 Transplant evaluation process

Dear Doctor,

Thank you for contacting our unit regarding a potential referral for lung transplantation. The Lung Transplant Program at The Alfred Hospital, Melbourne, in association with the Royal Children's Hospital evaluates children who are potential candidates for lung transplantation. At present, the Paediatric Lung Transplant Unit can consider referrals of children who are **above the age of 11 years and weigh greater than 30kg**.

Assessing suitability for lung transplantation involves a detailed medical and social evaluation of the patient, and allows the lung transplant team to:

determine that no other medical or surgical therapy is possible and that lung transplantation is the most appropriate treatment option.

identify medical problems which could potentially place the child at too great a risk for transplantation.

An assessment also provides the opportunity for the child and his/her family to meet the Alfred medical and allied health lung transplant team and ask any questions, and receive detailed medical and practical transplant information.

5.12.2 Indications for Lung Transplantation

As a guide lung transplantation should be considered for children with end-stage lung disease who demonstrate declining function despite optimal therapy, and in whom survival is limited. Lung transplantation is rarely appropriate in critically ill patients in desperate clinical situations (i.e. intubated patients in the intensive care).

In general, lung transplantation should be considered when the patient is breathless on minimal exertion (New York Heart Association class III or IV) and survival is expected to be limited to 2-3 yrs. Patients with CF experience a high mortality whilst on the waiting list and should be considered for transplantation earlier in the course of their disease. The decision on when a patient should be listed for transplantation should not be based on any single-point determinant rather should be based upon a combination of clinical, laboratory and functional findings.

There is very little data in the paediatric literature to guide the appropriate time to refer patients for consideration of lung transplantation. The following recommendations, extrapolated from the adult literature, should act only as a guide to when paediatric patients should be referred for lung transplantation.

5.12.3 Timing of Referral

Cystic Fibrosis	FEV ₁ <30% PCO ₂ >50 mmHg PO ₂ <55 mmHg Rapid decline in FEV1 Clinical deterioration Frequent hospitalisation Massive haemoptysis Recurrent pneumothoraces Wasting Young females with rapid deterioration
Pulmonary Hypertension	Functional status NHYA class III or IV Low exercise tolerance (6MWT <350 m) Uncontrolled syncope, haemoptysis or right heart failure Useful haemodynamic variables Cardiac index <2 L/min/m ² Right atrial pressure >15 mmHg Sv,O ₂ <60%

5.12.4 Contraindications for Lung Transplantation

Absolute contraindications for lung transplantation include;

- serious kidney and liver dysfunction
- active extrapulmonary infection
- progressive neuromuscular disease
- active malignancy within the past 2 yrs

Relative contraindications include medical conditions that can potentially worsen following lung transplantation or that could impair the viability of the lung allograft. In the absence of end-organ damage, diabetes mellitus is not a contraindication however glycaemic control should be optimized prior to transplant. Osteoporosis and associated bone fractures are a significant cause of morbidity following lung transplantation, and interventional strategies to preserve bone mass should be implemented pre-transplant. There is an increased perioperative mortality in patients who are under or overweight (BMI <18 or >30 kg/m²) and appropriate interventions should be trialed to normalize weight prior to listing. Non-compliance with medical therapy is a relative contraindication to lung transplantation.

5.12.5 Referral Process

Detailed referral letter



Consultation/Visit to Transplant Clinic at the Alfred Hospital



If appropriate, 5 day evaluation admission at the Royal Children's Hospital culminating in Alfred Hospital Lung Transplant multidisciplinary team meeting



Decision made regarding suitability and Timing of lung transplantation



If appropriate, patient will be placed on waiting list with subsequent primary care at the parent paediatric unit. Clinic visits will alternate between referring physician and the pre-transplant clinic at the Alfred Hospital

Following referral, patients will initially be reviewed as an out-patient in the Transplant Assessment Clinic at the Alfred Hospital by one of the lung transplant physicians. To facilitate our initial assessment we would request that the following information is included in the referring letter;

- **Cystic Fibrosis:**
 - date of diagnosis
 - clinical course since diagnosis
 - frequency of hospital admissions
 - sputum analysis: include date of first isolation and changes in antibiotic sensitivities. Bacteria and fungal culture details to be included
 - serial lung function
 - previous radiology incl CXR & CT scans
 - CF complications incl DM, osteoporosis, DIOS, GORD, intravenous access issues
 - previous surgery esp cardiothoracic operations
 - drug history and relevant allergies
 - nutritional status
 - physiotherapy
 - vaccination history

- **Pulmonary Hypertension/Congenital Heart Disease**
 - clinical course since diagnosis
 - medication history incl vasodilators and anti-coagulants
 - previous surgery incl copies of surgical notes if appropriate
 - previous investigations incl Echo, cardiac catheterization studies

- **Social history**
 - Family dynamics
 - Treatment adherence

If appropriate, a comprehensive five day in-patient evaluation will subsequently be arranged at the Royal Children's Hospital. The standard pre-transplant evaluation includes:

- **History and Physical Examination:** Performed by both Paediatricians from the Royal Children's Hospital and Physicians from the Lung Transplant Unit at the Alfred Hospital.
- **Blood test:** To evaluate blood counts, blood typing, kidney and liver function, vitamin levels, glucose tolerance test, prior exposure to certain viruses, oxygen content
- **24 hour urine test:** A collection of all urine passed for 24 hours to assess kidney function.
- **Sputum sample**
- **Lung Function Testing**
- **Chest X-ray**
- **CT scan of the Chest**
- **Ventilation/perfusion (V/Q) scan**
- **Bone Densitometry (DEXA scan):** To assess for osteoporosis
- **Electrocardiogram (ECG)**
- **Echocardiogram**
- **Cardiac Catheterization:** Patients with pulmonary hypertension will require this test to measure specific pressures in the lungs and chambers of the heart
- **Sleep study:** for patients with pulmonary hypertension
- **Exercise evaluation:** A measure of walking capacity and oxygen level during six minutes of supervised walking.
- **Transplant Education:** Patient and family will meet with the transplant doctors and nurses to receive education about lung transplantation.
- **Social Work Assessment:** Patient and family will meet with the transplant social worker to review psychosocial issues and concerns. To include an assessment of compliance. Quality of life (QOL) tool
- **Dietary Consultation:** An assessment of height, weight, body muscle and fat stores, and dietary intake will be made.
- **Neurodevelopment assessment:** Patient and family will meet with a paediatric psychologist to review cognitive and emotional functioning of the child and family.
- **Additional studies may be required on an individual basis**

During this 5 day admission an out-patient visit to the Alfred Hospital will be arranged to meet other key members of the lung transplant team. The transplant team members who consult on lung transplant evaluation include:

- Chest Physician
- Transplant Surgeon
- Paediatrician
- Anaesthetist
- Transplant Coordinator
- Social Worker

- Physiotherapist
- Child Psychologist
- Transplant Nurses
- Dietician

Once all medical tests have been completed, the results will be presented and discussed at the weekly multi-disciplinary cardiothoracic transplant meeting. At this meeting a decision will be made by the lung transplant team regarding the suitability of the patient for transplantation. Following this meeting, the patient and their family will be given an appointment to attend the Transplant Assessment Clinic at the Alfred Hospital where the decision regarding suitability for lung transplantation will be discussed. If deemed suitable for lung transplantation the patient will be added to the lung transplant waiting list at this meeting. While on the waiting list the patient will be reviewed every 3 months in the Transplant Assessment Clinic at the Alfred hospital. We advise that the patients should continue to alternate visits to the transplant clinic with regular routine review with their referring paediatrician. All patients should maintain regular contact with their own General Practitioner.

Initial referrals should be made to;

Dr Glen Westall
Fellow in Paediatric Lung Transplantation
Department of Allergy, Immunology and Respiratory Medicine,
The Alfred Hospital,
Prahran, Melbourne,
Vic 3181

Tel: 03 9276 3600
Fax: 03 9276 3601

6 NON-PULMONARY COMPLICATIONS OF CF

6.1 CF RELATED IDDM

6.2 ARTHROPATHY -

6.3 *POLYPS AND SINUSITIS*

7 **PHARMACOPEIA**

7.1 TREATMENTS USED FOR PATIENTS WITH CYSTIC FIBROSIS AT RCH MELBOURNE

DRUG	DOSE FORM & HOSPITAL COST	DOSE	Clinical and administration notes
Selection of antibiotics for inpatient treatment of chest infections and Tune up			
Flucloxacillin	250mg & 500mg caps \$0.17 and \$0.24/cap 250mg/5ml mixture \$7.50/100ml bottle	7.1.1.1.1 ORAL 25mg/kg/dose qid (up to 1g/dose)	<ul style="list-style-type: none"> ◆ Best taken on an empty stomach; half an hour before food or two hours after food. ◆ See <i>Paediatric Injectable Guidelines</i> for administration notes.
Gentamicin	80mg/2ml vial \$0.40/vial	IV 7.5mg/kg/dose daily	<ul style="list-style-type: none"> ◆ Daily dosing to be used as stated unless patient is a neonate. ◆ Monitor renal function. ◆ Therapeutic drug monitoring required; daily dosing requires a trough level only. Levels are to be taken on the third dose after starting or changing a dose and then at weekly intervals. ◆ See <i>Paediatric Injectable Guidelines</i> for administration notes.
Tobramycin	80mg/2ml vial \$2.20/vial	IV 12mg/kg/dose daily	<ul style="list-style-type: none"> ◆ Monitor renal function. Measure serum creatinine prior to administration then at the end of admission ◆ Therapeutic drug monitoring required; require a peak level (1 hour after the start of the infusion) AND a trough level (24 hours after the start of the infusion). Levels are to be taken on the first dose after starting or changing a dose and then at weekly intervals. Targets for levels are Peak at 30mg/L and Trough at <0.5mg/L ◆ See <i>Paediatric Injectable Guidelines</i> for administration notes

For treatment of more severe infections or 'tune up' regimes (usually for children over 2 years of age)

ADD one of the following antibiotics to one of the above therapies:

<p>Ticarcillin-Clavulanate 3g-100mg</p>	<p>Timentin \$11.02/3g vial</p>	<p>IV 100mg/kg/dose q8h (refers to Ticarcillin component) (max 6g/dose)</p>	<ul style="list-style-type: none"> ◆ Use probenecid in combination. ◆ Patients receiving Timentin do not require flucloxacillin dosing. ◆ See <i>Paediatric Injectable Guidelines</i> for administration notes.
<p>Probenecid</p>	<p>500mg tablets \$0.57/tab</p>	<p>for children over 2 years of age only</p> <p>7.1.1.1.1.1 ORAL <35kg 250mg bd >35kg 500mg bd</p>	<ul style="list-style-type: none"> ◆ Only for patients on Timentin or piperacillin. ◆ To be given 30 minutes before the daytime doses of Timentin.

In special circumstances (ie: resistance or allergy) the following may be used:

Ceftazidime	1g & 2g vials \$16.09 and \$32.19/vial	IV 50mg/kg/dose q8h (max 2g/dose)	<ul style="list-style-type: none"> ◆ Add oral flucloxacillin in combination. ◆ See <i>Paediatric Injectable Guidelines</i> for administration notes. ◆ DUC approval not required for CF patients
Meropenem	500mg & 1g vials \$27.81 and \$55.32/vial	children >3months IV Usual 10-20mg/kg/dose q8h Severe 40mg/kg/dose q8h Adults 500mg-1g dose q8h (max 2g/dose)	<ul style="list-style-type: none"> ◆ See <i>Paediatric Injectable Guidelines</i> for administration notes. ◆ Requires Drug Utilisation Committee Approval (Dr Nigel Curtis). ◆ Doses recommended are for non-CF patients. For highly resistant organisms use high end of dosing scale (max 6g/day).
Cefepime	1g & 2g vials \$15.79/gram	IV 50mg/kg/dose q8h-q12h (max 2g/dose q8h)	<ul style="list-style-type: none"> ◆ For HITH use only; at least one dose must be given on the ward. ◆ See <i>Paediatric Injectable Guidelines</i> for administration notes.
Aztreonam	1g vial \$21.55/vial	IV 50mg/kg/dose q8h (max 2g/dose)	<ul style="list-style-type: none"> ◆ See <i>Paediatric Injectable Guidelines</i> for administration notes. ◆ Requires Drug Utilisation Committee Consultant Approval. ◆ No longer commonly used.
Piperacillin	2g & 4g vial \$9.99 and \$16.40/vial	IV 100mg/kg/dose q8h (max 24g/day)	<ul style="list-style-type: none"> ◆ Add probenecid and oral flucloxacillin in combination. ◆ See <i>Paediatric Injectable Guidelines</i> for administration notes. ◆ Requires Drug Utilisation Committee Consultant Approval. ◆ No longer commonly used.
Cefpirome	1g vial and 2g vial \$20.10 and \$35.62/vial	IV 50mg/kg/dose q12h Adults 1-2g q12h	<ul style="list-style-type: none"> ◆ Use depending on age and severity of infection; limited data for paediatrics. ◆ See <i>Paediatric Injectable Guidelines</i> for administration notes. ◆ Requires Drug Utilisation Committee Approval (Dr Nigel Curtis).

Accompaniments to antibiotic therapy in a Tune-Up			
Clarithromycin	250 mg tablet \$0.87/tab 250mg/5mL mixture \$10.54/50mL	7.1.1.1.2 Oral 7.5mg/kg bd (max 500mg bd)	<ul style="list-style-type: none"> • Used for antiinflammatory effects rather than antimicrobial activity
0.9% sodium chloride drug line	500mL bag \$1.43/bag	IV prn	
Heparin flush	50 units/5ml \$0.15/amp	IV 50 Units per 5ml prn	<ul style="list-style-type: none"> ◆ Port-a-cath: q8h post IV antibiotics ◆ Long Line: q8h post IV antibiotics ◆ Long Term Port-a-cath flush: 1ml Heparin 1:1000 + 9ml 0.9% sodium chloride, administer 10ml post access or every 30 days.
0.9% sodium chloride flush	10ml poly amp \$0.25/amp	IV 5ml prn	<ul style="list-style-type: none"> ◆ Give between IV pushed antibiotics and q4h post IV antibiotics (and between doses for a court needle).
Pancreatic enzymes	Pancrease \$0.20/cap 7.1.1.1.2.1 Creon 5000 \$0.21/cap Cotazyme S Forte \$0.30/cap Creon Mini Microspheres \$0.28/cap Creon Forte \$0.56/cap	ORAL as required for food intake/feeds as per Doctor/Dietician.	<ul style="list-style-type: none"> ◆ Enzymes to be given at commencement and at conclusion of a continuous feeding regime (of non-predigested formula) or as recommended per Dietician.
Vitamin supplement	VitABDECK Capsules \$0.28/cap (VitABDECK mixture unavailable at time of printing – please check with Pharmacy)	ORAL as required as per dietician	<ul style="list-style-type: none"> ◆ Fat-soluble vitamin levels to be taken annually or as necessary. ◆ Contact dietician if patient unable to swallow capsules.
Electrolyte supplement	Oral Electrolyte Powder \$23.15/500g 7.1.1.1.2.2 Salt tablets \$0.04/tab	ORAL as required.	<ul style="list-style-type: none"> ◆ Supplementation requirements may increase during warmer times of the year due to increased sweating.

Oral and inhaled antibiotic therapy for HOME USE upon discharge			
Ciprofloxacin	250mg tabs \$0.56/tab 500mg tabs \$1.06/tab 750mg tabs \$1.55/tab	ORAL 15mg/kg/dose bd (max 750mg/dose)	<ul style="list-style-type: none"> ◆ Tablets may be crushed or broken in half. ◆ Best taken on an empty stomach. Separate doses from iron supplements, antacids and milk by 2 hours. ◆ Can cause photosensitivity. ◆ Important to maintain an adequate fluid intake.
Amoxicillin/Clavulanic Acid <i>Augmentin Duo</i> <i>Augmentin Duo Forte</i> <i>Augmetnin Duo 400 Mixt</i>	500mg/125mg tab \$0.84 per tab 875mg/125mg tab \$0.71 per tab 400mg/5ml Duo 400 mixt \$6.61/60ml	ORAL Less than 3 months: 15mg/kg/dose q12h Less than 40kg: 12.5-25mg/kg/dose q12h (max 875mg/dose q12h of amoxicillin component)	<ul style="list-style-type: none"> ◆ Tablets may be crushed or broken in half. ◆ Best taken with food.
Colistin for inhalation	1 x 10⁶ units/ml \$65.00 per 30ml vial	INH 1 x 10 ⁶ units (1ml)/dose bd +/- dilution to 4ml with 0.9% sodium chloride or sterile water.	<ul style="list-style-type: none"> ◆ For administration after physiotherapy. ◆ Nebulised antibiotics should be administered through an appropriate nebuliser.
Tobramycin for inhalation	80mg/2ml vial \$2.20/vial	INH 80mg/dose bd +/- dilution to 4ml with 0.9% sodium chloride or sterile water.	<ul style="list-style-type: none"> ◆ For administration after physiotherapy. ◆ Nebulised antibiotics should be administered through an appropriate nebuliser.
Saline 0.9%, diluent for inhalation	500mL bottle \$1.63/500mL	INH make up antibiotics to 4mL using saline	<ul style="list-style-type: none"> ◆ Optimal volume for nebulisation of antibiotics is 4mL
Other therapies that may be used			
Tranexamic Acid	500mg tabs \$0.40/tab	ORAL 12-25mg/kg/dose 3-4 times a day (max 1.5 g)	<ul style="list-style-type: none"> ◆ Tablets may be halved and quartered
Ursodeoxycholic Acid	250mg caps \$1.43/tab 50mg/ml mixture \$140.00/250mL	ORAL <45kg 15-20mg/kg/day in 2-3 doses >45kg 10-20mg/kg/day in 2-4 doses	

7.2 PRESCRIPTION GUIDELINES

7.2.1 Supply Issues

This information is intended to clarify supply issues for CF inpatient, outpatient and Home and Community Care (HaCC) patients. Please page the ward pharmacist or call Pharmacy on extension 5491 for more information.

All medications are available for inpatients to use except:

- Pulmozyme
- Oral contraceptives
- Vitamin supplements other than those available on the RCH formulary
- Complementary and alternative therapies

Patients are to bring their own supply of these medications when admitted to hospital

7.2.2 Types of Prescriptions

DISCHARGE

- RCH PBS prescription (A4)
 - For RCH Pharmacy Department (ground floor) AND retail/community pharmacies
 - PBS authority may be required for increased quantities and repeats. See prescription form for instructions.
 - If a non-PBS item is prescribed the patient will be charged a higher private fee if taken to a retail/community pharmacy and may not be able to obtain the item.

OUTPATIENTS

- Standard PBS (Yellow) and Authority PBS (Blue and White)
 - NOT for RCH Pharmacy Department (ground floor)
 - For retail/community pharmacies
- RCH PBS prescription (A4)
 - For RCH Pharmacy Department (ground floor) AND retail/community pharmacies
 - PBS authority may be required for increased quantities and repeats. See prescription form for instructions.
 - If a non-PBS item is prescribed the patient will be charged a higher private fee if taken to a retail/community pharmacy and may not be able to obtain the item.
- White RCH Outpatients
 - For RCH Pharmacy Department (ground floor) only where patients will be charged \$4.60/month with a maximum of 3 months supply.
 - The patient will be charged a higher private fee if taken to a retail/community pharmacy and may not be able to obtain the item.

7.2.3 DISCHARGE Prescribing

The following table shows the most commonly prescribed medications on discharge and how they are to be ordered according to hospital policy.

Quantities specified are maximal PBS quantities. (R=no. of repeats allowed)

(NB: PBS quantities and restrictions may change. Please check the PBS book)

Drug	RCH PBS Prescription		No prescription required ('over the counter' preparation)	Comments
	Standard	Authority		
Augmentin Duo Amoxicillin 500mg and clavulanic acid 125mg	10 tabs + 1R	Authority required for larger quantities		
Augmentin Duo Forte Amoxicillin 875mg and clavulanic acid 125mg	10 tabs + 1R	Authority required for larger quantities		
Augmentin Duo Suspension Amoxicillin 400mg and clavulanic acid 57mg/5mL	60mL +1R	Authority required for larger quantities		Must be discarded 7 days after dispensing
Budesonide 100mcg, 200mcg, 400mcg turbuhaler	1 inhaler + 5R			Pulmicort®
Budesonide and eformeterol 200/6mcg, 400/12mcg inhaler	1 inhaler + 5R			Symbicort® Restricted benefit. See PBS book
Ciprofloxacin 250mg, 500mg, 750mg tab		Authority required 14 tabs + nil R		See PBS book for restrictions
Colistin 1,000,000 units/mL (30mL)	✓ (non PBS)			May need to prescribe 0.9% sodium chloride to dilute colistin (1 bottle supplied per month)
Cotazyme S Forte	500 tabs + 10R			
Creon Minimicrospheres 10,000 U/ 5,000 U	500 tabs + 10R			

Creon Forte	200 tabs +10R			
Pancrease	500 tabs + 10R			
Clarithromycin 250mg	14 tabs + 1R	Authority required for larger quantities		
Clarithromycin Suspension 250mg/5mL (50mL)	✓ (non PBS)			
Flucloxacillin 250mg, 500mg caps	24 caps	Authority required for repeats and larger quantities		
Flucloxacillin 250mg/5mL	100mL	Authority required for repeats and larger quantities		
Fluticasone 50mcg, 125mcg, 250mcg inhalers 100mcg, 250mcg, 500mcg accuhalers	1 inhaler + 5R			Flixotide®
Fluticasone and salmeterol 50/25mcg, 125/25mcg, 250/25mcg inhalers 100/50mcg, 250/50mcg, 500/50mcg accuhaler	1 inhaler + 5R			Seretide® Restricted benefit. See PBS book
Heparin 1:1000 ampoule (1mL)	✓ (non PBS)			For long term port-a-cath lock. Dilute 1ml of heparin to 10 ml with 0.9% sodium chloride ampoules to make 100units/ml)

DISCHARGE Prescribing continued....

Drug	RCH PBS Prescription		No prescription required ('over the counter' preparation)	Comments
	Standard	Authority		
Hypertonic Saline 3%, 6% (100/box)	✓ (non PBS)			For inhalation and oral use
Oral Electrolyte Powder 500g	✓ (non PBS)			
Omeprazole 10mg, 20mg tablets	30 tabs + 1 or 5R	Authority required for larger quantities		See PBS book for no. of repeats available (according to indication)
Omeprazole 2mg/ml mixture (RCH)	✓ (non PBS)			Only available at RCH Pharmacy department for patients taking medications via nasogastric and PEG tubes
Prednisolone 5mg/mL mixture (30mL)	1 bottle + 5R			
Prednisolone 1mg tablet	100 tabs + 4R			
Prednisolone 5mg tablet	60 tabs + 4R			
Prednisolone 25mg tablet	30 tabs + 4R			
Dornase Alfa (Pulmozyme) 2.5mg (2500 units)/2.5mL solution for inhalation	✓			PBS section 100 See PBS book for restrictions
Ranitidine 15mg/mL mixture 300mL	2 bottles + 5R			
Ranitidine 150mg tablet, 150mg effervescent tab	60 tabs + 5R			

Ranitidine 300mg tablet	30 tabs + 5R			
Salbutamol 100mcg/dose inhaler	2 inhalers + 5R		✓	More expensive OTC
Sodium chloride 0.9% solution 500mL bottle	✓ (non PBS)			Used to dilute inhaled antibiotics. 1 bottle supplied per month
Sodium chloride 0.9% 10mL ampoules	✓ (non PBS)			To dilute 1ml of 1000 units/ml heparin to 10 ml for long term port-a-cath lock
Salt Tablets (600mg NaCl)	✓ (non PBS)		✓	Only from RCH for newly diagnosed patients
Tobramycin Injection for inhalation 80mg/2mL	✓ (non PBS)			May need to prescribe 0.9% saline to dilute tobramycin (1 bottle supplied per month)
Tranexamic acid 500mg tablets	100 tabs + 2R			
Ursodeoxycholic Acid 250mg caps 250mg/5mL suspension (250mL bottle)	✓ (non PBS)			Capsules PBS for primary biliary cirrhosis only
VitABDECK capsules	✓ (non PBS)		✓	Only from RCH for newly diagnosed patients

7.2.4 OUTPATIENT CLINIC Prescribing

The following table shows the most commonly prescribed medications in outpatient clinic and how they are to be ordered according to hospital policy.

Quantities specified are maximal PBS quantities. (R=no. of repeats allowed)

(NB: PBS quantities and restrictions may change. Please check the PBS book)

Drug	RCH PBS Prescription		Standard PBS Prescription		White RCH OP	No prescription required	Comments
	Standard	Authority	Standard	Authority			
Augmentin Duo Amoxicillin 500mg and clavulanic acid 125mg			10 tabs + 1R	Authority required for larger quantities			
Augmentin Duo Forte Amoxicillin 875mg and clavulanic acid 125mg			10 tabs + 1R	Authority required for larger quantities			
Augmentin Duo Suspension Amoxicillin 400mg and clavulanic acid 57mg/5mL			60mL +1R	Authority required for larger quantities			Must be discarded 7 days after dispensing
Budesonide 100mcg, 200mcg, 400mcg turbuhaler			1 inhaler + 5R				Pulmicort®
Budesonide and eformeterol 200/6mcg, 400/12mcg inhaler			1 inhaler + 5R				Symbicort® Restricted benefit. See PBS book
Ciprofloxacin 250mg, 500mg, 750mg tab				Authority required 14 tabs + nil R			See PBS book for restrictions
Colistin 1,000,000 units/mL (30mL)	✓ (non PBS)				✓		May need to prescribe 0.9% sodium chloride to dilute colistin
Cotazyme S Forte			500 tabs + 10R				

Creon Minimicrospheres 10,000, 5,000 U			500 tabs + 10R				
Creon Forte			200 tabs +10R				
Pancrease			500 tabs +10R		✓		Only from RCH for newly diagnosed patients
Clarithromycin 250mg			14 tabs + 1R	Authority required for larger quantities			
Clarithromycin Suspension 250mg/5mL (50mL)	✓ (non PBS)				✓		
Flucloxacillin 250mg, 500mg caps			24 caps	Authority required for repeats and larger quantities			
Flucloxacillin 250mg/5mL			100mL	Authority required for repeats and larger quantities			
Fluticasone 50mcg, 125mcg, 250mcg inhalers 100mcg, 250mcg, 500mcg accuhalers			1 inhaler + 5R				Flixotide®

OUTPATIENT CLINIC Prescribing continued....

Drug	RCH PBS Prescription		Standard PBS Prescription		White RCH OP	No prescription required	Comments
	Standard	Authority	Standard	Authority			
Fluticasone and salmeterol 50/25mcg, 50/25mcg, 250/25mcg inhalers 100/50mcg,250/50mcg, 500/50mcg accuhaler			1 inhaler + 5R				Seretide® Restricted benefit. See PBS book
Heparin 1:1000 ampoule (1mL)	✓ (non PBS)				✓		For long term port-a-cath lock. Require 0.9% saline 10mL ampoules to dilute heparin
Hypertonic Saline 3% or 6% (100/box)	✓ (non PBS)				✓		For inhalation and oral use
Oral Electrolyte Powder 500g	✓ (non PBS)				✓		
Omeprazole 10mg, 20mg tablets			30 tabs + 1 or 5R	Authority required for larger quantities			See PBS book for no. of repeats available (according to indication)
Omeprazole 2mg/ml mixture (RCH)	✓ (non PBS)				✓		Only available at RCH Pharmacy department for patients taking medications via nasogastric and PEG tubes
Prednisolone 5mg/mL mixture (30mL)			1 bottle + 5R				
Prednisolone 1mg tablet			100 tabs + 4R				
Prednisolone 5mg tablet			60 tabs + 4R				
Prednisolone 25mg tablet			30 tabs + 4R				
Dornase Alfa (Pulmozyme) 2.5mg (2500 units)/2.5mL solution for inhalation	✓				✓		PBS section 100. See PBS book for restrictions
Ranitidine 15mg/mL mixture 300mL			2 bottles + 5R				

Ranitidine 150mg tablet, 150mg effervescent tab			60 tabs + 5R				
Ranitidine 300mg tablet			30 tabs + 5R				
Salbutamol 100mcg/dose inhaler			2 inhalers + 5R			✓	More expensive OTC
Sodium chloride 0.9% solution 500mL bottle	✓ (non PBS)				✓		Used to dilute inhaled antibiotics. 1 bottle supplied per month
Sodium chloride 0.9% 10mL ampoules	✓ (non PBS)				✓		To dilute 1ml of 1000 units/ml heparin to 10 ml for long term port-a-cath lock
Salt Tablets (600mg NaCl)	✓ (non PBS)				✓	✓	Only from RCH for newly diagnosed patients, otherwise OTC
Tobramycin Injection for inhalation 80mg/2mL	✓ (non PBS)				✓		May need to prescribe 0.9% sodium chloride for to dilute tobramycin
Tranexamic acid 500mg tablets			100 tabs + 2R				
Ursodeoxycholic Acid 250mg caps 250mg/5mL suspension (250mL bottle)	✓ (non PBS)				✓		Capsules PBS for primary biliary cirrhosis only
VitABDECK capsules	✓ (non PBS)				✓	✓	Only from RCH for newly diagnosed patients, otherwise OTC

7.3 **TOBRAMYCIN MONITORING IN CYSTIC FIBROSIS PATIENTS AT RCH MELBOURNE**

7.3.1 **DOSE**

12mg/kg given once per day (**Cystic Fibrosis patients ONLY**)

Dilute dose to 20 ml with normal saline and infuse over 30 minutes

NOTE:

The Larger dose of tobramycin is required for CF patients as:

- CF patients have unique metabolism and physiology and clear many drugs more rapidly than those who do not have CF.
- The bacteria grown in CF lungs require higher concentrations of tobramycin for treatment to be effective.

- Non-CF patients should be commenced on usual doses of tobramycin (refer to RCH pharmacopoeia)

7.3.2 **MONITORING AND TIMING**

- Requires 0.5mL finger prick blood
- Trough: Taken immediately before a dose is administered
- Peak: Taken **half an hour** after the end of tobramycin infusion

The time of collection, time of dose, dose and dose interval given must be clearly marked on the pathology card.

NOTE:

Target levels:

Peak: **30mg/L (+/- 5mg/L)**

Trough: **<0.5mg/L**

Patients with CF require peak levels to ensure effective treatment.

If traditional ("tds") dosing is used peak and trough levels are required, however the target levels are different (refer to RCH pharmacopoeia).

The first level should be taken before the 2nd dose (trough), and after the 2nd dose (peak). These should be repeated every 7 days.

NOTE:

- If the peak level is low (<30mg/L), a dose increase is required.
- If the trough level is high (>0.5mg/L), HOLD the dose and repeat level in a further 12 hours. If <0.5mg/L, restart tobramycin at the same dose, but given every 36 hours. If the level remains high, hold tobramycin until an appropriate level is obtained and consult respiratory physician or pharmacy.
- Levels are to be repeated with the second dose after every dose/interval change

OTHER MONITORING

Renal Function: Baseline serum creatinine and urea on day 1 of admission and monitor progress at end of admission

Questions:

Contact Clinical Pharmacist on pager 4355, or Respiratory Fellow pager 5818

8 USEFUL NAMES & ADDRESSES

ADDITIONAL SECTIONS NEEDED FOR MELBOURNE HANDBOOK

8.1 ***GASTRO-OESOPHAGEAL REFLUX – ADD TO GI SECTION ACTION:
MARK***

**8.2 LIVER DISEASE – MOVE TO GI SECTION
MARK**

ACTION:

8.4 **ENDOCRINE-RELATED DISEASE – IDDM, BONE DENSITY ACTION: FERGUS**

- **Adolescent Section** ACTION: **Susan**
 - influence of adolescence on CF and vice versa
 - puberty
 - sexual health, drugs, alcohol,
 - adolescent services
 - managing adolescence
 - incontinence

- **Transition/ transfer** ACTION: **Martine**
- **Incontinence** to be incorporated into section on adolescence by Susan
- **Investigations and Procedures**
 - sweat tests,
 - HRCT and Bhalla score,
 - bronchoscopy and BAL
 - lung function tests

- **Palliative care/end of life issues** ACTION: **Colin**
 - to go with transplantation in a section called end-of-life issues
 -

- **Educational services** ACTION: **Barb**
 - To include details of referral

- **Glossary of terms used in CF** ACTION: **Angela**