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# Cardiorespiratory symptoms

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## Introduction

Dyspnoea and cough are invariably listed in the top ten most prevalent and distressing symptoms in paediatric palliative care for patients both with cancer, advanced heart disease, and other illnesses. Breathlessness, cough, and difficulty managing secretions represent a significant burden both to patients and to those caring for them. Breathing is arguably the only bodily system vital for immediate survival that is under both volitional and autonomic control, making it impossible to separate breathlessness from the child's overall clinical and emotional situation. The range of possible treatments available continues to expand, encompassing everything from simple non-pharmacological measures to long-term mechanical ventilation (1), or for the child with heart failure, ~~or~~ mechanical circulatory support (MCS) (2, 3). This chapter will outline a holistic approach to the management of the child with cardiorespiratory symptoms, in the context of paediatric palliative care, where improving quality of life is usually the most important measure of success.

Incorporated into the chapter are unique features of paediatric advanced heart disease as they relate to the overlapping cardio-respiratory symptoms of children requiring palliative care. The establishment of surgical interventions in the 1950s and developments in paediatric transplantation have resulted in an increasing population of children with advanced heart disease who require ongoing symptom management to improve quality of life (3, 4). The recent publication by Balkin et al. points out the large discrepancy between the perceived prognosis in advanced and complex paediatric heart disease between families and cardiologists (5). Ongoing support of palliative care teams in reducing symptom burden and achieving important goals of care at end of life will continue to be required (6, 7).

Healthcare professionals are generally well-trained in the management of acute cardio-respiratory failure. Whilst essential for most of clinical practice, this expertise may be counterproductive in end-of-life care and when misapplied may compromise dignity and increase suffering of the dying child. It could therefore be argued that understanding the patient's best interest and agreed goals of care should be part of mandatory training in resuscitation (see Table 25.1).

## Breathlessness/dyspnoea

Breathlessness is a common and distressing symptom with a negative impact on quality of life, psychological wellbeing, and functional status. Dyspnoea has been defined by the American Thoracic Society as ~~follows:~~

> *a subjective experience of breathing discomfort that consists of qualitatively distinct sensations that vary in intensity. The experience derives from interaction among multiple physiological, psychological, social and environmental factors and may induce secondary physiological and behavioural responses.*

These distinct sensations include work of breathing, chest tightness, and air hunger (~~Figure 25.1~~) (9).

Breathlessness is a multi-dimensional symptom, involving numerous receptors (chemoreceptors and mechanoreceptors), mechanisms (biological, psychological, social), and pathways. Thus, conditions may lead to breathlessness via many routes including 'increased respiratory drive', 'mechanical impedance', 'respiratory muscle failure', 'wasted ventilation', and 'psychological mechanisms' (10). Whilst we now know that optimization of underlying diseases has an inconsistent impact on the symptom of breathlessness, most research in patients with cystic fibrosis and Duchenne muscular dystrophy is aimed at demonstrating improvement in blood gas perimeters, rather than the subjective symptoms, or overall quality of life. Mixed cohort studies including children with cancer, cerebral palsy, metabolic conditions, and congenital abnormalities, who were receiving palliative care, all feature breathlessness as one of the top ten most frequently reported symptoms, with approximately 50% of children being affected according to one study. Marcus et al., also showed that dyspnoea is very common in children with advanced heart disease (6). Lastly, breathlessness is a commonly reported symptom in cancer patients even in the absence of known lung pathology. This may be related to muscle weakness as a result of general debility, but could just as well be a somatic manifestation, fear, or anxiety (9).

## Assessment of breathlessness

The only reliable measure of dyspnoea is patient self-report, which may be difficult or impossible to obtain from pre- and non-verbal

**Table 25.1** Causes of respiratory symptoms in paediatric palliative care

| Cause | Dyspnoea | Cough | Haemoptysis | Tachycardia | Retained secretions |
|---|---|---|---|---|---|
| Infection | ✓ | ✓ | ✓ | | ✓ |
| Anaemia | ✓ | | | | |
| Pain | ✓ | | | ✓ | |
| Anxiety | ✓ | | | | |
| Respiratory muscle weakness | ✓ | ✓ | | | ✓ |
| Cardiac failure | ✓ | ✓ | | ✓ | |
| Arrhythmia | ✓ | | | ✓ | |
| Cyanotic heart disease | ✓ | | ✓ | | |
| Plastic bronchitis (in single ventricle heart disease) | ✓ | | | | ✓ |
| Pulmonary oedema | ✓ | ✓ | ✓ | | |
| Pleural or pericardial effusion | ✓ | ✓ | | | |
| Pneumothorax | ✓ | | | | |
| Tumour mass | ✓ | ✓ | ✓ | | ✓ |
| Superior vena cava obstruction | ✓ | ✓ | | | |
| Aspiration | ✓ | ✓ | | | |
| Reflux | | ✓ | | | |
| Impaired ability to swallow | | ö | | | ✓ |
| Abnormalities of clotting, (e.g. haematological malignancy) | | | ✓ | | |

Adapted with permission from Craig F, et al. Management of respiratory symptoms in paediatric palliative care. *Curr Opin Support Palliat Care*. 2015;9(3):217–25. DOI: 10.1097/SPC.0000000000000154.

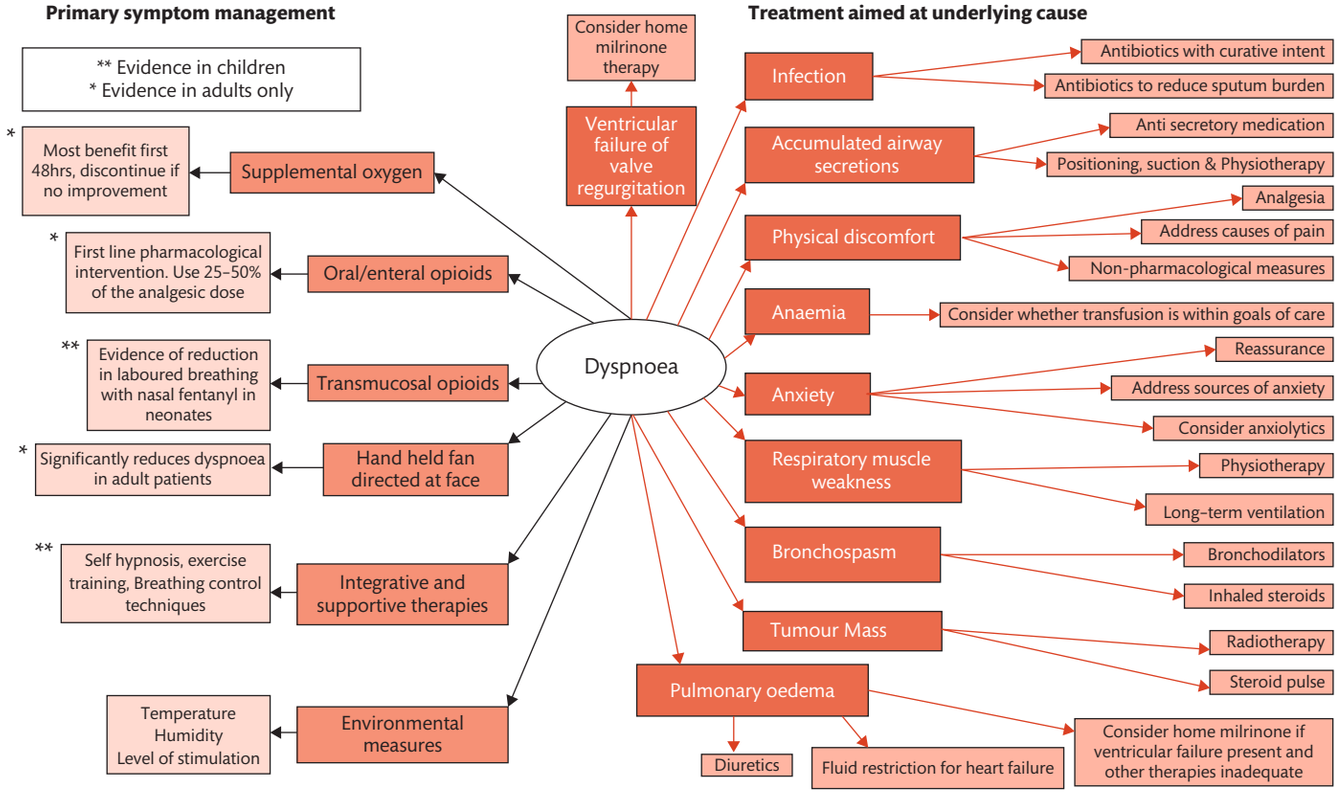


**Figure 25.1** Management of dyspnoea

children. The reporting of breathlessness can also be influenced by cultural background, environment, life experiences, and psychological state. When age/developmentally appropriate, a visual analogue scale anchored with 'no breathlessness' and 'worse possible breathlessness' at either end, or scored with appropriate visual images, can be used for sequential measurements in the same patient (1). Whilst numerous validated dyspnoea scales have been proposed in adult practice, none have been validated in the paediatric palliative care population (9).

## Management of breathlessness

The management of breathlessness can thus be divided into treatments aimed at modifying an underlying cause, and those targeting the subjective sensation of breathlessness (1). As mentioned previously, anxiety and other symptoms (including pain) are likely to wind up the sensation of breathlessness, and these may therefore need be separately addressed. Some of the strongest evidence in the area of breathlessness management relates to non-pharmacological strategies (1, 9).

When managing chronic breathlessness in situations other than the immediate end-of-life phase, it may be helpful to consider the 'Breathing, Thinking, Functioning' model (Figure 25.3). This addresses the mechanics of the breathing process, the negative thoughts caused by breathlessness, as well as the impact of de-conditioning on the progression of the symptom. Ideally, a multidisciplinary team including physiotherapists, and psychologists is used to address each of these areas. Examples of the sorts of approaches used to counsel patients are shown in ~~Figure 25.4.~~

In adult studies, there is clear evidence of improved quality of life outcomes when patients with chronic conditions participate in their own care through self-management, including exercise training and psychological approaches. Vicious circles of decline can be turned into 'cycles of improvement' with less reliance on pharmacological therapies (9). In children, self-hypnosis has been shown to be of benefit, and other techniques for breathing control (such as 'Square Breathing') may also be helpful.

Even in the context of acute breathlessness at the end of life, non-drug interventions can make a big difference (1). There is further evidence from adult studies strongly supporting the use of hand-held fans directed at the face. Other environmental measures, such as careful adjustment of the temperature, humidity, and levels of stimulation can also be very helpful, on an individual patient basis. Physical approaches including percussive physiotherapy, suction, and careful airway positioning are also important.

### Oxygen

Studies on the benefits of supplemental oxygen therapy have failed to show a consistent benefit over room air. Acknowledging this uncertainty, it would seem reasonable to offer a therapeutic trial of oxygen, if the child is able to tolerate a mask or nasal cannula. If this is poorly tolerated, or confers no benefit, it should be discontinued, and the rationale for this should be carefully explained to the child and family (1). Of note, specific to pulmonary hypertension, oxygen is often used therapeutically chronically for pulmonary vasodilation and decreasing precipitants of pulmonary hypertensive crisis. Increasing oxygen delivery may add symptomatic relief with

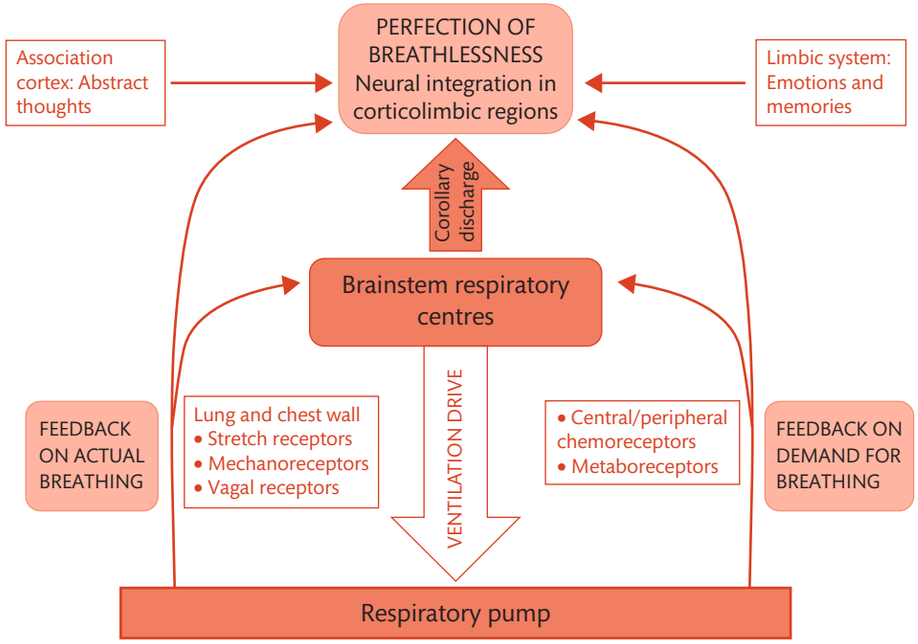


**Figure 25.2** The interplay between volitional and autonomic control within the control of breathing (9)

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Source: data from Rossano, JW et al. (2016). Clinical issues and controversies in heart failure and transplantation. *World J Pediatr Congenit Heart Surg.* 7(1):63<en dash>71. DOI: 10.1177/2150135115606622.10.1177/2150135115606622.

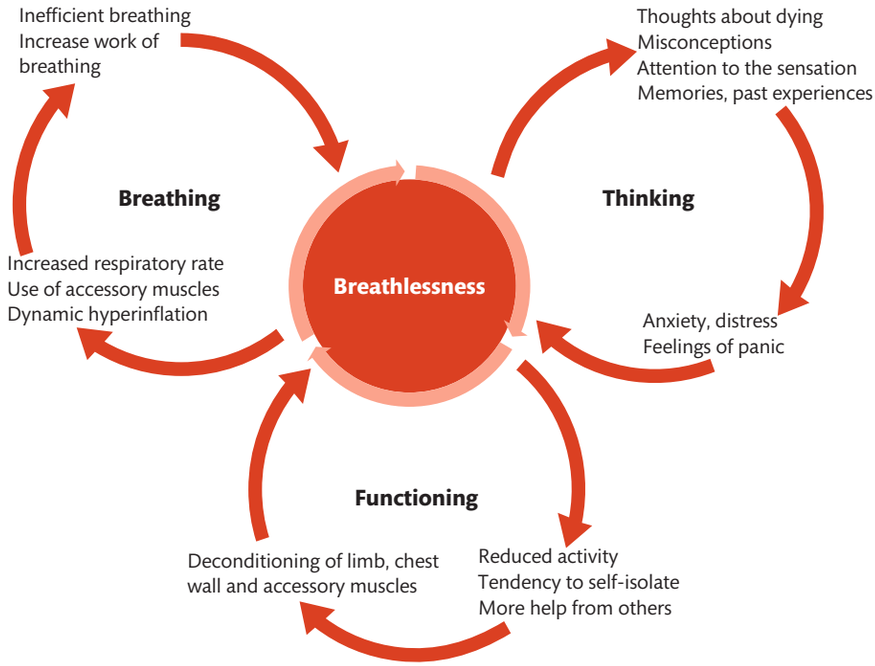


**Figure 25.3** Relationship between physical, social, psychological and spiritual elements and the impact of breathlessness on quality of life (9)



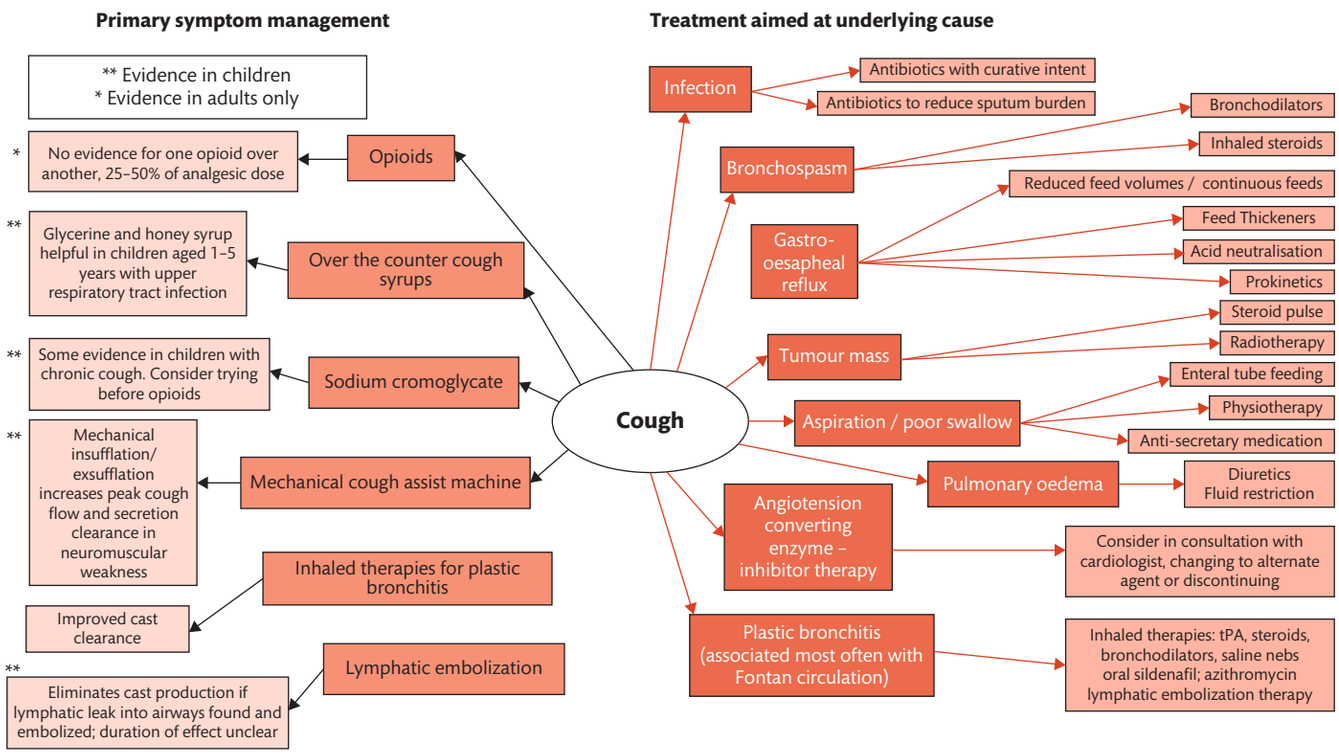


**Figure 25.4** Management of cough

worsening hypoxia, although this has not been studied in the context of end of life specific to pulmonary hypertension.

### Opioids

Opioids relieve the distress of breathlessness in many patients, without a measurable effect on their respiratory rate or blood gases (1). A Cochrane Review (11) of the adult studies concluded that there was some low-quality evidence that showed a benefit of using oral or injectable opioids in the management of breathlessness. They found no evidence of benefit from nebulized opioids, which should be avoided because of their potential to cause bronchospasm. Adult studies typically use 50% of the analgesic dose of a given opioid, although some studies have suggested that 25% may be enough. In the context of chronic dyspnoea, long-acting opioids should also be considered. Transmucosal, (buccal, nasal, sublingual) opioids classically have a rapid onset, and a shorter duration of action. These may be useful in managing acute sudden dyspnoea, as the rapid onset reduces the time over which anxiety may wind up the situation. Nasal diamorphine, and buccal fentanyl are examples for which there is some reported use. In the small amount of research published in children, clinically significant benefits of opioid administration include relaxation, decrease in distress, or a 'comfortable look'. Respiratory depression, significant sedation, or other adverse effects were not encountered at these low doses (10).

### Anxiolytics

A Cochrane review of benzodiazepines for the relief of breathlessness (12) in advanced disease in adults found a slight but non-significant trend towards a beneficial effect. Benzodiazepines caused more drowsiness than placebo, but less than morphine, making them a reasonable second- or third-line treatment when non-pharmacological measures or opioids have failed to adequately control symptoms. In practice, low-dose buccal midazolam is particularly useful when anxiety is a significant factor in the overall symptom burden (1), or when hypoxic agitation is felt likely. Midazolam may also be used as an adjunct to morphine in severe resistant dyspnoea. Interventions directed at an underlying cause, include treatments targeting malignant disease in the chest, (palliative chemotherapy or radiotherapy) and drainage of pleural effusions, where benefits are felt to outweigh burdens (see Figure 25.1).

### Heart failure medications, diuretics, fluid restriction

Standard therapies for heart failure such as angiotensin converting enzyme inhibitor (ACE-I) therapies, angiotensin receptor blocker (ARB), and beta blocker therapies are of benefit for cardiac remodelling but may have limited benefit at end of life (3, 13). The adjustments of these medications, along with the multiple diuretic therapies that are common in advanced heart failure is best reviewed with the patient's cardiologist to understand the physiologic impacts of increasing, decreasing, or stopping them unique to each child's cardiac physiology.

Restricting fluid intake is standard therapy for heart failure. It minimizes congestive symptoms such as dyspnoea, tachypnea, tachycardia, and peripheral oedema. However, both restriction of fluids and conjunctive diuretic therapy can escalate symptoms of thirst. Dealing with the psychosocial impacts of stringent fluid restriction in attempts to minimize symptom impact from worsening heart failure can become counterproductive. Although, in many phases of advanced heart diseases, reducing fluid overload is key to decreasing the symptoms of heart failure, at the end stages of disease, psychological burdens of insatiable thirst will impact the child and family. Relaxing fluid restriction and addressing increasing dyspnea and oedema with alternate treatment strategies, such as opioids, may greatly improve quality of life. If symptoms of thirst or dry mouth persist, careful mouth and lip care are likely to provide comfort (1).

### Home inotropic therapy

If symptoms of dyspnoea are predominately stemming from underlying ventricular dysfunction or severe valve regurgitation, children may benefit with symptom reduction from inotropic therapy such as milrinone or dobutamine as a continuous infusion. These can be administered safely from home via chronic vascular access. Although most commonly used for stabilization while awaiting transplantation, there has been increasing recognition that these can be helpful adjuncts for children with advanced cardiac disease to allow them time at home with good symptom management. Each patient may respond differently, and most commonly, home inotrope is utilized after trial(s) off inotropic support with conversion to oral therapies which have been unsuccessful in achieving sustained symptom reduction (14).

## Cough

Cough is a protective physiological reflex designed to expel particles and excess mucus from the airways. An effective cough depends on the ability to generate an adequate expiratory airflow. This, in turn depends on lung and chest wall elasticity, airway conductance, and expiratory muscle force. 'Management' of cough can therefore involve optimizing an ineffective cough mechanism, managing a cause of persistent airway irritation, or suppressing an unhelpful irritating cough. Successful management of cough in paediatric palliative care is thus likely to involve consideration of any potential underlying cause, before taking direct measures to stop the symptom. These typically include respiratory tract infection, aspiration, bronchospasm, and gastro-oesophageal reflux (~~Box 25.1~~). They may also include, specific to those with advanced cardiac disease, the side effects of angiotensin-converting enzyme inhibitors (ACE-I) therapy, (chronic dry cough) or lymphatic issues such as plastic bronchitis.

Recurrent aspiration may be addressed by considering feeding issues (oral vs enteral tube) or accumulation of oropharyngeal secretions, which may require suction, anti-secretory agents, or physiotherapeutic techniques. Respiratory tract infections should be addressed while carefully weighing the benefits and burdens of any potential treatments. For example, it may be appropriate to offer a course of enteral antibiotics, in the hope of minimizing sputum burden, but admission to hospital for intravenous antibiotics and invasive ventilator support may not be within the goals of treatment if a child is felt to be very close to the end of life. Nebulized saline may help to loosen thick secretions and gentle physiotherapy is likely to be helpful in most cases. Mechanical 'cough-assist' devices, which deliver insufflation/exsufflation cycles can be used to increase peak cough flow, particularly in the context of muscular weakness.

**Box 25.1** 'The Breathing, Thinking, Functioning' model

**Breathing**

- 'It is natural to think when you are feeling breathless that you need more air in. In fact, this isn't the case—we know that there is plenty of air in your lungs. Try instead to lengthen your out breath, which can make your breathing more efficient and create space for your next breath.'

**Thinking**

- 'Some people say that they're terrified that they are going to die gasping for breath. Although this is an understandable feeling, this almost never happens.' (Then give a relevant explanation for a particular patient, for example, 'At that time, waste gases tend to build up in the blood, making people feel calm and sleepy.)'

**Functioning**

- 'Choosing to make yourself moderately breathless by being active is not harming you. In fact, it builds up fitness in your muscles again and can improve your breathing and general health over weeks and months.'



Bronchospasm may manifest as persistent cough, particularly at night. This can be addressed using combinations of bronchodilators and inhaled steroids. If a child has significant muscular weakness, or limited ability to coordinate breathing, these may need to be delivered via a nebulizer rather than by inhaler and spacer device. In the rare situations in paediatric oncology, in which cough is related to a mass effect in the airway, the role of palliative radiotherapy or chemotherapy should be discussed with the patient's oncologist.

Pulmonary oedema commonly presents with coughing, which is usually productive and persistent. This is often associated with orthopnoea in the older child and irritability or sleep disturbance alone in the infant. Bronchodilators, while helpful in many instances of dyspnoea, should be approached with caution in the patient with advanced heart disease, as they may induce excess tachycardia and increase cardiac workload rather than relieve symptoms. Adjustments to diuretic therapies, ACE-I, or other cardiac therapies, and consideration for fluid restriction should be first considered. A trial of bronchodilators in disease-specific instances (where congenital heart disease is associated with abnormal bronchial development) may additionally be appropriate. However, at end of life, it may be more appropriate to utilize opioids to aid with the increasing dyspnoea that may result from end-stage heart failure.

Plastic bronchitis is relatively rare in the general population but is an increasingly recognized co-morbidity of single ventricle heart disease. This involves abnormalities in lymph flow and production such that there is leak of lymphatic material into the bronchii. This produces proteinaceous casts that cause coughing, and can create difficulties with cast clearance, hypoxia, and respiratory distress which, if the cast is large enough, can lead to respiratory arrest. Therapies to manage should be guided by the patient's cardiologist. There is a myriad of medical management options that have been used, both inhaled and oral. Inhaled tissue plasminogen activator, steroids, bronchodilators, and treatments with pulmozyme, dornase alpha, as well as oral sildenafil, bosentan, and azithromycin are utilized in a daily to weekly regimen. Additionally, many disease-directed catheter-based interventions have been used to reduce venous congestion. Emerging therapy is interventional, used in conjunction with magnetic resonance imaging (MRI) mapping and cardiac catheterization, to diagnose and embolize abnormal lymph drainage to resolve casting. Although the long-term duration of effect of this treatment is not yet known, it can have a significant impact on quality of life when accomplished (15).

### Opioids

Opioids have an antitussive effect distinct to their analgesic action, putatively mediated via central cough receptors. Evidence from studies conducted in adult patients confirm that opioids are more effective than placebo at reducing cough, but do not clearly suggest one opioid over another, nor clearly define the doses needed. A dose of 25–50% of the analgesic dose is usually recommended, in line with the doses used in the context of breathlessness.

### Sodium cromoglycate

Some evidence exists that cromones have a benefit in chronic cough in the context of adult lung cancer. Although evidence of benefit in children is very sparse, there is consensus opinion that a trial of sodium cromoglycate should be considered prior to starting opioids (8).

#### *Pharmacy-bought cough syrups*

There is no evidence for the use of cough syrups containing antihistamines, or decongestants, however, one small paediatric study shows benefit of honey containing syrups over placebo (8).

Local anaesthetics applied by spray or nebulizer have been used to suppress cough in adult practice but should be avoided in paediatric palliative care because of the potential to inhibit the protective gag reflex.

## Haemoptysis

Haemoptysis is relatively uncommon in the paediatric palliative care population, despite which it is understandably a cause of great anxiety. Smaller bleeds, as a result of clotting abnormalities (due to haematological malignancy or chronic disease), or in the context of infection are most common (see **Figure 25.5**). Large bleeds due to invasion of blood vessels are less common, but may complicate lung metastases in certain solid tumours, such as osteosarcoma. Preventative treatment may be directed at the cause, such as considering the benefits and burdens of continuing with platelet transfusion in the palliative phase of leukaemia. There is also evidence from adult studies that systemic antifibrinolytic agents (such as tranexamic acid) may be helpful in the prevention of bleeding, and also reduce the volume and duration of any blood loss (see **Figure 25.5**). Patients with advanced cardiac disease, particularly persistent untreated patent ductus arteriosus, pulmonary hypertension, and cyanotic heart disease may have intermittent and sometimes recurrent episodes of haemoptysis that generally are small volume initially but can become quite significant and rarely present as large volume haemoptysis. Often this is initially reported as hematemesis and while bleeding into the airways is the more common, oesophageal varices (due to chronic venous congestion or liver dysfunction), or duodenal ulcer may still need to be ruled out. Bronchoscopy can

**Box 25.2** Examples of cyanotic heart disease

- Norwood with cardiopulmonary shunt
- Pulmonary atresia with major aortopulmonary collaterals
- Bidirectional cavopulmonary connection
- Fontan circulation (or total cavopulmonary connection)
- Central shunt
- Eisenmenger's syndrome
- Unrepaired tetralogy of Fallot

localize the area of lung that is bleeding but rarely allows for clear diagnosis. Cardiac catheterization may be utilized in pulmonary hypertension to assess for feasibility of changes to pulmonary hypertensive therapy and right heart function. In cyanotic heart disease, however, the most likely cause is aortopulmonary collaterals, for which coiling or embolization may resolve the bleeding source. This is best done during acute haemoptysis episode for maximum diagnostic and therapeutic benefit. Hence, it is important to have review by cardiologist if haemoptysis presents in association with heart disease. Of course, the burdens of recurrent interventions on quality of life at the time of presentation need careful consideration, as this problem is often recurrent over time, despite intervention (see Box 25.2).

Finally, the anticoagulation strategy for either prophylaxis of important shunts or conduits, mechanical valves or systemic thrombus burden in patients with cardiac disease may need careful review in the setting of haemoptysis. This is particularly important in the presence of mechanical valve as thrombus formation on the valve can in itself be life-threatening. The guidance of the patient's cardiologist, and/or a haematologist are important in these situations.

Whilst catastrophic haemorrhage is thankfully a rare occurrence, honest discussions are needed (in the context of advance care planning) when this may be a significant possibility. Simple environmental measures such as the provision of dark bedding and dark towels will minimize the visual impact of any blood loss. Rapidly acting medication for anxiety and dyspnoea can also be made available (buccal midazolam/transmucosal opioids/subcutaneous equivalent).

## Tachycardia, palpitations, chest pain

It is important to recognize, for the patient with advanced cardiac disease, that worsening or increasing tachycardia can be a symptom of worsening heart failure or low cardiac output state. Alternately, it may be due to increasing arrhythmias, either new or recurrence of a previously diagnosed arrhythmia. Additional medications to achieve heart rate control may greatly reduce cardiac workload and symptomatology. Inquiring as to whether the tachycardia is precipitated by activity, or spontaneous in onset may point to different treatment paths. Regardless, antiarrhythmic therapy such as propranolol, can have significant negative consequence to heart function and should be undertaken with the guidance of the patient's cardiologist, potentially after a period of Holter monitoring. Additionally, tachycardia may be secondary to pain in general, or may be a symptom of worsening myocardial ischemia. Chest pain can be difficult to separate as a musculoskeletal complaint, symptom of anxiety, or association of ischemic or worsening myocardial failure. If an electrocardiogram is performed, it is important to compare to prior studies, as many patients with paediatric heart disease will have an abnormal baseline. Addressing these symptoms is likely best tailored with the guidance of the child's cardiologist specific to their heart disease. Whether due directly to chest pain, or general to the disease process, children with advancing heart

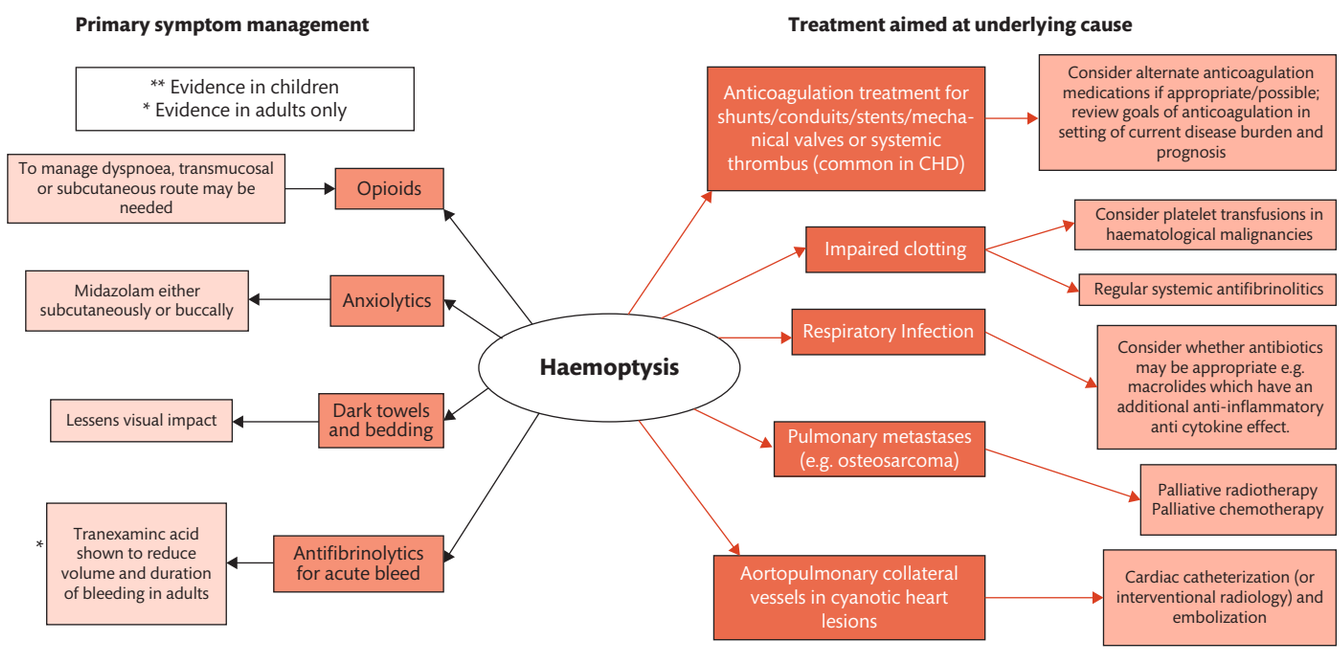


**Figure 25.5** Management of haemoptysis

disease often have increasing symptoms of pain near end of life that need to be managed (6).

## Fatigue, irritability, feeding intolerance

Fatigue is a predominant symptom of cardiac and respiratory diseases with progressive dysfunction of myocardial or musculoskeletal muscle. Symptom management to reduce symptoms, such as dyspnoea, tachycardia, and improve sleep quality may help to reduce or manage fatigue. Disease-specific treatments may be of little benefit as the patient nears end of life and interventions need to consider the balance of burden and effectiveness to promote comfort. Similarly, irritability can be an increasing symptom complaint of the child with worsening cardiac function or cardiac ischemia. Targeted therapies to reduce symptoms of congestion or support failing myocardial function may be of benefit for some time, but near end of life, a focus on sedation, anxiolytic therapy, and titration of analgesia are likely more appropriate. Finally, feed intolerance is common to patients with advanced cardiac disease and often is a result of either bowel congestion from generalized cardiac congestion, or from bowel ischemia from low cardiac output. Titrating therapies for underlying cardiac physiology may be helpful, although once again creating an adapted feeding regimen or transitioning to TPN support may be more appropriate to manage symptoms at end of life. Unique to the patient with single ventricle cardiac disease may be protein losing enteropathy. This causes loose stools and malabsorption as lymph is leaked into the bowel. Symptom management often includes intermittent albumin transfusions, and steroid therapies and should be guided by the patient's cardiologist. Emerging work utilizing catheter-based embolization of abnormal lymph drainage may provide some future benefit in symptom relief although these techniques are still evolving.

### Retained secretions at the end of life

Difficulty in clearing oropharyngeal secretions may lead to noisy or 'rattly' breathing. This is most likely to occur in the terminal phase, when the child's level of consciousness is diminished. The child is rarely aware enough to find this situation distressing, however it can be devastating for those surrounding the patient (8) (Figure 25.6). Positioning the head, so as to allow postural drainage, may be all that is required. Reassurance and explanation to the family is essential. Anti-secretory medication such as hyoscine or glycopyrronium may reduce the pooled secretion volume burden and can be tried on an individual case basis. Transdermal hyoscine hydrobromide presents an attractively non-invasive option. Suction may also be helpful, but the benefits and burdens of any invasive intervention close to the end of life must be carefully weighed, along with the risk of stimulating further secretion production by causing local irritation (8).

### The role of positive pressure ventilation

Use of long-term ventilation (LTV) in paediatrics has increased almost exponentially in the last 10 years (Table 25.2) (16). This increase is out of proportion with the rate of population growth, suggesting an evolution in the thresholds to initiate prolonged ventilatory support. The benefits of LTV are most likely to outweigh the burdens when it is used as a 'bridge' to either recovery or definitive treatment. Despite this, consideration must still be given to the overall function and progress of the disease, rather than the diagnosis alone, as studies show that some children will still die of causes unrelated to their need of LTV while on bridging ventilation (17). When LTV is more clearly a 'destination' therapy, where support is likely to be life-long, the situation is clinically, practically, ethically, and financially more controversial. The burdens are less easily offset, and may include painful airway suction, as well as discomfort associated with ventilator dys-synchrony (Table 25.2). Children may be more vulnerable to painful dys-synchrony for a number of reasons including relatively less voluntary control of breathing and ineffective triggering of the ventilator due to smaller tidal volumes (18).

Most LTV is delivered non-invasively via facemask or nasal 'pillows', although some children eventually progress to invasive ventilation via tracheostomy. The commonest use in paediatric palliative care is delivery of face mask ventilation to children with neuromuscular weakness, although it may also be considered in the context of chronic lung disease, respiratory control disorders, and to reduce cardiorespiratory workload in heart failure. Long-term, non-invasive ventilation is usually delivered only during sleep, as it is difficult to use a facemask system for >16 hours a day without the risk of skin/tissue break down. The main benefits and risks of LTV are outlined in Table 25.2. Some of the most compelling evidence that LTV is beneficial in paediatrics comes from individual trials of treatment (17). The clinical course of diseases associated with neuromuscular weakness is not always predictable, and the ethics of various levels of escalation in ventilator support may need re-evaluation as the clinical picture evolves (17). Many children will have presented with respiratory failure at a young age and may have required a period of invasive ventilation. LTV is started either after extubation, when it is clinically apparent that the child cannot manage without respiratory support, or when a sleep study shows that they have significant hypoxaemia or hypercarbia. In the neuromuscular patient group, LTV has been shown to be effective at reducing the symptoms of sleep-associated hypoventilation, such as morning headache, poor appetite, and day-time lethargy; as well as bringing about a reduction in unplanned admissions to hospital. Unsurprisingly, it is also possible to show an increase in survival both in spinal muscular atrophy and Duchenne muscular dystrophy when LTV is offered (16). Although the evidence base for the use of LTV remains weak, it is unlikely that there will be future randomized controls of this intervention, partly for ethical reasons. It is therefore essential that the benefits and burdens are explored on an individual patient basis. The development of potential disease-altering treatments for neuromuscular diseases is likely to further increase the demand for ventilator support, in an attempt to provide a period of stability from which to offer these emerging therapies (19).

## The role of mechanical circulatory support

There is an increasing burden of advanced cardiac failure in children for which mechanical device utilization is continuing to expand. MCS includes extracorporeal mechanical membrane oxygenation (ECMO) (used acutely and within an intensive care setting), ventricular assist devices (VAD) (left, right, or biventricular), and total artificial heart (TAH) (Table 25.3). The range of devices and options is beyond the

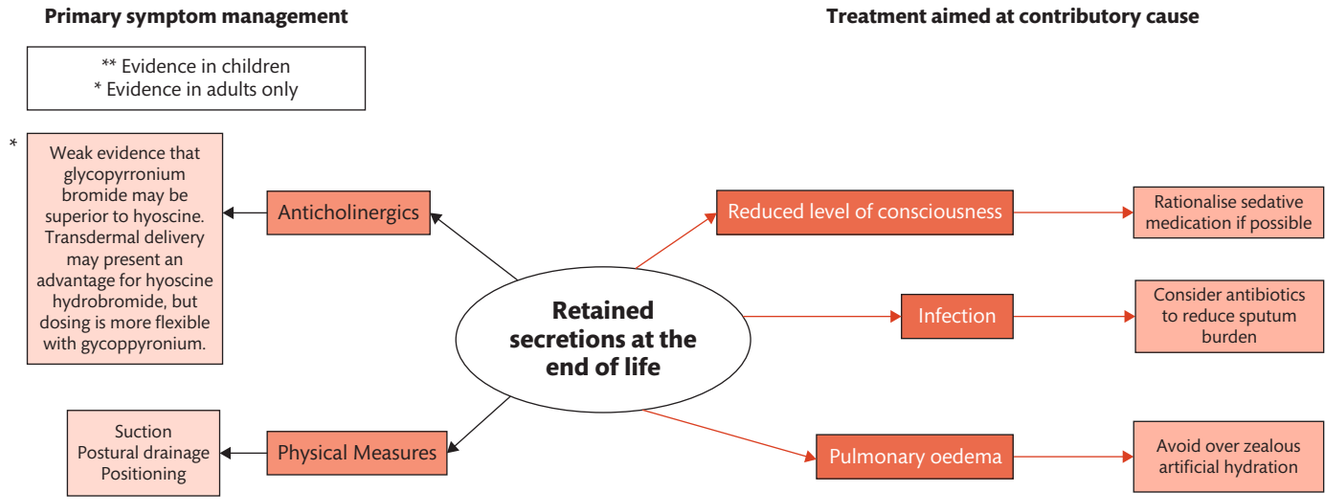


**Figure 25.6** Management of retained secretions

scope of this chapter, but it is important to recognize that adolescents often have options for devices that can be used in an outpatient setting similar to adults. The smaller patients are generally restricted due to size of devices available and are limited to an inpatient setting during their time on MCS due to device safety approvals (2, 3).

While ECMO can be emergently deployed and cannulation via carotid and jugular, or transthoracically, VAD support meant for durable management of heart failure is placed via cardiothoracic surgery with cannulas placed in the apex of the failing ventricle, and outflow cannula placed on the great artery the ventricle supplies. Cannula most commonly exit extracorporeally at approximately the level of the diaphragm with a pump device outside the body, connected by cords to a portable control box. Fully implantable devices, such as those used most frequently in adults and adolescents have only cords exiting at the skin. The decisions for when to place the device are generally driven by technical features of device and heart lesion/anatomy, absence of contraindications to anticoagulation therapy, potential for future transplantation, desire of patient/family to proceed towards potential transplantation. Device support comes with risks outside of the immediate surgical procedure that include thrombotic or embolic stroke, bleeding or clotting issues in other organ systems, thrombus affecting VAD function, the need for changes of VAD components due to thrombus burden, infection (both acute and chronic). Additionally, there is potential for new or ongoing end organ failure either due to inadequate systemic output from the device, or advanced end organ disease processes prior to device placement (2).

While MCS is generally used to improve symptom management and lessen the burden of advanced heart disease, while improving the patient's overall condition prior to transplantation, there are many children who will evolve to need end-of-life care while on ventricular assist devices. This is most often due to ongoing and/or increasing frequency and number of comorbidities, such as stroke. Accumulated comorbidities may mean they are no longer transplant candidates, or that their quality of life is so impacted transplant is no longer desired. Similarly, if the patient utilizes VAD as a 'destination' therapy to reduce symptoms of heart failure, escalating comorbidities, or burdens of anticoagulation and VAD management may make a goal of symptom reduction and acceptable quality of life no longer achievable. The volume of patients undergoing durable mechanical support (VAD that can be cared for in a hospital ward setting or as outpatient) will only continue to increase as this technology improves and becomes smaller and more accessible to the paediatric population (2).

**Table 25.2** Benefits and complications of non-invasive ventilation

| Benefits of long-term non-invasive ventilation | Complications of long-term non-invasive ventilation |
|---|---|
| Reduction of respiratory work | Skin breakdown from mask |
| Promotion of somatic (and hence pulmonary) growth | Eye irritation from mask leak |
| Correction of hypoxaemia/hypercapnia | Aerophagia and painful abdominal distention |
| Avoiding pulmonary hypertension | Full face mask asphyxia risk in the event of vomiting |
| Symptomatic relief | Mid-facial flattening (potentially severe deformities) |
| Prevention of chest wall deformity in neuromuscular disease | Risks of equipment failure/malfunction |
| Reduction in number of unplanned admissions with respiratory exacerbations in children with muscular weakness | Difficulty achieving good synchronisation at treatment initiation, or with disease progressions (close to end of life) |
| Prolonging life in neuromuscular disorders/respiratory control disorders | Difficult decisions to be made about progression to tracheostomy ventilation, if support is needed for >16 hours per day |

**Table 25.3** Benefits and burdens of mechanical circulatory support

| Benefits of longer-term mechanical circulatory support | Complications of long-term mechanical circulatory support |
|---|---|
| No need for effective cardiac ventricular pump | Thrombus causing organ injury or device failure |
| Volume unloading/decongestion of circulation | Stroke—thrombotic or haemorrhagic |
| Re-established stable perfusion for end organs | Bleeding complications |
| Reversal of end organ (ex-renal) failure | Infection at cannula site, acutely or chronically; may necessitate removal of device |
| May reduce or avoid pulmonary hypertension | |
| Symptomatic relief from heart failure | Inadequate cardiac output support not achievable |
| Ability to re-establish feeds/growth support | Risks of equipment failure/malfunction |
| Ability to extubate, engage in rehabilitation/physiotherapy | Re-operation for device replacement/bedside procedures for pump or cannula changes |
| Ability to return to home (approval for home management device specific and largely only available to adolescents at present) | Intensive care stay required for recovery after pump placement—prolonged if early complications of bleeding or thrombus or inadequate pump function |
| Prolonging life in advanced heart disease; prolongs ability to wait for transplantation | Prolonged in-hospital stay due to device specific approvals restricting outpatient management |

## Compassionate discontinuation of ventilator or MCS

It is often difficult for both medical teams and families to accept the need to withhold or even withdraw a treatment that may prolong life. The palliative care team may have an advocacy role in supporting individual patient-focused ethics meetings allowing space for wider discussions of 'best interest', quality of life, and suffering. Often this occurs between numerous treating teams and family members (Figure 25.7). The output of such discussions ideally includes a detailed advance care plan (ACP) with suggested ceilings of treatment, as well as options to address symptoms and improve quality of life (1). Paediatric VAD providers are also recommending, similar to adult programmes, that an ACP be developed prior to device implantation (2, 3). There are, however, a number of countries in which patients have as yet no legal right to be disconnected from a respirator, pacemaker, or MCS, nor physicians any legal right to extubate or stop MCS. This means that the options available within an ACP are likely to differ on a worldwide scale.

For those jurisdictions where discontinuation of technologic support is legal, it is based on several ethical justifications. These include when burdens are high and continue to escalate with diminishingly low likelihood of benefit (or no benefit), and the therapy is not in the patient's best interests, and voluntary decision to forgo or discontinue is by the patient with capacity. These are defensible within moral theories of deontology and consequentialism as well as utilizing the four principles. Stopping MCS or pacemaker is no different morally than stopping mechanical ventilation. The proximity of death to withdrawal does not dictate the ethical permissibility (3, 20).

Ventilation via endotracheal intubation, in an intensive care setting, is a means of life support, and not in itself a 'treatment'. If there is no prospect of the child's condition improving as a result of the active treatment of an acute exacerbation of their condition, then long-term survival without ventilation is unlikely. There may be other options to explore in certain cases, including the long-term ventilation regimes described previously, however it is essential to consider the quality of life achievable for the child (1). Similarly, MCS is a means of life support and not in itself a treatment. In some instances, durable VAD support is likely to improve symptoms and allow future treatment options, and in some instances it is not. As noted, long-term technologic support needs to consider the potential quality of life that may be truly achievable and at what burden this may come, particularly considering the need for surgical intervention and potentially complicated recovery after VAD placement, often with an uncertain future transplant option. These considerations will vary widely based on the underlying disease precipitating the question of potential MCS utilization.

If it is agreed that the burdens of technologic support outweigh its benefits, and that the purpose of the support—for reversal of underlying disease, for time for diagnosis and prognosis, for evaluation of transplant options, or interventional options to improve quality of life—has been lost, then careful, unhurried information sharing should occur with the family (1, 3). At a time such as this, it can be helpful to elicit 'what the family still hope for' and 'what they most fear'. If hopes include leaving hospital, it may be possible to facilitate withdrawal of ventilation or discontinuation of a VAD in a children's hospice or even in the family home. If the family's greatest fear is future suffering, then discussion can take place about the management of any symptoms seen at the time of extubation, along with plans for the event of any medium-term survival (such as offering supplemental oxygen and non-invasive hydration/nutrition options). It is also important to consider that some children felt likely to die rapidly after extubation will survive unexpectedly. This is more likely in some situations that others, but a prognostication of 'immediate death' on the withdrawal of support should be given with caution (1). Similarly, although many children will die quite rapidly after MCS is discontinued, depending on the underlying heart function, they may survive longer than initially anticipated and will need re-escalation and titration of symptom management for a recrudescence of heart failure symptoms.

Careful planning for every step of the process from counselling the family, to organizing any change of setting, and to managing parallel planning for the outcome needs to be documented and shared between the teams involved (1). Most paediatric VAD programmes develop a preparedness plan for the instance of need to discontinue VAD support prior to transplantation, or due to failure

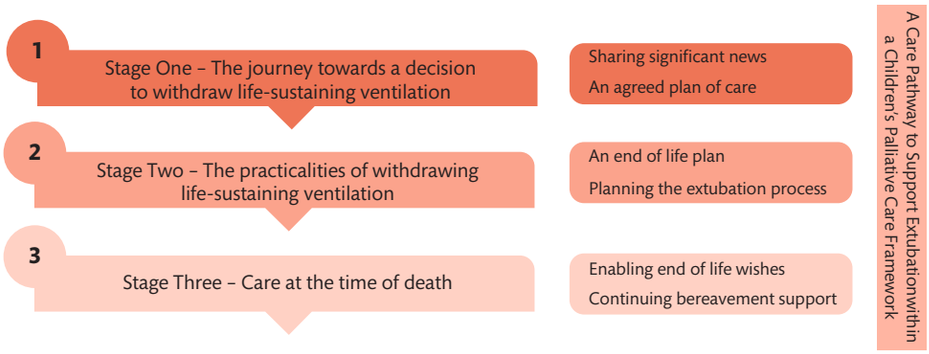


**Figure 25.7** Pathway summary diagram: A care pathway to support extubation within a children's palliative care framework
Reproduced with permission from Association for Children's Palliative Care (ACT). (2011). *A Care Pathway to support extubation within a children's palliative care framework*. Bristol, UK: ACT. Copyright © 2011 Together for Short Lives. www.togetherforshortlives.org.uk/assets/0000/1059/Extubation_Care_Pathway.pdf

to adequately manage symptoms, or because the patient with capacity no longer wishes to be technologically dependent (2). Figure 25.7 shows a suggested flow diagram for planning withdrawal or discontinuation of ventilation in an out of hospital setting (21). It is ff importance to note, even in countries where discontinuation of MCS is legally allowed, many cardiologists continue to feel conflicted or refuse to discontinue MCS support. This may require care provider meetings and support outside of engagement with the family. Additionally, in some centres this has required an increasing role of the patient-aligned care team (PACT) in aiding with the discontinuation of the device. This should be planned according to centre support and provider comfort. If there is question of the ethical permissibility to stop any technological support (ventilator or MCS) a bioethics consultation can be helpful (3).

### Compassionate withholding or discontinuation of prostaglandin therapy

In neonates with congenital heart disease, prostaglandin therapy is frequently employed to maintain patency of the ductus arteriosus to maintain either systemic or pulmonary perfusion. In situations of complex congenital heart disease, or heart disease in combination with additional malformations or morbidities, a plan for compassionate withholding or discontinuation of prostaglandin therapy may be appropriate. In this setting, it is important to both recognize and prepare the family for what can be hours, days, or weeks of ongoing survival. The closing of the ductus arteriosus is not predictable and symptom management for either worsening cyanosis, or decreasing cardiac output, or both will be necessary across the course and a plan for inpatient hospital stay, transfer to hospice, or ongoing outpatient palliative care from home, should be developed (22).

## Case 25.1

A 16-year-old girl (N), diagnosed with metastatic osteosarcoma, was admitted to a children's hospice for symptom relief. She had become increasingly distressed at home, as a result of episodes of acute breathlessness, sometime also associated with escalation in her pain, which was otherwise well controlled with sustained release morphine. At these times, top-up doses of oral morphine were not offering N rapid enough symptom relief and her parents had begun calling emergency ambulances for access to Entonox gas. On admission to the hospice, a detailed history revealed the following;

- The episodes were of very sudden, apparently unprovoked onset.
- Pain escalation was sometimes a preceding factor.
- Anxiety/panic ensued leading her into a vicious circle.
- N's maternal grandmother had died of breast cancer with extensive pulmonary metastases and had suffered terrible breathlessness prior to her death.

A personalized symptom management was constructed, as follows:

- Transmucosal diamorphine was offered at the onset of the 'crises'.
- Buccal midazolam was also available if she remained anxious or appeared to 'wind up'.
- Supplemental oxygen was available (but was not always felt to be helpful). It was left up to N whether to continue with this, as the episode abated.
- N's own mother remembered being taught a breathing control technique (Square Breathing), when N's grandmother was dying. She was supported by a physiotherapist in teaching the technique to N, in the hope that she may be empowered to control the episodes at their onset.
- The risk of haemoptysis was openly discussed. This has also been a feature of her grandmother's palliative phase. Dark coloured bedding and towels were discreetly made available.

Although her symptom management remained complex, N's crisis episodes fell in frequency, and the impact of the individual episodes was much reduced. She died 2 weeks after admission.

## Case 25.2

C was a 17-year-old girl with spinal muscular atrophy type II. C had been involved in decisions relating to her own health since she was a young teenager. She had led on the writing of her advanced care plan from the age of 14 years, her parents had always supported her decision-making. C had been dependent on night-time non-invasive ventilation for several years and had always been clear that she did not wish to escalate to invasive ventilation via tracheostomy. She had carefully weighed the quality of life implications, including

the likely loss of her ability to sing (a hobby about which she was passionate), and had made a competent decision to put a ceiling on her future treatment. At the age of 17 she developed a severe lower respiratory tract infection. This required admission to her local hospital for intravenous antibiotics, as well as constant support from her mask which delivered positive pressure ventilation. C became increasingly weak and found it difficult to synchronize with her ventilator. She asked her family to contact the local hospice for young adults, to arrange her transfer, rather than being considered for more invasive respiratory support. On admission C was able to clearly articulate her preference to have her ventilation withdrawn, as it now felt very uncomfortable. She understood that this would be likely to acutely shorten her life. She was supported by the hospice to gather family and friends at her bedside. She selected one of her favourite musical films and asked us to share a glass of wine with her. On withdrawal of her ventilation, she remained lucid for several hours, needing only low-dose morphine and supplemental oxygen to manage her breathlessness. She died later the same day.

## Case 25.3

G was a lively, eloquent, and mature 12-year-old, with ventricular failure secondary to congenital heart disease. She had had previous surgery but had no further therapeutic options at the time of presentation with acute on chronic heart failure. She required intubation, inotropic therapy, and ECMO support during the acute illness. This was provided due to likelihood of reversal of end organ dysfunction with adequate cardiac output. Once this was achieved, and once it was clear that ventricular recovery was unlikely or would take a prolonged period, she was reviewed for transplant candidacy, deemed a candidate, and underwent biventricular VAD placement. After an intensive care stay for recovery, she was able to extubate, transition back to oral feeds, and engage in rehabilitation activities to regain strength. As is common in adolescents transitioning to VAD, a period of depression was treated with the aid of psychiatric consultation and antidepressant medication. Three months after VAD placement, she was in a ward setting engaging in daily physiotherapy, school, and activities in the adolescent lounge. She required ongoing rehabilitation therapies but was not able to transition to a rehabilitation-specific setting due to that institution's discomfort managing VAD. However, she was on track for transition to the home setting within a few weeks. One morning she complained of headache which evolved to decreasing level of consciousness and an emergent head computerized tomography (CT) scan revealed a stroke. She returned to the intensive care setting for management of evolving neurologic injury and anticoagulation of the VAD. After acute recovery, she was left with a mild hemiparesis of the left leg. However, during this period she acquired a pneumonia, required reintubation, and developed renal failure despite increasing VAD support. An ongoing cascade of complications and organ dysfunction led to a point where she was no longer a candidate for heart transplantation. Throughout this period, G remained wakeful and interactive. She had been very involved in discussions about the VAD placement. The cardiology VAD team, transplant team, social work, nursing, cardiothoracic surgery team, palliative care team, G, and her mother had met to discuss a preparedness plan. G and her mother were in agreement about her reducing quality of life and recognized that the VAD was not going to gain them the time hoped for to get a transplant. G herself noted that her VAD 'wasn't working' and 'she felt awful'. She acknowledged to the cardiology team that she was going to die. Across many conversations, important goals were met, such as hosting a prom in her ICU room, having her dog stay with her overnight, and meeting a local celebrity were accomplished. G asked to be asleep for the time the VAD was turned off, and her mother was present as palliative sedation was achieved and the VAD was discontinued.

## Conclusion

Cardiorespiratory symptoms exemplify perfectly the need for a multidimensional approach to symptom management, centred around the patient's own report of their experience. The relationship between objective signs and symptoms is often poor, and a range of interventions that include pharmacological, non-pharmacological, and psychological approaches needs to be made available in order to best support the patient. Specific evidence to guide paediatric cardiorespiratory palliative care practice is largely lacking, making this an important area for research (1).

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