Best practice in the provision of nebuliser therapy


Summary
Nebulisation is an important and common method of administering medication to patients with respiratory disease. Although the routine use of nebulisers is contentious, they are helpful when the patient is unable to use other devices, perhaps because of illness or poor dexterity, and are recommended in certain clinical situations, such as acute, life-threatening asthma. This article aims to inform nurses of current evidence regarding the advantages and limitations of nebuliser therapy. Patient experiences of receiving nebulisers are discussed, as well as the importance of cleaning and maintaining the equipment.

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Keywords
Drug administration, nebuliser treatment, patients: education, respiratory system and disorders

Aims and intended learning outcomes
This article aims to encourage critical thinking about the use of nebuliser therapies and to enable the nurse to review his or her practice in the light of current evidence and consensus. After reading this article and completing the time out activities you should be able to:

- Describe the function of a nebuliser.
- List the factors that contribute to the efficiency of nebulisers and their limitations.
- Describe the indications for nebuliser therapy and identify the drugs commonly delivered by nebulisation.
- Describe the nurse’s role when advising on and administering nebuliser therapy.

Introduction
Drug delivery via inhalation is the mainstay of treatment for many respiratory diseases, most commonly asthma and chronic obstructive pulmonary disease (COPD) (British Thoracic Society (BTS) and Scottish Intercollegiate Guidelines Network (SIGN) 2009, National Institute for Health and Clinical Excellence (NICE) 2010). The lungs provide an efficient route for the administration of several classes of drugs, as they allow receptors in the airways to be targeted by therapeutic agents (Boe et al 2001).

There are a number of devices and delivery methods available for the administration of specific drugs, and these include multidose pressurised inhalers (MDIs), breath-actuated inhalers and dry powder inhalers. Nebulisation is an important and common method of delivering drugs to the airways, and it is vital that nurses caring for patients receiving nebuliser therapy understand the advantages and limitations of nebulisers.

Nebuliser therapy
A common misconception is that a nebuliser is a device that includes a mask, tubes and perhaps an air compressor. However, the nebuliser is found in the plastic holding chamber – the ‘acorn’ – which
converts a liquid drug into a fine aerosol. There are two common types of nebuliser – air-jet and ultrasonic nebulisers. The air-jet nebuliser is driven by pressurised gas, air or oxygen, usually powered by an electric compressor or gas cylinder. The compressor is often incorrectly referred to as the nebuliser. Ultrasonic nebulisers are driven by an ultrasonically vibrating crystal that produces aerosol particles. These machines are often smaller and quieter. Such devices tend to be more portable, but are also more likely to malfunction. It is crucial that the nebuliser chamber is matched to the type of compressor because mismatching nebulisers and compressors will result in alterations to flow rate and drug delivery (Smith et al 1995).

The word ‘nebuliser’ is derived from the Latin ‘nebula’, meaning a cloud of dust or gas in outer space. It was first defined in medicine in 1874 as an instrument for converting liquid into fine spray (Muers 1997). The rationale for using inhalation therapy is to produce a local effect in the lungs, maximising the speed of administration and efficacy of the drug. As the administration is local, drug doses are lower than would be required to produce similar effects systemically, for example using the oral or intravenous route. Inhaled therapy therefore has the potential to result in fewer side effects (The Nebulizer Project Group of the British Thoracic Society Standards of Care Committee 1997).

The popularity of nebulisers grew in the latter part of the 20th century and, with the advent of evidence-based respiratory guidelines, nebuliser therapy became an established part of the treatment of common respiratory diseases. The first guidelines concerning nebuliser therapy were published in the UK by the British Thoracic Society (BTS) (1997). These guidelines set out to address gaps that had been recognised in clinical practice and supporting scientific evidence. They have been superseded by other publications including the European Respiratory Society Guidelines on the use of nebulizers (Boe et al 2001).

Although nebuliser-administered therapies are common in clinical practice, their use has become increasingly contentious (Barta et al 2002). One systematic review demonstrated no difference in efficacy between nebulisers and alternative inhaler devices (Brodklebank et al 2001). A Cochrane review concluded that MDIs and spacers (holding chambers used with an MDI to increase drug deposition and minimise oral side effects) perform at least as well as nebuliser therapy in patients with COPD (Ram et al 2002). This lack of evidence may lead to inconsistencies and controversies in clinical practice, for example nebulisers being recommended by some practitioners, but not others.

Drug delivery
Nebulisers are inefficient, with approximately 12% of the drug reaching and being deposited in the lungs. The rest is wasted through expiration or residue or being nebulised into the surrounding air (Rees 2005). The efficiency of drug delivery to the lungs depends on a range of factors including the type of chamber, flow rate, volume of liquid, the patient’s breathing pattern and the age and condition of the lungs (Boe et al 2001).

A nebuliser converts a liquid solution into an aerosol using a combination of high gas flow, and precise Venturi orifices (small holes) and a baffle (the loose part that sits inside the nebuliser and acts to direct gas flow and create droplets) in the nebuliser to produce particle sizes that can be inspired (Figure 1) (BTS 1997). The droplet size is crucial to drug deposition in the lungs and therefore drug efficacy. To reach the target airways, the droplet size should be less than 5μm (micrometres). However, if droplets become too small (less than 1μm), they are likely to be deposited in the peripheries of the lung, where they do not have a therapeutic effect (Boe et al 2001).
learning zone respiratory focus

Manufacturers’ guidance should be adhered to, but generally the gas flow rate needs to be over 6L per minute to produce sufficiently small particles throughout the five to ten minutes of a typical administration (BTS 1997). While nebuliser chambers vary, the fill volume is usually between 2.5mL and 5mL. It is important not to exceed the maximum fill volume because this will reduce nebuliser performance and prolong administration time (BTS 1997).

The nebuliser continues to work until the volume is reduced and the nebuliser emits a characteristic ‘splutter’. The chamber does not empty completely and a residual volume of 0.5-1.5mL remains (Boe et al. 2001). This residual fluid should be discarded before the next nebulisation. Breath-activated nebulisers may reduce waste and increase lung deposition but they are not commonly used in practice. This may be due to greater cost or greater familiarity with, and availability of, more traditional devices. Some nebuliser chambers incorporate reservoir and valve systems to increase the efficiency of particle delivery during inspiration and reduce environmental losses during expiration (BTS 1997), but again these are not commonly used.

**TABLE 1**

**Drugs commonly used in nebulisation**

<table>
<thead>
<tr>
<th>Drug</th>
<th>Some indications</th>
</tr>
</thead>
<tbody>
<tr>
<td>Beta2 agonists</td>
<td>Bronchodilators, commonly used in asthma and chronic obstructive pulmonary disease (COPD).</td>
</tr>
<tr>
<td>(for example salbutamol, terbutaline)</td>
<td></td>
</tr>
<tr>
<td>Anticholinergics</td>
<td>Bronchodilators, commonly used in COPD and useful as adjuncts in acute asthma.</td>
</tr>
<tr>
<td>(for example ipratropium bromide)</td>
<td></td>
</tr>
<tr>
<td>Corticosteroids</td>
<td>Topical anti-inflammatory action in cystic fibrosis.</td>
</tr>
<tr>
<td>(for example budesonide, beclometasone)</td>
<td></td>
</tr>
<tr>
<td>Antibiotics</td>
<td>Colomycin is commonly used as an inhaled therapy in cystic fibrosis and bronchiectasis; pentamidine is indicated for patients with human immunodeficiency virus to treat or prevent pneumonia caused by Pneumocystis carinii.</td>
</tr>
<tr>
<td>(for example colomycin, pentamidine)</td>
<td></td>
</tr>
<tr>
<td>Antifungals</td>
<td>Used to treat and prevent pulmonary aspergillosis (in susceptible individuals).</td>
</tr>
<tr>
<td>(for example amphotericin)</td>
<td></td>
</tr>
<tr>
<td>Recombinant human deoxyribonuclease (rhDNase)</td>
<td>rhDNase is a genetically engineered synthetic enzyme that hydrolyses deoxyribonucleic acid in bronchial mucus, reducing viscosity and facilitating expectoration. It is used to treat cystic fibrosis.</td>
</tr>
<tr>
<td>(for example dornase alfa)</td>
<td></td>
</tr>
</tbody>
</table>

(For further information on drug doses, effects and side effects please refer to the British National Formulary 2010)

**Time out 1**

Dismantle a jet nebuliser and identify the individual components and clean them. Notice the small holes (Venturi orifices) through which air is driven; if cleaning instructions are not followed, drug residue can easily crystallise and block these orifices. Consider how any difficulties you encounter in cleaning the nebuliser might pose a problem for a patient with reduced manual dexterity.

**Indications for nebulised therapy**

Nebulisers can be useful when the patient is unable to use other devices, perhaps as a result of severe illness or poor manual dexterity (BTS 1997). Administering nebulisers can also require less time from carers in contrast to handheld devices. For example during an acute exacerbation or when treating young children or older people (BTS and SIGN 2009, NICE 2010).

In some cases the drug is available only in a nebulised preparation, for example dornase alfa (Table 1). However, in many cases the use of an MDI and spacer produces similar deposition in the lungs and equivalent drug efficacy (Cates et al 2006a, 2006b). Despite these considerations, patients tend to have confidence in nebulisers and often choose this delivery method in preference to handheld devices. As part of a recent national COPD audit, a patient survey reported that many patients feel that they benefit from receiving oxygen or a nebuliser (Royal College of Physicians et al. 2008). The reasons for this are unclear, but it may be related to the physical sensation of oxygen or nebuliser therapy (Schwartzstein et al 1987).

**Time out 2**

Ask five patients about their experiences of nebuliser therapy. Do they prefer it to using handheld devices, and if so why? Does nebuliser therapy cause any problems for these patients? Do patients vary in their experiences of nebulisers, and can this be used to inform prescribing practice?

**Nebuliser therapy for asthma** The BTS and SIGN [2009] guideline no longer recommends nebulised therapy for the majority of asthma care. An MDI and spacer is recommended for first-line delivery of bronchodilators in patients with mild to moderate asthma. The guideline...
suggested that the use of an MDI and spacer is ‘at least as good as’ nebulisers in adults and children. In particular (BTS and SIGN 2009):

- Treatment with an MDI and spacer is more effective and has fewer side effects because of better patterns of deposition.
- MDIs and spacers are light, cheap, maintenance free, portable and available on prescription.
- MDIs and spacers may reduce prescribing costs, compared with nebulisers.

The BTS and SIGN (2009) guideline recommends administering nebulisers in life-threatening asthma, initially as a bolus, although continuous nebulisation using an appropriate device may be more effective in patients with acute asthma if the response to initial therapy is poor. If a nebuliser is used in an emergency with air-driven compressors, there is a risk of oxygen desaturation. Patients experiencing an acute exacerbation of asthma often become hypoxaemic and require supplemental oxygen. In these circumstances nebulisers should be driven with oxygen, using a cylinder with a high-flow regulator to provide the necessary flow rate of over 6L/min (BTS and SIGN 2009).

Nebulisers are less useful for domiciliary management of patients with stable asthma and have been found to be detrimental. This is because patients tend to rely on them, rather than using preventers, and to treat the symptoms (with bronchodilators) of the acute exacerbation rather than the cause (inflammation) (BTS and SIGN 2009).

Some patients – especially those with brittle asthma – may have more confidence in the use of nebulisers than MDIs, and therefore nebuliser therapy may be indicated in this discrete group (BTS and SIGN 2009). In such circumstances it is essential that a verbal and written plan for self-treatment is provided, together with a reiteration that repeated use of the nebuliser should not result in failure to seek medical help (BTS and SIGN 2009).

**Nebuliser therapy for COPD** Nebulisers have traditionally been the delivery device of choice for the treatment of patients with acute exacerbations of COPD and management of severe end-stage disease in the community (BTS 1997). Domiciliary nebulisers are commonly used by patients with COPD, although there is no evidence of their advantage over other handheld devices. NICE (2010) guidance on nebuliser therapy in COPD is outlined in Box 1.

Guidelines have always advocated the use of trials for assessing the efficacy of nebuliser therapy for patients before prescribing long-term treatment. Trials traditionally involved measuring outcomes such as symptoms, peak flow and patient preference (BTS 1997). More recent findings have concluded that, if a patient does not respond to an inhaled drug with an objective improvement in lung function, this does not mean that they will not benefit from the drug (NICE 2010). Peak flow is not a sensitive indicator of response to inhaled therapy, and more subjective variables such as symptom management and patient-reported benefit and preference may be more sensitive indicators (NICE 2010). However, it is important to ensure that any potential for optimising therapy with handheld devices is exploited fully before proceeding to nebuliser therapy.

**Time out 3**

Read the policy in use in your clinical area concerning nebuliser therapy and assessment. Does it include subjective measurements of benefit, for example symptom management, or does it rely on objective measurement of lung function?

**Nebuliser therapy for other disorders** Nebulisers may be used to deliver bronchodilators, corticosteroids and recombinant human deoxyribonuclease (rhDNase) to patients with cystic fibrosis. While bronchodilators are administered with the aim of reducing airway obstruction, they may also increase mucociliary clearance. Nebulised corticosteroids are used as topical anti-inflammatory therapy. The evidence for administering these drugs via nebulisation rather than handheld devices is weak (BTS and SIGN 2009, NICE 2010), and there are no Cochrane systematic reviews available. rhDNase reduces the viscosity of sputum through digestion of extracellular neutrophils and inflammatory mediators that occur in large numbers as part of chronic epithelial inflammation in the lungs of people with cystic fibrosis. Specified nebuliser systems are necessary to deliver the drug (BNF 2010).

Patients with bronchiectasis or cystic fibrosis may also benefit from nebulised antibiotics, in either the long or the short term. This therapy will

**BOX 1**

**Recommendations for the use of nebuliser therapies in patients with chronic obstructive pulmonary disease**

- Consider a nebuliser for patients with distressing or disabling breathlessness despite maximal therapy with inhalers.
- Assess the individual and/or carer’s ability to use the nebuliser before prescribing, and arrange appropriate support and servicing of equipment.
- Allow the patient to choose whether to use a face mask or mouthpiece where possible.
- Continue nebuliser treatment only if there is an improvement in symptoms, daily living activities, exercise capacity or lung function.

(National Institute for Health and Clinical Excellence 2010)
be part of a management plan for the patient that may include postural drainage, chest clearance and the use of intravenous antibiotics in an acute exacerbation (Flume et al 2007, Pasteur et al 2010).

Nebulised drugs are sometimes used in palliative care, particularly for the relief of dyspnoea. The evidence base is lacking and, while opioids are valuable in controlling dyspnoea, nebulised therapies do not appear to be more advantageous than oral preparations (Qaseem et al 2008). As with short-burst oxygen therapy, there may be an element of patients experiencing symptom relief through the effect of facial cooling (Schwartzstein 1987) and relief of anxiety (Muers 2005, Booth and Dudgeon 2006). Regardless of the condition being treated, the advantages and disadvantages of nebulising drug therapies should always be considered (Table 2).

**Provision of equipment for nebuliser therapy**

Nebulisers and compressors are not available for prescription on the NHS. The reason for this is unclear, but a factor could be that nebulisers were traditionally prescribed by secondary care clinicians with a readily available supply of compressors to loan to patients. As the care and management of patients with chronic respiratory conditions has shifted to primary care, this resource is less readily available. Patients are often required to meet the costs of purchase, and although they qualify for VAT exemption (BNF 2010), this situation seems unsatisfactory if there is a medical indication for the prescription, given that other drug delivery devices are provided on prescription.

The BTS (1997) guidelines state that the prescriber should also be the provider, and many healthcare organisations do have comprehensive nebuliser services where compressors can be loaned with maintenance and servicing provided. However, in the authors’ experience, many patients choose to purchase the compressor themselves. When a patient is incapacitated by breathlessness and desperate enough to use this equipment, it may prove difficult for healthcare professionals to refuse these prescriptions. The result is that many nebulisers in use in the community are not necessarily medically indicated and the patient may not have been adequately assessed; the compressor may not be regularly serviced and maintained and nebuliser chambers may not be cleaned or replaced regularly.

The implications of this are manifold, including unnecessary expense for health service budgets and time-consuming regimens for patients. There is therefore a need for thorough assessment of the patient’s symptoms, disease severity, inhaler technique, medication regimen and ability to use a nebuliser before initiating therapy, and ongoing support for the maintenance of equipment. In addition, it is important to inform patients of the potential advantages and disadvantages of nebuliser therapy.

<table>
<thead>
<tr>
<th>TABLE 2</th>
<th>Advantages and disadvantages of nebulisers</th>
</tr>
</thead>
<tbody>
<tr>
<td>Advantages</td>
<td>Disadvantages</td>
</tr>
<tr>
<td>Easy to use both when self-administered and when administered by carers (especially when patients experience acute breathlessness), although this can be offset by the cognitive and manipulation skills needed to load and operate the device (NICE 2010).</td>
<td>Expensive in terms of provision of equipment and ongoing maintenance.</td>
</tr>
<tr>
<td>Patients express confidence in nebulisers (Royal College of Physicians et al 2008).</td>
<td>Require maintenance and cleaning</td>
</tr>
<tr>
<td>Some drugs necessitate nebulisation for inhalation.</td>
<td>Lack of portability of compared with handheld devices.</td>
</tr>
<tr>
<td>May provide some relief of dyspnoea and anxiety.</td>
<td>Not all equipment is available on prescription.</td>
</tr>
<tr>
<td>May help patients to self-manage their condition (BTS 1997).</td>
<td>Greater physical, social and psychological demands on patients, relatives and carers compared with handheld devices.</td>
</tr>
</tbody>
</table>

**Time out 4**

Describe the instructions you would give a patient on how to clean and maintain his or her nebuliser equipment.

**Maintenance and cleaning**

Air-jet devices require annual servicing and maintenance checks. Nebuliser chambers are intended for single use or single-patient use and this is usually visible on the outer packaging. It is important that the manufacturer’s instructions are followed. Single-use devices should not be used multiple times because this could result in poor performance and poor drug delivery, as the durability of the product is often diminished following one use. However, single-patient use nebulisers can be reused for up to three months provided that cleaning and storage instructions are followed.

It is important that nebulisers are thoroughly cleaned and dried. This process involves cleaning with warm soapy water and being left to air dry, and it should be performed at least daily if...
Nebulisers are used regularly. Nebulised drugs are delivered directly to the lungs and may be a source of infection if equipment is contaminated. Residual solutions should be discarded after use or fill volume will be increased, which will reduce the efficacy of the nebuliser.

**Use of face masks and mouthpieces**

Patients who are breathless generally prefer to use a face mask, as this minimises exertion and feels more comfortable, although for others the mask can feel more suffocating and a mouthpiece may be preferable. The use of a mouthpiece should be advised when inhaling corticosteroids (to avoid contact with facial skin and eyes) and when administering anticholinergics (contact with the eyes can cause or aggravate glaucoma) (BNF 2010). Antibiotics should be administered using a mouthpiece, again to avoid skin contact, which could result in a rash. Another precautionary measure with nebulised antibiotics is the need to filter or exhaust the exhaled gas. This is necessary to avoid the nebulised antibiotic circulating in the room air and therefore being inhaled by other patients, staff or family members. This is especially important with cystic fibrosis patients if there are siblings at home or, in the case of hospital settings, neighbouring patients to avoid antibiotic resistance developing (Flume et al 2007).

**The nurse’s role**

It is imperative that any patient receiving nebulised therapy is given adequate support and instruction on the use, cleaning and maintenance of nebulisers and compressors. Practical advice such as information on travelling with a nebuliser can be useful for patients wishing to maintain mobility and independence. Nurses have an important role in educating patients on disease management and medication, often helping them to choose a suitable device. It is essential that any decisions the patient makes are informed fully. Therefore, it is important that the nurse is able to discuss with the patient the advantages and disadvantages of nebuliser therapy (Table 2).

The BNF (2010) provides recommendations on the use of home nebuliser therapy. The patient should:

- Have clear instructions from a doctor, nurse specialist or pharmacist on the use of the nebuliser, including maintenance and cleaning.
- Be instructed not to treat acute episodes at home without also seeking help.
- Have regular follow up by a doctor, nurse specialist or physiotherapist after one month of starting therapy and annually thereafter.

**Patients’ experiences of nebuliser therapy**

It is possible that psychological dependence may become a problem for a patient. Over-reliance on a nebuliser can restrict a patient’s lifestyle and result in a routine governed by the timing of nebuliser therapy (Boyter and Carter 2005). Patients with cystic fibrosis often have complex and time-consuming routines to adhere to and this can lead to frustration and poor adherence, especially in adolescence (Patterson et al 2008). Unnecessary restrictions or routine should be avoided.

Studies of concordance with nebuliser therapy show mixed results. One survey reported excellent concordance with therapy; patients felt the nebuliser helped them to control and manage their respiratory disease and as a result they were less dependent on health care (Barta et al 2002). However, a postal survey by Boyter and Carter (2005) found that compliance with instructions on the care and maintenance of home nebulisers was suboptimal. This highlights the need for clear information and instructions and dialogue between patients and staff, not only when the therapy is initiated but also as an ongoing aspect of care.

**The future of inhaled therapy**

It is anticipated that technological advances will improve nebuliser therapy of the future. Significant advances have occurred with the advent of inhaled insulin, although insulin administered in this way has not proven to be cost-effective (Black et al 2007). One of the key areas for future developments in nebuliser therapy will be the need to reduce waste and determine drug dose deposition more accurately (Boe et al 2001).

Newer, long-acting bronchodilators that are not available as nebulised products are now in use and there is ongoing research and development in this area. These drugs are designed to be delivered daily, for example tiotropium bromide, or twice daily, for example salmeterol (BNF 2010). Trials have been conducted and demonstrate efficacy using handheld devices (BTS and SIGN 2009, NICE 2010). Perhaps as a result of these pharmaceutical developments, current practice suggests that the use of nebulisers in the community is becoming less common. According to the published evidence, the drugs used in regular
neculiter therapy are not as effective as a long-acting bronchodilator administered via handheld devices (BTS and SIGN 2009, NICE 2010).

**Conclusion**

Current evidence suggests that the clinical effectiveness of nebuliser therapy is no more efficient than using an MDI and spacer, and the latter is a more cost-effective and convenient option. Coupled with advances in inhaled therapies for asthma and COPD that are not available as nebuliser preparations, it is becoming more difficult to justify the routine use of nebulisers in clinical practice, in either the acute or domiciliary setting. That said, nebuliser therapy remains common in clinical practice and is still the only means of delivery of some drugs, for example rhDNase and antibiotics, to the lungs. It is essential therefore that nurses administering nebuliser therapy or supporting patients to self-administer this medication have the knowledge and skills to ensure that this is done correctly.

Nebuliser therapy should be considered in patients who are unable to use handheld devices or who require inhaled drugs that are not available for delivery via an inhaler device (Boe et al 2001, BTS and SIGN 2009, BNF 2010, NICE 2010) 

**Time out 6**

Now that you have completed the article you might like to write a practice profile. Guidelines to help you are on page 60.

**References**


