Nebulisers: uses and abuses

Jet nebulisers are used to deliver a wide range of drugs as aerosols. The *British National Formulary* lists not only six bronchodilator solutions in doses up to 10 mg (available in single dose ampoules, multidose vials, or both), but also one corticosteroid, one prophylactic agent (sodium cromoglycate), and two mucolytics as being suitable for nebulisation.¹ In addition, nebulisers have been used with varying degrees of success with other solutions, including water, saline, antihistamines, local anaesthetics, and antibiotics. They may also have a role to play in achieving high systemic concentrations of certain other drugs (for example, insulin²) that cannot be given orally. Nebulisers are operated by compressed gas (from a cylinder, hospital air or oxygen line or oil free compressor), and convert a drug solution into a respirable spray.³

In hospital, nebulisers are used mainly to treat children and adults with asthma and bronchitis—for example, using large doses of beta adrenergic bronchodilators. This means of treatment is associated with less tachycardia or tremor than oral or parenteral treatment. The addition of intermittent positive pressure breathing is no longer thought to have any advantage over tidal breathing from the nebuliser mouthpiece or facemask.⁴ Mist tents, although favoured in the past,⁵ are now rarely used.

Nebuliser/compressor units are not available on prescription, but each year many thousand such units are sold to outpatients. This recent increase in the use of home nebulisers has been called the 'nebuliser epidemic',⁶ perhaps an unfortunate term, but one brought about by ignorance of their use and limitations. Many patients—or their parents—purchase a nebuliser and compressor because they believe that a larger dose of drug will be more effective than that given by metered dose inhaler. Others may be unable to use an inhaler because of incoordination (a particular problem in very young children), and others believe that the nebuliser will reduce the frequency of hospital admission.

The increased use of home nebulisers has, however, been the subject of recent concern. The major worry is that many patients might place too much reliance on their nebulisers and delay seeking medical advice—for instance, during a potentially fatal asthmatic attack. This problem has been suggested though not proved as a cause of the recent increase in asthma deaths in New Zealand.⁷ A recent survey of a group of 53 users of home nebulisers, most of whom were less than 15 years of

age, found that many were poorly supervised and instructed.⁸ Eight of 49 patients with 'moderate' to 'severe' asthma were not attending a hospital clinic. Two thirds of those aged 7–15 years took inhaled beta agonists only and were taking neither oral nor inhaled corticosteroids. Several of those questioned said that in an acute asthmatic attack they would take more inhaled beta agonist rather than seeking their doctors' advice. A subsequent editorial advocated tighter control over the use of home nebulisers, with improved assessment, monitoring, and instruction of patients.⁹

Specifications

During the last few years a confusing variety of nebulisers and compressors has been introduced. Not all nebulisers, however, are the same, and the output and delivery time vary according to the equipment used and the manner in which it is operated. Manufacturers often tell us little about their products, particularly regarding droplet size, nebulisation time, drug output, and required flow rate and volume fill.

Droplet size is often ignored, but only those droplets <5 µm diameter may be ideal for adequate penetration into the bronchial tree and lung periphery. Droplet size and *nebulisation time* vary inversely with the compressed gas *flow rate*,¹⁰ hence domiciliary oxygen cylinders that operate at flows not exceeding 4 l/min may produce inappropriately large droplets, and the treatment time may be unacceptably long. Electric compressors vary in power and produce flows through nebulisers between 6 and 15 l/min. A footpump compressor is also available commercially and is an inexpensive alternative when no electrical supply is available, but a considerable expenditure of energy is required to operate it.¹¹ The *fluid volume* placed in the nebuliser is also relevant: as this volume is increased nebulisers become more efficient, although nebulisation time also rises, and a volume fill of 4 ml is often a satisfactory compromise.

Drugs and doses

The dose of drug used by nebuliser is often empirical. For instance, with beta adrenergic bronchodilators doses severalfold greater than those given by metered dose inhaler are used, sometimes for no good reason. An average dose of salbutamol

may be 2.5–5 mg, of which about 10% would reach the lungs—that is, 250 µg–500 µg; by comparison 200 µg (two puffs) from an inhaler would deliver only 20 µg to the lungs. As the bronchodilator threshold is fairly low the large nebuliser doses may be effective even if the nebuliser is incorrectly set up, but may often be unnecessarily high. There is now evidence, previously lacking, that efficient operation of nebulisers is important for delivery of bronchodilators; improved small airways bronchodilation may be produced using nebulisers and flow rates that deliver aerosols of droplet size approximately 2 µm diameter.¹²

Nebulisers can be used with virtually any drug solution or suspension, and sometimes it may be appropriate to deliver as much 'respirable' aerosol to the patient in the shortest possible treatment time. This may be the case for antibiotic aerosols, which have been used with moderate success to treat respiratory tract infection since the 1940s and which are now regarded as highly effective in the treatment of pseudomonas infection in some patients with cystic fibrosis.¹³ Antibiotic solutions (particularly those made up from powders) are fairly viscous and hence are 'difficult' to nebulise.

In our laboratory at the Royal Free Hospital we have evaluated nebuliser systems in vitro to set out guidelines for delivery of aerosol antibiotics. Using gentamicin solution,¹⁴ drug delivery was optimised by specific brands of nebuliser (DeVilbiss and Upmist) filled with 4 ml drug solution and operated at flows equivalent to those from the most powerful compressors available for domiciliary use. Overall, the output of 'respirable' (<5 µm diameter) gentamicin aerosol varied over a 10-fold range according to the type of nebuliser and its operating conditions.

In a subsequent study using carbenicillin the conclusions were broadly similar, except that the Turret nebuliser was most efficient when used with 1 g carbenicillin powder plus 3 ml diluent (making a total volume 3.7 ml).¹⁵ Again, drug output was optimised and nebulisation time made acceptably short by the use of powerful compressors.

Conclusion

It is difficult to recommend specific brands of nebuliser and compressor as the range of equipment available is changing continuously. Nevertheless, these results suggest that not all nebulisers and compressors are suitable for use with antibiotic solutions and that the use of inappropriate apparatus, inappropriately set up, may have been a cause of unsuccessful aerosol treatment in some previous

clinical studies. Our data may also serve as a 'model' for the efficient delivery of various drug solutions not only for topical but also for systemic treatment.

We believe that rational nebuliser therapy can be a valuable addition in the management of several lung diseases. We would like to make a plea, however, for more consideration to be given to the specific indications for its use (namely, the delivery of fairly large doses of drugs, use by patients with poor metered dose inhaler technique, and the aerosolisation of drugs that cannot be delivered by other devices). We also stress the importance of satisfactory equipment properly set up in terms of flow rate and volume fill. Such supervision will dispel any fears of dangerous side effects and quell any 'nebuliser epidemic'.

References

- 1 British Medical Association and Pharmaceutical Society of Great Britain. *British National Formulary*. No 10. London: British Medical Association and Pharmaceutical Society of Great Britain, 1985.
- 2 Salzman R, Manson JE, Griffing GT, *et al*. Intranasal aerosolised insulin. Mixed meal studies and long-term use in type I diabetes. *N Engl J Med* 1985;**312**:1078–84.
- 3 Newman SP. Therapeutic aerosols. In: Clarke SW, Pavia D, eds. *Aerosols and the lung: clinical and experimental aspects*. London: Butterworths, 1984:197–224.
- 4 IPPB Trial Group. IPPB in COPD. *Chest* 1984;**86**:341–2.
- 5 Mearns MB. Aerosol therapy in cystic fibrosis. *Arch Dis Child* 1970;**45**:605–7.
- 6 Anonymous. The nebuliser epidemic [Editorial]. *Lancet* 1984;**ii**:789–90.
- 7 Grant IWB. Asthma in New Zealand. *Br Med J* 1983;**286**:374–7.
- 8 Laroche CM, Harries AVK, Newton RCF, Britton MG. Domiciliary nebulisers in asthma: a district survey. *Br Med J* 1985;**290**:1611–3.
- 9 Cochrane GM, Prior JG, Rees PJ. Home nebulisers for airflow limitation. *Br Med J* 1985;**290**:1608–9.
- 10 Sterk PJ, Plomp A, Van der Vate JF, Quanjer PH. Physical properties of aerosols produced by several jet and ultrasonic nebulisers. *Bull Eur Physiopathol Respir* 1984;**20**:65–72.
- 11 Dunn AM, Darvell F, Wilson RSE. An evaluation of the footpump as a driving source for nebuliser solutions. *Br J Dis Chest* 1985;**79**:172–6.
- 12 Clay MM, Pavia D, Clarke SW. Does nebulised bronchodilator aerosol size matter? *Thorax* 1985;**40**:222.
- 13 Hodson ME, Penketh ARL, Batten JC. Aerosol carbenicillin and gentamicin treatment of pseudomonas aeruginosa infection in patients with cystic fibrosis. *Lancet* 1981;**ii**:1137–9.
- 14 Newman SP, Pellow PGD, Clay MM, Clarke SW. Evaluation of jet nebulisers for use with gentamicin solution. *Thorax* 1985;**40**:671–6.
- 15 Newman SP, Pellow PGD, Clarke SW. Choice of nebulisers and compressors for delivery of carbenicillin aerosol. *Eur J Respir Dis* 1986. (In press).

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