rocephaly. After shunting, however, ventricular size failed to return to normal in many infants, indicating further atrophy possibly related to hydrocephaly itself. The perinatal factors examined related to the occurrence of hydrocephalus but not obviously to its eventual outcome. Therapeutic variables, such as the age at surgery and the number of spinal or ventricular taps before shunting, did not seem to relate to later major impairment. But these treatments were determined by a number of other factors, such as the condition of the infant, rate of progression of the hydrocephalus, and changing management policies, and were not randomised. Current trials may clarify the place of such management.

The strong relation of major impairment to cerebral cysts that were present before the hydrocephaly and indicated brain injury may indicate, however, that any benefit from early treatment of hydrocephalus will not be seen in a reduction in major early impairment but possibly later in the minor motor disabilities and coordination problems that characterise other forms of hydrocephalus. Follow up into primary school may be needed to detect this in such trials.

I thank Miss I Irving, Professor J Lister, Mr R Cudmore, and Mr R C M Cook for their advice and the surgical management of these babies.

References

- Chaplin ER, Goldstein GW, Myerberg DZ, Hunt JV, Tooley WH. Post-hemorrhagic hydrocephalus in the preterm infant. *Pediatrics* 1980;65:901-9.
- Sasidharan P, Marquez E, Dizon E. Short-term follow-up of grade 3 and grade 4 intraventricular hemorrhage with and without VP shunt. In: Ross Laboratories. *Syllabus of the second special Ross Laboratories conference of perinatal intracranial hemorrhage*. Columbus, Ohio: Ross Laboratories, 1982:799-809.
- Cooke RWI. Early prognosis of low birthweight infants treated for post-haemorrhagic hydrocephalus. *Arch Dis Child* 1983;58:410-4.
- Liechty EA, Gilmor RL, Bryson CQ, Bull MJ. Outcome of high-risk neonate with ventriculomegaly. *Dev Med Child Neurol* 1983;25:162-8.
- Lipscomb AP, Thorburn RJ, Stewart AL, Reynolds EOR, Hope PL. Early treatment for rapidly progressive post-haemorrhagic hydrocephalus. *Lancet* 1983;i:1438-9.

Correspondence to Dr R W I Cooke, Department of Child Health, Liverpool Maternity Hospital, Oxford Street, Liverpool L7 7BN, England.

Received 5 November 1986

Evaluation of nebulisers for bronchial challenge tests

J N TSANAKAS, A J WILSON, AND A W BOON

Department of Paediatrics and Medical Physics and Clinical Engineering, University of Sheffield, Children's Hospital, and Royal Hallamshire Hospital, Sheffield

SUMMARY The reproducibility of the output of seven different nebulisers was tested. Nebulisers with a minimal increase in output at higher flow rates had less variability in the output. The selection of a nebuliser for bronchial provocation tests depends on the intranebuliser variability. Two nebulisers had highly reproducible outputs.

Recently, bronchial challenge tests have been used increasingly for research and clinical purposes.¹ The solutions used for these tests are nebulised and administered by using either a dosimetric technique² or inhalations from a nebuliser for two minutes.³ The results from the two techniques have been shown to be quantitatively similar. Many workers prefer to use the latter method ('tidal breathing' technique), because although it is more time consuming, it is much cheaper. In addition, only this

method is feasible in young children. Bronchial provocation tests are quantitative and therefore the administered dose must be accurate. Among the important factors determining the amount of substance inhaled is the output of the nebuliser, which must be constant throughout the test. In the present study we have determined the reproducibility of the output of seven commercially available nebulisers under standardised conditions to assess their accuracy and suitability for use in bronchial challenges.

Material and methods

A single device of seven different commercially available nebulisers was evaluated (Table). Each device was tested 10 times under identical conditions. Before and after use the nebuliser was cleaned with industrial alcohol, dried, and filled to half its maximal capacity with distilled water. The device was then put into a thermostatically controlled bath

Table Output of nebulisers driven at the manufacturer's recommended flow rate. Each measurement was made 10 times

	Nebuliser type						
	Wright	Turret	Hudson 1720	Acorn	Inspiron	Hudson 1730	Cirrus
Flow rate (l/min)	8	6	6	6	6	6	6
Mean (SD) [coefficient of variation] output (mg/min)	166 (6) [3.6]	313 (22) [7.0]	267 (8.5) [3.1]	326 (26) [7.9]	395 (30) [7.6]	380 (20) [5.2]	311 (21) [6.7]
Range (mg/min)	155-175	275-340	255-285	275-360	345-440	345-420	280-350

at a temperature of 26°C for 15 minutes. Subsequently, it was removed from the bath, clamped in a stand, and driven with air coming from a compressed air cylinder at a pressure of 60 psi at the manufacturer's recommended flow rate to produce an aerosol with particles of less than 5 µm in size. Flow rates were measured at the input using a rotameter. Each nebuliser was then operated for two minutes. Its output was calculated by weighing the device before and after nebulisation with an electronic balance (Sauter SD-100T) to the nearest 10 mg, and the mean of three measurements was taken as the representative 'weight'. The output of the nebulisers was also studied at flow rates between 4 and 10 l/min because of a possible relation between the reproducibility of aerosol output and flow.

Results

Inspection of the coefficient of variation of output (Table) shows that two nebulisers, the Wright and

the Hudson 1720, were similar and much more reproducible than the other five. The same nebulisers also had a smaller increase in output at high flow rates (Figure).

Discussion

Different types of commercial nebulisers are being used currently for bronchial challenge tests. We have devised a simple and easily reproduced method for evaluating nebulisers. Nebuliser output has been shown to be an important determinant of the response to bronchial provocation,⁴ and a desirable nebuliser should have minimal variation in output. Output has been reported to vary not only between different types of nebulisers but also among different devices of the same type.⁵ Recent reports suggest that some nebulisers are unsuitable for bronchial provocation tests because of great variation in their output.⁶

The results of the present study confirm that even if a single nebuliser is used under standardised conditions its output may vary considerably over several operations. This is not important during the administration of therapeutic solutions, where a fairly large amount of fluid is usually administered, but is critical in bronchial provocation tests, where the total administered dose is small. In this study, of the seven types of nebulisers tested, only the Wright and the Hudson 1720 had a low variation in output with repeated use. The results shown in the Table indicate that the higher the output the greater the variation. In theory smaller variations in output could be achieved by operating a nebuliser at a lower flow rate. In practice this is not feasible because lower rates of flow would result in an increase in particle size, with different airway penetration and a different clinical response.

In conclusion, before selecting a nebuliser for bronchial provocation testing there should be an awareness of the intranebuliser variability of output. Nebulisers of 'high reproducibility' should be the choice of preference for these tests.

Figure Mean output from the seven nebulisers at varying flow rates.

We thank Professor R D G Milner for helpful discussion.

References

- 1 Lowhagen O, Lindholm NB. Short-term and long-term variation in bronchial response to histamine in asthmatic patients. *Eur J Respir Dis* 1983;64:466-72.
- 2 Chai H, Farr RS, Froelich LA, *et al.* Standardization of bronchial inhalation challenge procedures. *J Allergy Clin Immunol* 1975;56:323-7.
- 3 Cockcroft DW, Killian DN, Mellon JJ, Hargreave FE. Bronchial reactivity to inhaled histamine: a method and clinical survey. *Clin Allergy* 1977;7:235-43.
- 4 Gibson G. Inhalation challenge tests and bronchial hyperactivity. In: Gibson G. *Clinical tests of respiratory function*. London: McMillan Press, 1984;171-4.
- 5 Massey DG, Miyauchi D, Fournier-Massey G. Nebulizer function. *Bull Eur Physiopathol Respir* 1982;18:665-71.
- 6 Arossa W, Quagliotti F, Sala M, Spinaci S, De Candussio G. Different performance of two commercial nebulizers. *Respiration* 1984;46:128-32.

Correspondence to Dr J N Tsanakas, Department of Paediatrics, The Children's Hospital, Sheffield S10 2TH, England.

Received 1 December 1986

Stunting in African children

W A M CUTTING, R A ELTON, J L CAMPBELL, E J MINTON, AND J M SPRENG

Department of Child Life and Health, University of Edinburgh, and Medical Statistics Unit, Edinburgh

SUMMARY A total of 651 preschool children from rural central Africa were selected by random cluster sampling, weighed, and measured. Two per cent were wasted, but 47% were stunted. As linear growth recovers more slowly than weight repeated infections may give inadequate time for height catch up.

Severe malnutrition is obvious among children in the African Sahael, and the eco-political aetiological factors are familiar and tragic. We set out to establish the nutritional state of children in more stable rural communities of subequatorial Africa.

Patients and methods

Three medical students, during their elective periods, attempted to find out the nutritional state of children in rural communities in subequatorial

Africa by using small numbers but a statistically valid cluster sampling technique in rural Tanzania, Zaire, and Zambia.¹

With local help in each area, the population was divided into 30 groups roughly equal in numbers. In each area, starting at a randomly selected point, a cluster of between seven and 10 children were selected who lived nearest and were aged between 12 and 60 months. Their weights were measured with a CMS MP25 spring balance and their heights against a scale on a vertical board with a spirit level on their heads. Birth dates were recorded.²

Results

Wasting was defined as less than -2 standard deviations (SD) below an international reference population (National Center for Health Statistics) for weight for height and stunting as less than -2 SD height for age (the World Health Organisation-Waterlow classification of malnutrition).³ Of the 612

Table Standard height for age of preschool children (aged 12-69 months) in three rural African communities

Standard height for age	Rural African communities							
	Tanzania		Zambia		Zaire		Total	
	No	(%)	No	(%)	No	(%)	No	(%)
<-3	43	(19.5)	24	(11.1)	58	(28.3)	125	(20.4)
-3 to -2	61	(27.6)	59	(27.3)	58	(28.3)	178	(29.1)
-2 to -1	65	(29.4)	76	(35.2)	21	(24.9)	162	(26.5)
-1 to 0	38	(17.2)	42	(19.4)	18	(8.8)	98	(16.0)
0 to 1	11	(5.0)	10	(4.6)	16	(7.8)	37	(6.0)
1 to 2	1	(0.5)	4	(1.9)	4	(2.0)	9	(1.5)
>2	2	(0.9)	1	(0.5)	0		3	(0.5)
Total	221		216		205		612	