The importance of the effect of residual volume on quantity of aerosol can be illustrated in the following example:

**Nebulizer A**
- Fill volume 2 ml, Residual volume 1 ml
- Total output = 50%

**Nebulizer A**
- Fill volume 4 ml, Residual volume 1 ml
- Total output = 75%

It can be seen that only half of the initial volume is nebulized with a 2 ml fill volume and there is a significant (50%) increase in total output when we move from 2 to 4 ml.

If we now consider the same two cases with Nebulizer B, having a residual volume of 0.5 ml, it can be seen that the increase in the total output is less significant when we move from 2 to 4 ml. More importantly, however, is the fact that Nebulizer B with a 2 ml fill volume gives the same total output as Nebulizer A with a 4 ml fill volume.

**Nebulizer B**
- Fill volume 2 ml, Residual volume 1.5 ml
- Total output = 75%

**Nebulizer B**
- Fill volume 4 ml, Residual volume 0.5 ml
- Total output = 87.5%

In practice, if the residual volume of a nebulizer is inherently high, then it is common to add saline to the initial fill volume in an effort to increase total output.

**QUALITY OF AEROSOL**

The quality of the aerosol produced by a nebulizer is extremely important as this determines how much of the aerosol can penetrate the lungs and thus deposit drug to the targeted site. In practice, if the percentage of output in the respirable range is inherently low for a particular nebulizer, the only option left to increase the quantity of drug depositing in the lung is to increase the fill volume.

**TIME TAKEN TO COMPLETE TREATMENT**

Diluting the initial fill volume with saline substantially increases the treatment time (2). This increase in fill volume may have a detrimental effect on the prescribed treatment as longer treatment times result in poor compliance due to the patient becoming irritated, bored or uncomfortable.

It is often the case that the higher quantity and increased quality of aerosol mean longer treatment times. However, by designing nebulizers that work efficiently and have low residual volumes, it is possible to reduce nebulization time at no cost to quality or quantity of aerosol produced. One such nebulizer is the Sidestream®. In a recent research paper comparing 17 commercial jet nebulizers, the total output ‘TO of Sidestream was significantly greater than all the others’ (3), the percentage of output in the respirable range (1–5 μm) ‘PORR of Sidestream was significantly greater than all others’, and the treatment time for a 2.5-ml fill volume was 7-14 min.

The point is highlighted further in a paper which looked at how the output of four drugs varied with fill volume. The authors state that ‘overall the Side-stream offered the best performance for each drug, consistently releasing relatively large fractions of the initial mass of each of the drugs in aerosol form in relatively short times’ (4). Furthermore, in two of the four drugs used ‘the percentage of drug released by the Sidestream varied by only 15% over the range 2 to 6 ml ’ (4).

In conclusion, I would like to quote from a research paper produced by Queen’s Medical Centre, Nottingham in which the final two sentences state ‘In the meantime, the acceptability of this form of treatment (nebulization) would be improved by attempting to shorten rather than extend treatment times (5). The most effective way would be to use more concentrated solutions, use smaller fill volumes, and design nebulizers with smaller ‘dead volumes’ rather than rely on measures such as diluting solution and tapping the nebulizer chamber’ (6).

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References