

# Nebulizer Output

The basis of nebulizer output assumes that regardless of deposition nothing can be available to the patient unless it is aerosolized. All nebulizers have a volume of liquid that is either retained by the device (residual) or lost from the device by evaporation. What is not retained or evaporated is nebulized. The aerosol itself has two possible routes to travel: (1) that which is delivered and retained in the patient; (2) that which is lost to the atmosphere either directly or indirectly by exhalation from the patient.

Traditionally nebulizer output has been correlated to drug delivery as measured in ml/min. or by the speed at which a volume of liquid is completely aerosolized. Neither of these parameters can characterize actual drug delivery to the patient. Current methods determine the amount of residual by measuring the difference in weight of the device (plus its volume of fluid) after a period of nebulization. This is called the gravimetric method. There is no method to account for evaporation.

The residual volume of a nebulizer is a function of the liquid used, the humidity of the gas source and the environment, the driving pressure, the flowrate used, and the construction of the nebulizer itself (i.e. baffling etc.). The gravimetric method inefficiently measures output because it fails to account for evaporation and the effects of particle trapping in the device, which interferes with particle regeneration.

We have chosen to apply the gravimetric method in a different way. Instead of measuring the residual weight of a nebulizer, we have chosen to measure the weight of aerosol output trapped in an absorbent material. Essentially an HME (heat and moisture exchanger) is used to trap the entire aerosol output and the difference between the starting dry weight HME filter and the final wet weight is used to extrapolate nebulizer output. We feel that this method is more direct since we are actually quantifying aerosol output. There is still loss to evaporation in the system, but it remains intangible. This method can also be modified using simulated breathing patterns to extrapolate total drug delivery.

## Method Rationale

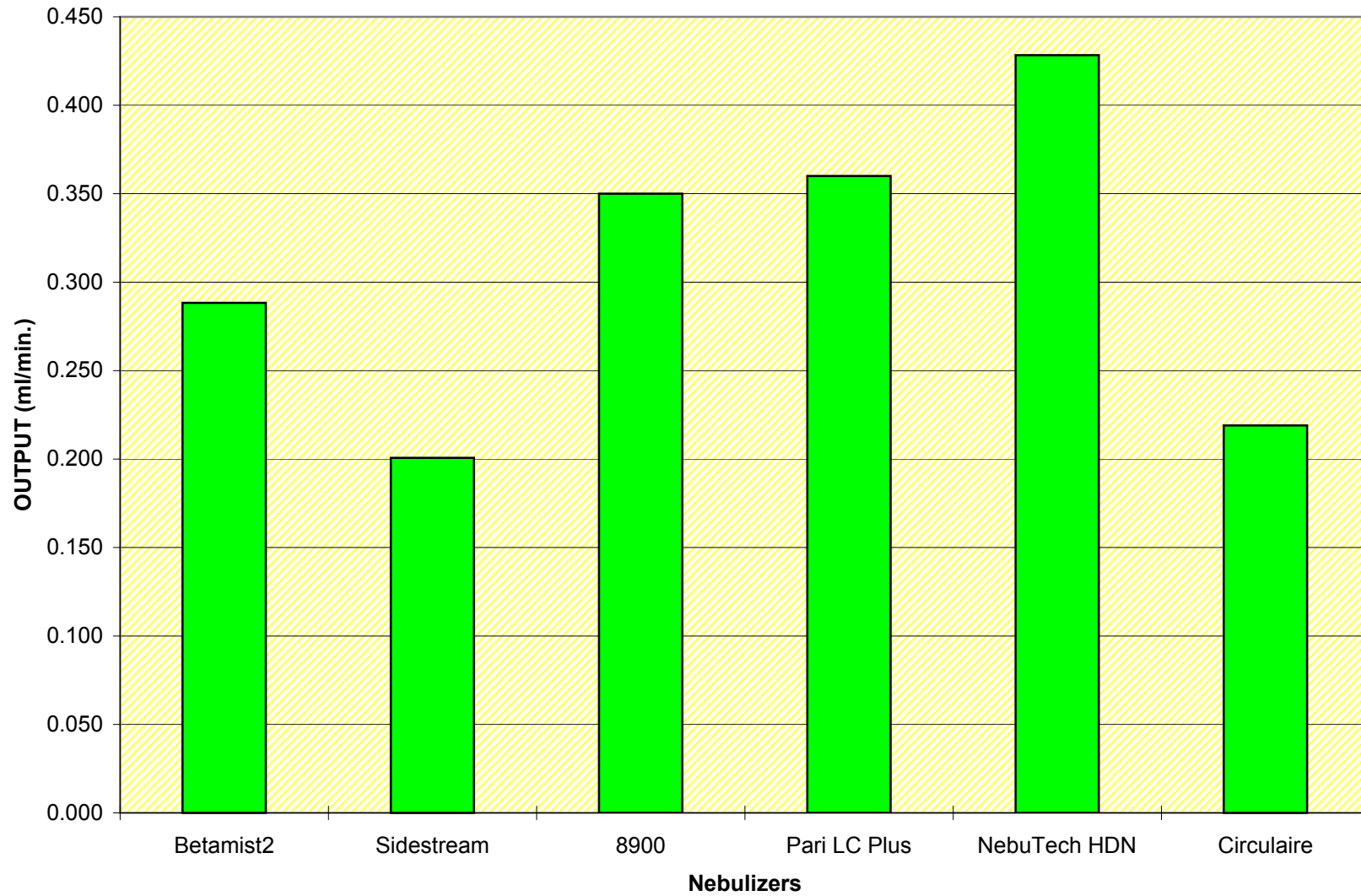
By shifting emphasis from residual volume measurement to quantifying aerosol output, we feel that we have taken the assessment of nebulizer output to the next level. The number of respirable particles generated and their availability to the patient are far more important to the efficacy of an aerosol treatment than what is left behind in the nebulizer. Our system is flawed in that it cannot differentiate what particles the patient will retain, but it does reasonably estimate the total amount of aerosol available to the patient. The laboratory evaluation of particle size and nebulizer output should have some correlation to clinical results; otherwise, we have lost sight of the real goal of aerosol medicine.

## Conclusion

The output of a nebulizer is simply the volume of aerosol that physically leaves the device over time as measured in milliliters per minute. It is important to remember that this does not represent what is available to the patient. Only the respirable particles, which are actually delivered to the site where pharmacologic action takes place, can be counted as being the effective output of a device. Nebulizers with high output claims (i.e. nebulize faster) which do not provide a high density of respirable particles will not have the same efficacy as the NebuTech<sup>®</sup> HDN<sup>®</sup>.

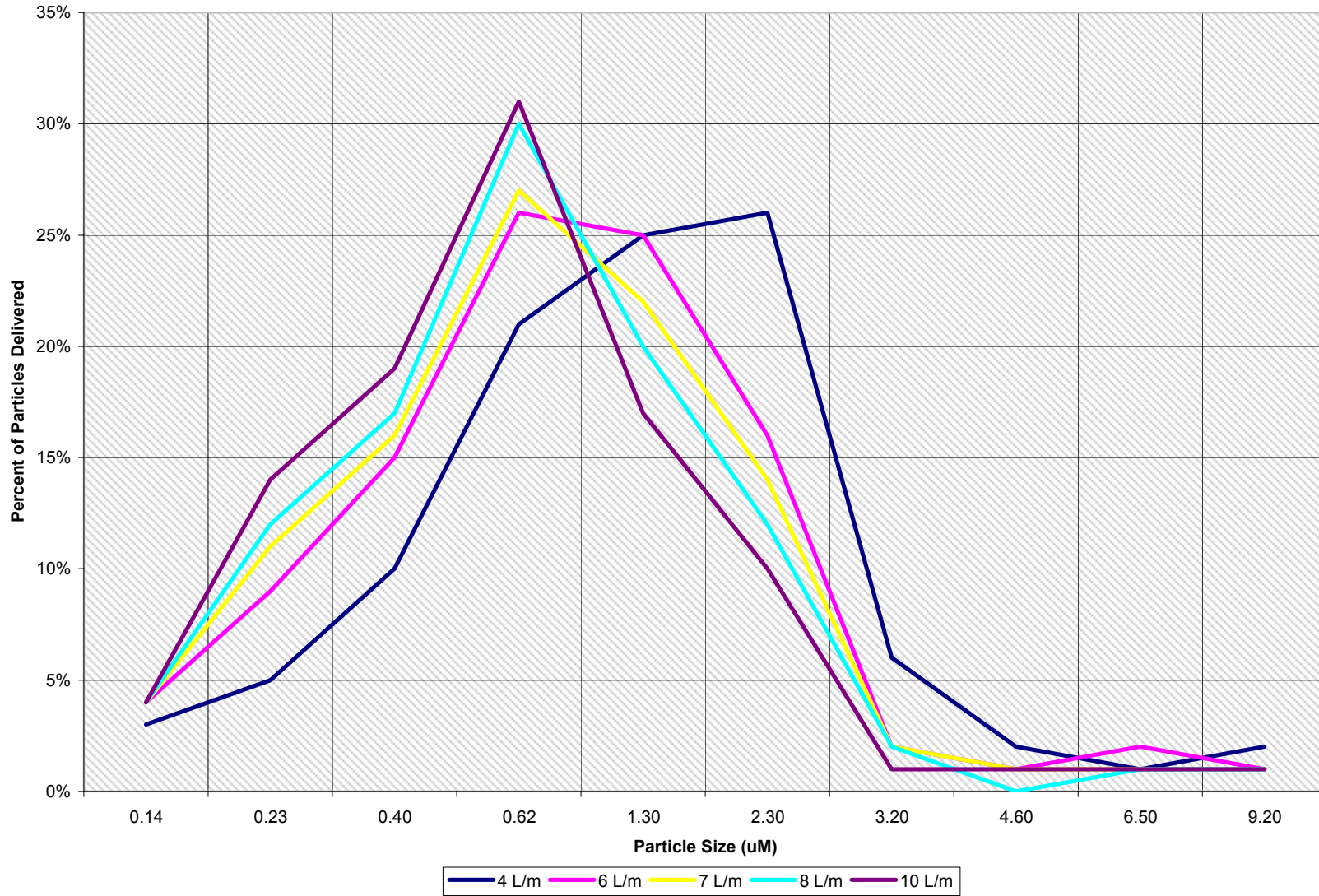
Such devices will quickly aerosolize their liquid volume but much of the drug will be lost to the device, atmosphere, or as rainout in the oropharynx. Since the exhalation portion of the respiratory cycle is at least twice the inspiratory time, high output devices that do not significantly increase the density of their aerosol plume, will lose some of their respirable aerosol to the atmosphere.

## Performance Comparison OUTPUT



Test Specifications: Comparison tests were performed at 50 psi source pressure at 7 lpm flow with 0.9% NaCl

### NebuTech HDN



Test Specifications: Tests were performed with 50 psi compressed air and with 0.9% NaCl. Particle Size Distribution measured by QCM Cascade Impactor.