Letters to the Editor

Quality Control in the Production of Radioaerosols

Because of recent technical advances, radiolabeled aerosols have enjoyed a renewed interest (*1*). Taplin and Poe (*2*) and Pircher et al. (*3*) in 1965 first introduced radioactive aerosols for the assessment of regional ventilation. However, due to technical difficulties the ventilation images were often difficult to assess. Aerosol technology has currently produced particles less than 1 micron in diameter, which are optimal for penetration beyond the small airways into the alveoli (*4,5*). This letter reviews some important technical aspects of aerosol production, which can produce images of uniformly high quality avoiding some of the technical difficulties of the past.

An aerosol may be defined as a suspension of fine solid or liquid particles in gas. For the imaging of alveoli, droplet diameter should be less than 1 micron. Droplets with diameters greater than 1 micron are too massive and impact upon the trachea and larger central airways causing central deposition (*4*). Smaller droplets are carried by airflow into the distal respiratory tree where they impact upon the alveolar endothelial cells. Once the droplets impact the alveolar wall, the radioactivity remains available for the assessment of regional ventilation.

Two important aspects of quality control in the production of high quality aerosol are the addition of a surfactant to the radioactive fluid in the nebulizer and an accurate measurement of the air flow rates used to generate the aerosol. A surfactant is defined as a surface-active agent that reduces the surface tension of fluids. We have demonstrated that droplet density is almost doubled with the addition of 10% ethanol by volume added to the fluid in the nebulizer. The droplet diameter remains unchanged with the addition of ethanol. Therefore, by adding ethanol, a greater density of droplets can enter the respiratory tree (*6*). This results in high quality ventilation images with good peripheral penetration of the aerosol.

Accurate air flow rates are an important factor in the production of high quality aerosols. Most manufacturers recommend air flow rates of greater than 9 l/min through the nebulizer for generation of aerosols. Air flow rates between 10 and 15 l/min do not greatly affect the particle size (*7*); however, flow rates less than the manufacturers' recommended limit may result in particles with diameters too large, resulting in central disposition (*8*).

We have identified and measured three potential sources of air flow measurement error. These are:

1. The intrinsic variability between different air flow meters.
2. Variation of air flow rates measured by a single meter from wall sources.
3. The effect of tilt on Thorpe air flow meters.

Since these errors are additive, significant artifact may degrade image quality when these potential problems are not monitored.

The intrinsic error of Thorpe air flow meters was measured in nine different meters with three measurements per meter. Thorpe meters use a "floating ball" within a tapered glass cylinder to measure air flow. An air flow calibration analyzer was used as the "gold standard" for air flow. At 10.0 l/min measured by the air flow calibration analyzer*, the average intrinsic error was 6.7% (range 9.1–12.9 l/min).

Air obtained from wall outlets is a very convenient and easily accessed source. However, because the use of wall air is uncontrolled and randomly accessed throughout the hospital, we have investigated potential variations of air flow rates. Using the air flow calibration analyzer, we sampled air flow rates from eight wall outlets over a 3-wk interval (128 measurements). Thorpe meters measured air flow rates from wall sources. The average percentage variation between observed and actual flow rates is 2.5%. With air flow rates of 10.0 l/min measured by Thorpe meters, the range of actual flow rates measured by an air flow calibration analyzer is 8.9–10.9 l/min. Although the average percentage variation is not great, the range is found to vary up to 11% of actual flow rates.

A third potential source of air flow measurement error is a Thorpe meter attached to a tilted compressed air tank. We have shown that inclined Thorpe meters may have a 20% variation between observed and actual rates when the compressed air tank is at the stable cradle angle (*9*).

Since errors are additive, the total potential error introduced when using a wall source (the percentage variability of the Thorpe meter plus the maximum fluctuation of the wall source) is 18%. The total potential error introduced when using a compressed air tank (the error from a tilted Thorpe meter plus the intrinsic variability of the meter) is 27%.

In summary, high quality aerosol can be easily produced by following a few simple quality control procedures. We recommend that nuclear medicine technologists use 10% ethanol added to technetium-99m-DTPA, in order to decrease the surface tension. This increases the delivery efficiency of the aerosol. Also because of the large variation of air flow rates from wall outlets, we strongly recommend using a dedicated compressed air tank with an air flow meter properly calibrated at the angle in which it will be used.

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NOTES

*Timeter Calibration Analyzer, Lancaster, PA.

REFERENCES

1. Ramanna L. Interest growing in new aerosol imaging methods. *Diagnostic Imaging* 1985;8:64–67, 118.

2. Taplin GV, Poe ND. A dual lung scanning technique for evaluation of pulmonary function. *Radiology* 1965;85:365–368.

3. Pircher FJ, Temple JR, Kirsch WJ, et al. Distribution of pulmonary ventilation determined by radioisotope scanning. *Am J Radiol* 1965;94:807–814.

4. Hayes M, Taplin GV. Lung imaging with radioaerosols for the assessment of airway disease. *Semin Nucl Med* 1980;10:243–251.

5. Heyder J. Mechanisms of aerosol particle deposition. *Chest* 1981;80: 820–823.

6. Brain JD, Valberg PA. Deposition of aerosol in the respiratory tract. *Am Rev Resp Dis* 1979;120:1325–1373.

7. Sirr SA, Juenemann PJ, Tom H, et al. Effect of ethanol on droplet size, efficiency of delivery and clearance characteristics of technetium-99m DTPA aerosol. *J Nucl Med* 1985;26:643–646.

8. Swift DL, Swift KL. Test of an aerosol inhalation apparatus to administer Tc-99m labeled DTPA employing a modified raindrop nebulizer. Report prepared for Cadema Medical Products, Inc. 1983.

9. Sirr SA, Miltz-Miller S, Notman DN. Airflow measurement inaccuracies in aerosol imaging. *Radiology* 1986;159:268–269.