Lung Ventilation Studies: Surface Contamination Associated with Technetium-99m DTPA Aerosol

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Aerosol ventilation studies are assumed to have negligible room contamination when used correctly. This study was undertaken to determine whether a measurable amount of surface contamination is associated with routine technetium-99m DTPA aerosol ventilation studies. Three potential sources of contamination were evaluated: aerosol leakage related to the patients, aerosol leakage at the exhaust of the delivery system, and aerosol leakage related to operator error. A predefined protocol was used for setting up the apparatus and performing wipe tests. A GM survey was performed, and in all cases, no levels above background were detected. The results of the wipe tests, however, showed that 57% of patient studies had contamination underneath the exhaust of the device; 35% of the studies had floor contamination; and 39% of the studies contaminated the area adjacent to the patient.

Lung ventilation studies may be performed with radioactive gas, such as xenon-133 (^{133}Xe), or with a radioaerosol, such as technetium-99m (^{99m}Tc) DTPA (*1,2*). Xenon-133 gas has the disadvantage of poorer intrinsic spatial resolution and is limited to a single projection.

Although radioaerosols are considered gases and regulated as airborne radioactivity, the regulatory considerations are more stringent for radioactive gases than for radioaerosols (*3*). (See Table 1.) The regulations stipulate that the radioaerosol must be administered within a closed, shielded system that either is vented to the outside atmosphere through air exhaust or provides for collection and disposal of the radioaerosol. Collection and disposal is provided by commercially available radioaerosol delivery systems. To receive Nuclear Regulatory Commission (NRC) approval, the commercial manufacturers submit calculations for anticipated airborne levels of ^{99m}Tc and surface contamination resulting from the use of their delivery systems.

This study was undertaken to determine the sources and amount of surface contamination that results from routine ^{99m}Tc-DTPA aerosol lung ventilation studies.

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MATERIALS AND METHODS

Forty-nine patients were randomly selected to participate in this study from October 1989 to May 1990. Forty-seven patients were referred for evaluation of pulmonary embolism or chest pain. Two additional patients had known diagnoses of lung mycosis and congestive heart failure. The ages ranged from 18–90 yr with a mean value of 55.9; 28 of the patients were females and 21 were males.

Two area hospitals participated in the study which included ten technologists. For postperfusion ventilation imaging, an activity range of 60–90 mCi in 3–4 ml of ^{99m}Tc-DTPA was used, as suggested by the manufacturer (Mallinckrodt, St. Louis, MO). For preperfusion ventilation imaging, an activity range of 20–30 mCi in 2 ml of ^{99m}Tc-DTPA was used. The oxygen flow rate was 10–12 l/min at both facilities. The average administered dose to the patient was 2–5 mCi of ^{99m}Tc-DTPA aerosol. All technologists were educated on proper protocol for setting up the apparatus, performing the wipe tests, and recording the data. The patient's condition was ranked by the technologist as critical, fair, or good, based on his or her ability to cooperate. The choice of mask or mouthpiece was left up to the discretion of the technologist. The patients were given the option of an upright or supine position. The condition of the patient, whether a mask or a mouthpiece was used, and whether the patient was upright or supine was recorded.

Only two patients were ranked as critical in this study. Taken as a group, 70% (12/17) of the critical and fair condition patients were positioned supine, while only 35% (8/32) of those ranked in good condition were supine ($p < 0.05$). The majority of patients used a mouthpiece (43/49). Of the six patients who used a mask during the study, 83% (5/6) were ranked in critical or fair condition.

Immediately following each procedure, wipe tests were performed on the following three areas: underneath the exhaust, the floor, the area adjacent to the patient (under the head for supine, on the patient's chest for upright). A 100-cm^2 template was used as a reference for performing the wipe tests (alcohol swabs). Immediately after imaging, the wipes were counted in a sodium iodide well counter and were

TABLE 1. Regulatory Considerations for Radioaerosols and Radioactive Gases

Regulatory Considerations	^{99m}Tc-DTPA Radioaerosol	^{133}Xe Radioactive Gas
NRC license amendment required	No	Yes
Special trapping system required	No	Yes
Room airflow measurements required	No	Yes
Determination of MPC* in restricted area required	No	Yes
Determination of MPC in unrestricted area required	No	Yes
Administration of dose in patient's room permissible	Yes	No
Special storage of used and unused doses required	No	Yes

* Maximum Permissible Concentration (μCi/ml).

converted to dpm/100 cm^2 based on counting efficiency. We considered 1000 dpm/100 cm^2 to be contaminated. This more stringent criterion was selected because contamination can be easily transferred from a restricted to an unrestricted area (*4*).

RESULTS

The results of our study are shown in Table 2. The range of contamination was 1000 to 494,774 dpm/100 cm^2. Fifty-seven percent (28/49) of patient studies had contamination underneath the exhaust; 35% (17/49) of the studies had floor contamination; and 39% (19/49) of the studies contaminated the area adjacent to the patient. When any one area was contaminated, there was a higher probability that one or more other area would be contaminated ($p < 0.001$).

The patient condition (critical, fair, or good) was not a good predictor of whether contamination would be present or not. Seventy percent (12/17) of patients who were ranked critical or fair had studies that resulted in contamination, while 50% (16/32) of patients who were ranked in good condition had studies that resulted in contamination. This was not a significant difference ($p = 0.70$).

Patient positioning (upright versus supine) was not significantly related to contamination in Area 1 (underneath exhaust) or Area 2 (floor). However, positioning was significant (borderline) for Area 3 (area adjacent to patient); the supine patients were more likely to have contamination. Fifty-five percent (11/20) of supine patients contaminated Area 3, while only 28% (8/29) of upright patients contaminated Area 3 ($p = 0.06$). The overall amount of contamination in Area 3 was significantly greater for supine patients (38,846 dpm/100 cm^2 ± 65,904) than for upright patients (3,736 dpm/100 cm^2 ± 22,077) ($p = .027$ by ANOVA).

The use of the mouthpiece or mask was not a significant determinant for contamination. Fifty-six percent (24/43) of mouthpiece studies were contaminated, while 67% (4/6) of mask studies were contaminated. In 20 studies where contamination was found, a GM survey was also performed (using either a stainless steel or thin-end window GM meter, calibrated annually with cesium-137), and in no case, was a reading above background detected.

TABLE 2. Contamination at Three Sites After Administration of ^{99m}Tc-DTPA Aerosol

Criteria	Area 1 Exhaust	Area 2 Floor	Area 3 Patient
Patient Position			
Supine	14/20 (70%)	9/20 (45%)	11/20 (55%)
Upright	14/29 (48%)	8/29 (28%)	8/29 (28%)
Method			
Mask	4/6 (57%)	2/6 (33%)	3/6 (50%)
Mouthpiece	24/43 (56%)	15/43 (35%)	16/43 (37%)
Patient Condition			
Critical	1/2 (50%)	1/2 (50%)	1/2 (50%)
Fair	11/15 (73%)	6/15 (40%)	7/15 (47%)
Good	16/32 (50%)	10/32 (31%)	11/32 (34%)
Total % Contamination	28/49 (57%)	17/49 (35%)	19/49 (39%)

DISCUSSION

In 57% of the patient studies, there was at least one area that was significantly contaminated. Three potential sources of contamination were evaluated: aerosol leakage related to the patient, aerosol leakage at the exhaust of the delivery system, and aerosol leakage related to operator error.

The fact that the patient condition, position, or method of delivery was not significantly related to the presence of contamination indicates that the patient was not the major source of contamination. This is further supported by the fact that the area near the exhaust of the device was contaminated more frequently (57%) than either the patient (39%) or the floor between the patient and the device (35%). In all cases where contamination was found, the area near the exhaust of the device was also contaminated.

Operator error due to improper assembly of the device by the technologist or failure to monitor the device and patient during the procedure did not appear to have a significant effect on the presence of contamination. Between the two hospitals participating, there was no interhospital variation in the amount or areas of contamination detected.

The results show that a primary source of contamination is the exhaust of the device. At the oxygen flow rates employed, it should not be assumed that the filter will be able to trap the exhausted aerosol adequately enough to prevent escape from the delivery system of airborne contaminates, which are in excess of NRC regulations for surface contamination.

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