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# Radioation Protect during the Ventilation Scintigraphy of Tc99m DTPA Radioaerosol in Pediatric Application

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## Abstract

Lung ventilation-perfusion scintigraphy is of great value for the management of patients with both primary lung disease and heart disease, by proving patho- physiological information of importance for the diagnosis, follow-up and functional evaluation of the patients. Krypton 81m radioactive gas is preferable for pediatric application due to its short half-life. However, the rubidium-krypton 81m generator is not popular in hospital of our country. Tc99m DTPA radioaerosol ventilation scintigraphy has its unique convenient for clinical application. But, The most disadvantage of clinical application of Tc99m DTPA radioaerosol is contamination of environment when the poor-cooperative patient can't breathe by mouth. For this reason, we design the certain procedure to reduce the radioaerosol contamination. Patients / Methods: during May to Aug., 1999, we collect 36 pediatric patients ( male to female ratio 2 : 1; age from 6 months to 20 years old ) with clinical history of lung or heart disease, including congenital heart disease, asthma and so on. Before the cases receive 10 to 15 mCi Tc99mDTPA radioaerosol ventilation scan, all of them were trained with breath training. And during the ventilation scintigraphy, the special mouth mask is designed to prevent the radioaerosol leakage into atmosphere. Then Geiger-Muller survery meter was arranged to detect the environmental contamination of radioaerosol in the mask, one and two meters away from the mask every 10 minutes during ventilation scintigraphy procedure and 1 hour after finishing image. Two nuclear medicine physicians evaluated imaging quality of ventilation scintigraphy. Results: Among thirty-six pediatric patients with prior breath training, thirty- two cases are successful to proceed the Tc99mDTPA ventilation scintigraphy. The other four cases that were under three-year- old fail to receive ventilation scintigraphy. There is limited detectable radioactivity in the mouth mask at early 10 minute by Geiger-Muller counter. No significant environmental radio-aerosol contamination is detectable. Conclusions: (1) Tc99mDTPA aerosol ventilation scintigraphy is available for pediatric patients with prior breath training. (2) Under protection of mouth mask, the leakage of Tc99mDTPA radioactive aerosol into atmosphere is reduced.

Key words: Tc99m DTPA radioaerosol ventilation scintigraphy, pediatric application

## Introduction

Although, the most common indication for lung ventilation-perfusion scintigraphy is detection of pulmonary embolism in adult patients. (1) However, lung ventilation-perfusion scintigraphy is of great value for the management of pediatric patients with both primary lung disease and congenital heart disease, by proving path-physiological information for the diagnosis, follow up and functional evaluation of the patients. Tc99m MAA (macroaggregated albumin) pulmonary perfusion scintigraphy provides a usefully noninvasive imaging diagnosis for evaluation of pulmonary vascularity in the bilateral lung fields. But, radionuclide ventilation scintigraphy is an assistant method for confirmation of diagnosis of perfusion scintigraphic findings. Traditionally, xenon-133, krypton-81m and Tc99m labeled radioaerosol are the major three agents, which provide the clinical application. However, infants and small children often cannot cooperate with the radioxenon closed circuit rebreathing procedure and have to be sedated. And high-absorbed radiation of radioxenon is not suiting for pediatric application. The Krypton-81m method is less complicated, but the agent is expensive, must be delivered each day in the form of a generator system, and is not easily available in all locations. (2) Tc99m labeled radioaerosol is the agent choice for pediatric pulmonary perfusion application in our country. In this article, we will discuss the available age groups of pediatric patients and the correlation between the patient's ability to cooperate and the environmental contamination of radioaerosol under special designed procedure.

## Patients and Methods

Patients: During May - Aug 1999, we collected 36 pediatric patients (male/female: 2 /1; age from 6 months to 20 years old, mean age: 9 years old) including clinical history of congenital heart disease (TOF, ASD and VSD) and lung disease (asthma, pneumonia). Four cases with age under 3 years old were poor cooperation. The thirty-two cases received breath training before scintigraphic imaging. Methods: Both of Tc99m DTPA radioaerosol ventilation and Tc99m MAA pulmonary perfusion scintigraphy were performed in the same day. First, certain amounts of radioactivity of Tc99m DTPA radioaerosol (370 to 555 MBq [10 to 15 mCi]) in a volume of 1 to 2 ml of saline was placed in the reservoir of the jet nebulizer (Aero/Vent, MEDI-NUCLEAR Inc. USA). The aerosol was generated by an above 5-liter/min flow of oxygen. Children with the nose occluded breath directly from the mouthpiece attached to the nebulizer. Mouth mask over children's faces was another radiation protective procedure. The average size of aerosol particles from jet nebulizer is about 200 nm in diameter. The static projection images were acquired by gamma camera ( Toshiba GCA 602A, LEGP) after equivalent radioaerosol inhalation. At the same time, several Geiger-Muller (G-M) survey meters (Bicron Surveryer 50MT) were placed at the different distant points in the room, such as one and two meters away from the mouth mask over patient's face. The contamination of radioaerosol in air was measured every 10 minutes during procedure. The final environmental activity levels one- hour later post scintigraphy was also measured by G-M survey meter. There were no other imaging acquisition was performed at the same time in the surrounding. The radioactivity over the nostril of technologists, with paper mask, was measured finally also. Tc99m MAA pulmonary perfusion was finished, continuously.

## Results

Because of filtration of nose, the particles of radioaerosol are inhaled through mouth. There are some technical difficulties for pediatric application, especially poor cooperation of patients. Therefore, previous breath training for children who will have a ventilation scintigraphic examination is necessary to reduce the contamination of radioaerosol in atmosphere and technologists who perform the procedure. In our patient group, four cases that are under 3 years old are more difficult to communicate. The ventilation scintigraphic examination is avoided finally, because of no definite necessity for clinical diagnosis. Thirty-two patients are all received both Tc99m DTPA radioaerosol ventilation and Tc99m MAA perfusion scintigraphy.

The measured activity levels by G-M survey meter at different distant points in atmosphere show as table 1.The inverse correlation between the contamination of radioaerosol and the distance away from patients is demonstrated in our data. Significantly decreased the environmental measurable radioactivity in the distance beyond one meter away. And there is no evidence of environmental radioaerosol contamination in the same measured points one hour later post acquisition of image. We have four poor cooperative children with age above three years old. In this group of patients, environmental activity levels increase significantly at distant points within one- meter area away from patient's mouth. The radioactivity in the room one- hour later post scintigraphy reached to background levels in most of case studies. There is no measurable contamination over the nostrils of technologists who perform the studies.

Table 1. The average measured radioactivity levels of environment by Geiger-Muller survey meter during Tc99m DTPA radioaerosol ventilation scintigraphy for thirty-two pediatric patients.

| | Original point around patient's mouth | Point around one meter away the original area | Point around two meter away the original area | Back ground area |
|---|---|---|---|---|
| 10 minutes during image acquisition | 1666.6 +/- 124.7 cpm | 75.0 +/- 4.1 cpm | 65.0 +/- 4.1 cpm | 20.0 +/- 0.0 cpm |
| 20 minutes during image acquisition | 3300.0 +/- 697.6 cpm | 78.3 +/- 16.7 cpm | 55.0 +/- 4.1 cpm | 20.0 +/- 0.0 cpm |
| 1 hour post finishing acquisition of image | 20.0 +/- 0.0 cpm | 20.0 +/- 0.0 cpm | 20.0 +/- 0.0 cpm | 20.0 +/- 0.0 cpm |

## Discussion

In model described in Publication 66 (ICRP, 1994a), the respiratory tract is represented by five regions, such as extrathoracic (anterior nasal, posterior nasal and oral passages), thoracic (bronchial and bronchiolar) and alveolar-interstitial airways. (3) Lymphatic tissue is associated with the extrathoracic and thoracic airways. The deposition efficiencies of radioaersol in each region are related to different characteristic parameters. For the extrathoracic regions, particle size, airflow and variable anatomical structures are the major factors to interfere the deposition efficiencies. The lung size and breathing rate are the factors effect the deposition of radioaerosol in the regions of thoracic and alveolar-interstitial airways. Competitive action between aerodynamic (gravitational settling, inertial impaction) and thermodynamic (diffusion) processes determinates the deposition efficiencies of radioaerosol. From respiratory tract model, we know that the radioaerosol particle size, nature of respiratory patho-physiology and patient's cooperation, especially in pediatric application, will determinate the image quality of Tc99m DTPA aerosol ventilation scan and contamination of radioaerosol in the room.

Actual absorbed radiation dose to lungs of Tc99m DTPA aerosol ventilation scan in different age group of children has been studies previously. (4,9) There is an inverse correlation between radiation dose and the age of child. The results reveal that 16 mrad absorbed radiation in newborn age group is two time of absorbed radiation dose than the group of child above 5 years old. (4) This is due to the reduction in lung size with age without a corresponding reduction in the amount of radioaerosol administered. In previous study, the younger, incorporated children received radioaerosol with anesthetic management in the same time. But this procedure is not performed in our study. In fact, the major absorbed radiation to lungs is from the Tc99m MAA perfusion lung scan when children received both of pulmonary perfusion and radioaerosol ventilation imagines. (4)

The Geiger-Mueller survey meter (G-M survey meter) is the choice of apparatus to detect the environmental contamination of Tc99m DTPA radioaerosol in our study. Although the sensitivity of G-M survey meter will reduce when the photon energy of detected radioisotope is above 100 Kev. (6,7 ) However, the G-M survey meter is still the most convenient and low-cost apparatus to provide reference data of contamination of radioaerosol in space of room. From data of the table 1, we demonstrate that activity levels of Tc99m DTPA radioaerosol during ventilation imaging acquisition is limit measurable at certain distant points away from patient's mouth, such as within one meter zone from patient’s mouth. The inverse correlation between the measured activity levels of Tc99m DTPA radioaerosol in the room and the distance away from patient's mouth is identified also. There is about ten to twenty time difference of measurable activity between the original patient's mouth point and point of two meter away in the room. The measurable activity of point of patient's mouth reaches peak level when radioaerosol is expired in air after saturation of inhalation. The measurable activity is equal to background levels in the three-meter away from patient's mouth. For aspect of radiation protection, we suggest the medical workers who must have paper mask cover for prevention of inhalation of floating particle of radioaerosol and keep certain distance away the patient after procedure has been set completely.

Previous studies reveal contamination of Tc99m DTPA radioaerosol to nuclear medicine personnel is limited when strict guidelines for radiation protection are followed. (5) The studies even can be performed outside the Nuclear Medicine Department. However, caution still is advised, especially in- patients who are unable to cooperate. There is an inverse correlation between the patient's ability to cooperate and the amount of activity in the air and in the nostrils of technologists performing the studies. (8) Among our patients, four cases with age under 3 years old are poor communication with our workers. The radioaerosol ventilation scan is avoidable as possible, if there is no definite necessity for clinical diagnosis. We also demonstrate the excellent cooperation of patients with fewer amounts of contamination of activity in the room.

In conclusion, pulmonary perfusion-ventilation scintigraphy are of great value for providing pathophysiologic information of certain entities of pediatric heart and lung diseases, such as congenital heart disease and lobar pneumonia, in clinical follow-up. Tc99m DTPA radioaerosol ventilation scintigraphy, which is the most convenient method, is available for children with previous breathe training in pediatric application. We demonstrate contamination of Tc99m DTPA radioaerosol to nuclear medicine personnel and environment is limited when strict guidelines for radiation protection are follow. Under consideration of cost and benefit, we suggest the radioaerosol ventilation scintigraphy is avoidable as possible in the pediatric patients with age less than three years old.

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