



NUCLEAR MEDICINE AND THE RESPIRATORY THERAPIST

Michael McPeck BS RRT FAARC

This issue's column is about nuclear medicine. Well, actually, it's about one small aspect of nuclear medicine, namely: lung scanning. So what does all this have to do with aerosols or respiratory therapy? Two things. First, an alternate term for lung scanning is radioaerosol deposition lung imaging. Even though RTs do not conduct this procedure, perhaps they should have a general knowledge about diagnostic lung scanning which is most commonly employed for the purpose of confirming a diagnosis of pulmonary embolism. Lung scanning is also occasionally used in critically-ill patients with severe lung injury and those with unusual pulmonary pathophysiology due to lung cancer and/or pulmonary resection. Which leads us to the second reason RTs may be involved with lung scanning: it is rarely done at the bedside. Critically-ill ICU ventilator patients requiring a lung scan must be transported to the Nuclear Medicine Department where the procedure can be carried out using specialized equipment and interfacing the patient's ventilator to one of about 5 different brands of radioaerosol delivery system. This is where the RT comes actively into the picture. Nuclear medicine technologists are justifiably reluctant to disrupt the ventilator circuit to interface the radioaerosol delivery system and many RTs often find themselves in the Nuclear Medicine Department with a critically-ill vent patient and little or no training about nuclear medicine or lung scanning.

Nuclear medicine, that branch of molecular imaging that uses isotopes or radionuclides to form images of body organs, depends upon radiation, which is essentially energy that travels through space. Sunshine is one of the most familiar forms of radiation although most people do not think of it as such. Sunshine consists of visible light, infrared, ultraviolet radiation and other cosmic rays and particles. Radio waves and microwaves are other types of radiation. More recognizable to health care practitioners is ionizing radiation such as X-rays and gamma rays. Ionizing radiation is that which emanates from the atomic nucleus and occurs in two forms, rays and particles at the high end of the energy spectrum. Ionizing radiation produces electrically-charged particles called ions in the materials it strikes. Ionization in tissues of living organisms may cause damage depending on the amount and duration of exposure. However, in small controlled amounts for diagnostic purposes, a limited absorbed dose of ionizing radiation is relatively safe although a comprehensive explanation of radiation safety is well beyond the scope of this article.

The operational principle behind nuclear medicine is to introduce an appropriate gamma-emitting radioisotope or radionuclide into the body where it can be preferentially taken up by the organ(s) of interest, depending on how it is administered and what it is bound to. The patient is situated in front of a gamma scintillation camera that detects and measures the gamma energy being emitted through the body and skin of the patient from the organ of interest. A computer connected to the gamma camera conducts counts of the radioactive emissions and constructs images of the organ(s) being scanned. The most common radionuclides used for lung scanning are technetium (^{99m}Tc) which is prepared as a liquid bound to Diethylenetriaminepentaacetate (DTPA, for short) and Xenon (^{133}Xe) which is a gas. Both of these radionuclides may be inhaled thereby giving rise to the need for specialized delivery systems, attention to the prevention of leakage into the camera room, and the ability to filter or trap exhaled aerosol or gas. Not only would leakage represent a potential health hazard to the practitioners in the area, but it would also raise the background radiation in the room so high as to render it unusable for a number of days. An unused gamma camera room generates no revenue. ^{99m}Tc has a half-life of about 6 hours while the half-life of ^{133}Xe is 5.2 days. Generally, items, such as aerosol administration devices, that have come into contact with radioactive Tc-DTPA solution have surface contamination and must be sequestered for about 10 half-lives (~60 hours) before the isotope is sufficiently decayed to be rendered safe to touch. Gaseous Xe does not create surface contamination as such but, since the half-life is considerably longer than technetium, exhaled radioactive Xenon gas must be trapped in charcoal filters encased in lead shields and held to decay.

For the lung, there are two types of lung scan: ventilation (V) and perfusion (Q), and when both types of scans are conducted together as part of a single examination, it is known as a V/Q scan. As the terminology would imply, the scan attempts to evaluate the matching of ventilation and perfusion, inasmuch as the absence of one or the other would indicate some sort of pathology. Usually the goal is to evaluate the patient for the presence of a pulmonary embolism, which would present on the lung scan as ventilation without corresponding perfusion. For the ventilation scan, a radionuclide (aerosol or gas) is inhaled into the lungs. The patient's chest is situated in front of

the gamma camera. Images constructed by the gamma camera's computer can show areas of the lungs that have received inhaled radioactivity and are therefore ventilated. Areas of the lung with diminished or absent ventilation will emit correspondingly less radiation. Similarly, for the perfusion scan, 99mTc bound to macroaggregated albumin (MAA) particles are administered intravenously and travel through the venous system, to the heart, then into the pulmonary artery and finally into the pulmonary vasculature where, in the absence of a clot or lodged embolus, they are carried to the smallest vessels in the periphery of the lung. In the event of an embolus, radioactivity is not deposited distal to the embolus and that part of the lung image is not created. The ventilation and perfusion scans are compared visually and mathematically by the computer to evaluate the overall image as well as specific regions of interest, if desired.

As previously mentioned, there are about 5 major brands of radioaerosol delivery system on the US market (Amici "Swirler," Biodex "Venti-Scan," CIS-US "Aerotech," Mallinckrodt "UltraVent," and Medi/Nuclear "InstaVent" and "AeroVent." Each of the systems appears vastly different from the others, but upon close inspection certain structural similarities will be noticed. First, they all have a rather common-looking small volume nebulizer of some sort. However, each of those nebulizers has been reengineered internally to produce the extremely small particles necessary for depositing the radioactive material deep into the lung. For example, the nebulizer used on both of the two Medi/Nuclear products has an MMAD of ~ 0.3 µm. Second, they generally direct inhaled particles through one pathway in the device so they can be inhaled while excess aerosol and exhaled particles from the patient are directed through a different pathway so they can be trapped in a HEPA filter to prevent room contamination. Despite these similarities, there is a substantial amount of performance variation among the different devices which is generally manifested by variation in the nebulizer loading dose in millicuries (mCi) of 99mTc=DTPA required, or the amount of breathing time that must be used to obtain images of sufficient quality for analysis.

RTs who find themselves taking vent patients to Nuclear Medicine frequently would be well served to make an appointment with one of the nuclear medicine technologists at a non-busy time and take the opportunity to see and examine that department's choice of radioaerosol delivery system. This is an excellent preemptive opportunity for some meaningful interdisciplinary departmental inservice. Perhaps a practice run with a ventilator, a test lung and some saline in the nebulizer could be conducted as a learning experience so the procedure would not be foreign the next time it was conducted on a real patient. This would be a good time to discover any particular adapter or connectors that might be needed to facilitate the setup. Obtain the package literature for the specific radioaerosol delivery device in use, and read it carefully. All of these devices have their own specialized lead shields that they are placed into during the procedure to minimize radiation exposure to



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the adjacent personnel. The shield must be placed close to the patient so it may be a good idea to obtain one and practice methods of arranging the shield, the patient and the ventilator to render an effective scan with a minimum of commotion. As a general rule of thumb, when interfacing these devices to the ventilator, the following scheme may apply: interface the ventilator, radioaerosol delivery system, shield and patient together and check for proper ventilation before introducing the radionuclide into the nebulizer. The patient port of the radioaerosol delivery system should be connected to the patient's ETT or trach tube, using as short a length of tubing as possible to minimize rebreathed volume. The 'Y' piece of the ventilator tubing may be connected to the outlet of the HEPA filter supplied with the radioaerosol delivery system. In this manner, any radioactive aerosol generated in the delivery system will be insufflated into the patient during the ventilator's inspiratory phase. During exhalation, exhaled patient gas will pass through the device and its HEPA filter, through the ventilator 'Y' and into the expiratory tubing on the ventilator. Any radioaerosol in the exhaled gas stream will be trapped in the HEPA filter on the radioaerosol delivery device. The ventilator will therefore not be contaminated by radioactive exhaled aerosol and there should be no need to replace the circuit after the procedure.

Mike McPeck, RRT FAARC is President of Healthline Medical, Inc. Baldwin Park, CA. He is also an Assistant Professor for the RC Program at SUNY in Stony Brook, NY. He can be reached at michael.mcpeck@aerosol-medicine.com.