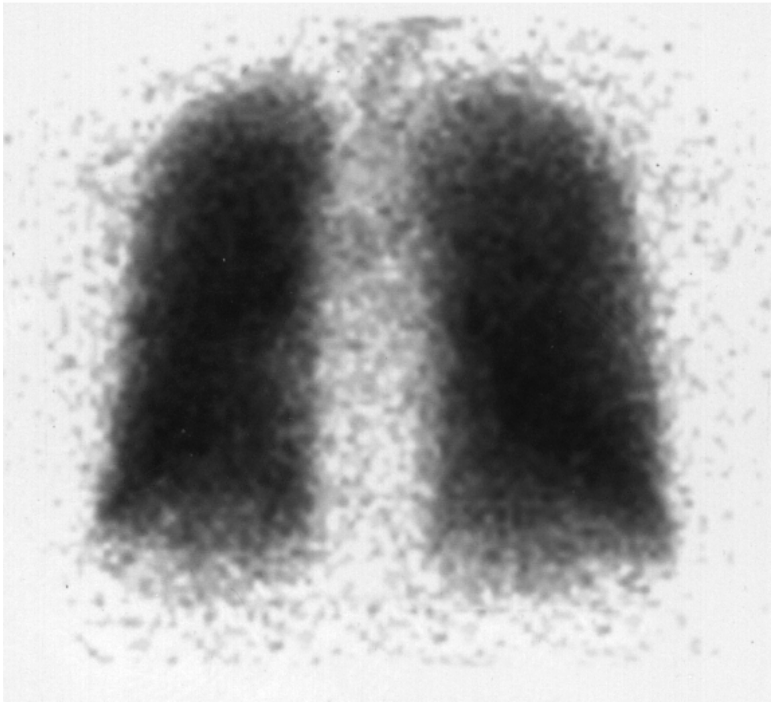
Helpful Hints
For
Radioaerosol Lung Imaging



Medi/Nuclear Corporation
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Foreword

The radioaerosol ventilation study is a very important part of the V/Q nuclear medicine study for the determination of pulmonary emboli in a patient's lungs. Such studies often are of an emergency nature and deserve optimal considerations to provide the referring physician with as accurate information as humanly possible.

The first technical consideration is particle size. In order to accurately image the entire lung, sufficient radioactive material must be deposited at the alveolar level throughout the lungs. Knowing that particles increase in size (hygroscopic growth) as they travel through the warm and humidified airways, it is important to start with very small particles. Although smaller particles will not grow too large, and will therefore be able to reach the alveoli, individually they will not carry as much radioactivity as larger particles. So it is imperative to use a radioaerosol delivery system that will provide a very large amount of small particles.

Secondly, if the aerosol stream contains an excess of medium to large particles, they will cause more radioactivity to deposit in the central airways ("clumping" or "hot spots") thereby making the visualization of the alveolar regions more difficult. The median size of the particles generated in Medi/Nuclear's nebulizer is less than 0.3 µM so clumping is virtually impossible.

The third consideration is patient comfort. The rate at which ^{99m}Tc - DTPA is deposited in the lungs is enhanced with the use of any Medi/Nuclear's high efficiency radioaerosol delivery systems; a needed deposition of 1.0 -1.5 mCi in the lungs for proper visualization usually is achieved in as little as 2 minutes. This allows for a shorter breathing period resulting in greater comfort and less anxiety for the patient. Patients are only required to perform normal resting tidal breathing while using our radioaerosol delivery systems. This deposition quantity is sufficient for 100-150,000 count images in one minute.

We are pleased to provide you, the Nuclear Medicine professionals, with the following pages to help you understand our radioaerosol imaging devices and how to use them in the most effective way.

MEDI/NUCLEAR® CORPORATION, INC.

A company specializing in the design, manufacture, and sales of radioaerosol delivery systems for pulmonary ventilation studies in nuclear medicine

Medi/Nuclear® is a privately held company located in Baldwin Park, CA, a suburb of Los Angeles. Medi/Nuclear® is recognized as a leader in the development and manufacture of radioaerosol delivery devices. It's Aero/Vent™ and Insta/Vent™ series are among the best selling radioaerosol delivery systems currently used in Nuclear Medicine.

Medi/Nuclear® was founded by Russell King and Ross Potter in 1973 and initially was a two person operation. In 1977, production began on Xe-133 gas and the Xeno/Cal™ Xenon Calibrator. This was followed in 1979 with introduction of the Xenon/Master™ Patient Delivery System. In 2004 Medi/Nuclear® ceased the manufacture and distribution of Xenon-133 gas. In 1987 the Aero/Vent™ + Plus Radioaerosol Delivery System was introduced. Over the years the Aero/Vent™ + Plus has been improved to deliver even smaller aerosol particles. All current models deliver fine particles, over 97% of which is less than 1 micron in size. This has been accomplished through the efforts of our own in-house research staff and the clinical assistance of several major medical centers. We are very please to introduce our Aero/Vent™ Jr delivery system. Priced competitively this new system is available in either a pole-mount or table top version and delivers a desirable patient dose in approximately two minutes of patient inhalation time. Additionally, our Insta/Vent™ Plus system, a two tube delivery system, is rapidly becoming the device of choice in many of the nation's most prestigious hospitals.

Medi/Nuclear® Corp. has grown and thrived over the years based on the development, manufacture and distribution of the highest quality radioaerosol products for use in nuclear medicine. Medi/Nuclear® will continue to grow as it provides new and innovative products for the healthcare industry.

Medi/Nuclear Family of Radiation Shielding Devices for Radioaerosol Delivery

I. Lead Shielding

1/16” on all surfaces
1/8” around nebulizer
1/8” on underside of cover

II. External Radiation: With 80 mCi ^{99m}Tc in 2 mL in Nebulizer*:

At breathing tube opening (surface):	3.00 mr/hr
At mouthpiece opening (@1 ft.):	0.05 mr/hr
All sides & top of shield (surface):	0.05 mr/hr
Background:	0.02 mr/hr

Note: Nebulizer was operated for 5 minutes prior to measurements to coat inner surfaces.
*Measurements made with Ludlum, Model 2, energy compensated side window G.M. survey meter.

III. Shield weight:

Insta/Vent™	Model IV-601	16 lbs
Aero/Vent™	Model AV-401	8.2 lbs
Aero/Vent™ MAX	Model AV-501	8.2 lbs
Aero/Vent ™Jr Pole	Model AV-101	8.2 lbs
Aero/Vent™ Table Top	Model AV-102	13.6 lbs

Note: Each of the above shields may be used with single-tube kits, two-tube kits or Ventilator kits.

Even though a HEPA Filter is 99.99% efficient, an extremely small amount of aerosol particles will pass through into the atmosphere. When using the Aero/Vent Jr shield, the release is contained within the Lead Shield. This internal shield contamination is so minimal that it is insignificant.

By Ross Potter, Technical Director, August 27, 2001, January 2006 and June 2006.

Lead Shields for Radioaerosol Delivery

Insta/Vent™ Lead Shield
IV-601

Aero/Vent™ MAX Lead Shield
AV-501

Aero/Vent™ Jr (Pole Mount) Lead Shield
AV-101

Aero/Vent™ Jr (Table Top) Lead Shield
AV-102

All shields may be used with single tube kits, two-tube kits, or Ventilator kits except for the Aero/Vent Jr which only uses a two-tube system and the Ventilator kit.

Mobile Cabinets

Insta/Vent™ Mobile Cabinet
(15 ¼" deep x 20 ¾" w x 39" h)
IV-603

Universal Mobile Cabinet
(14" d x 14 ¾" w x 33 ¼" h)
UV-203

These fully contained mobile cabinets can easily move about the department and hospital. The upper open area is for storage of new/unused radioaerosol kits and the lower lead-lined (1/8" lead) area with hinged door is for used units retained for radioactive decay.

Radioaerosol Kit Specifications

(All Models)

Nebulizer:	Medi/Nuclear NEB-3A+ Jet Nebulizer	
Nebulization Rate:	0.14 mL/min @ O_2 flow rate of 10 L/min	
Standard Flow Rate:	10 L/min	
Max. reservoir Vol.:	6 mL	
Working reservoir Vol.:	2 mL	
MMAD:	0.28 µM	
Particle size distribution:	< 0.2µM	40.8%
	0.2µ to 1.0µM	57.1%
	1.0µ to 5.0µM	2.1%
	> 5.0µM	0

Setting up your New Medi/Nuclear Lead Shield

Seating of radioaerosol unit into lead shield

1. Be sure the radioaerosol kit is properly inserted into the shield. This can be aided by guiding the filter with your finger through the exhaust opening and into the end of the exhaust filter.

2. If using a two-tube system, when attaching the second breathing tube/elbow to the HEPA filter under the lead shield, hold the body of the unit firmly in place.

3. Once the radioaerosol unit is in place be sure to press down firmly on the unit to ensure that the nebulizer fully seats.

Attaching and using the correct oxygen tubing

1. Medi/Nuclear has three oxygen inlet valves in use:

   A. If you have a multi-barbed oxygen inlet nozzle it is necessary that you use only the oxygen tube supplied with the Medi/Nuclear Lead Shield. This particular tube will assure a tight seal thus providing the proper pressure required to drive the nebulizer. (Other oxygen tubes may be slightly oversized thus presenting a possible avenue for oxygen leakage.) Please reorder the Medi/Nuclear Oxygen Supply Tubing (Catalog # IV-605).

   B. If you have a single barb oxygen inlet valve then you can use the oxygen tubing supplied with the lead shield or you may use the oxygen tubing supplied by the hospital.

   C. The Aero/Vent + Plus inlet nozzle requires a lead adapter attached to the oxygen tubing. Replacement tubing is available from Medi/Nuclear. (Aero/Vent 7' Oxygen tubing with Lead Adapter Model # AV-1010)

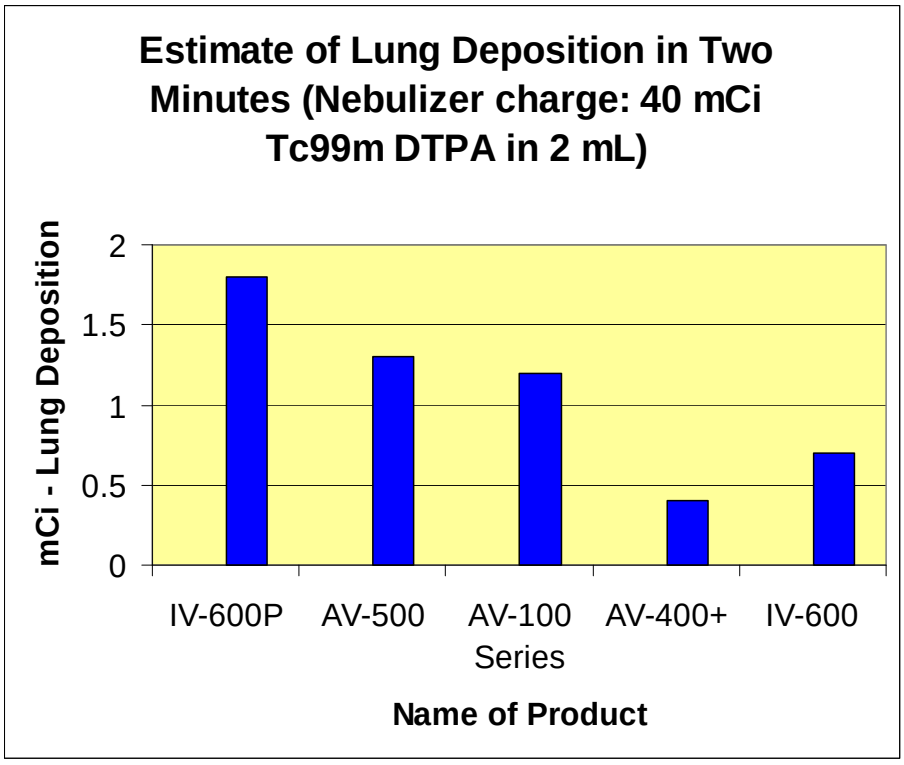
Important Points to Consider When Using The Medi/Nuclear Radioaerosol System

1. Press the nebulizer body firmly into the pressure port to ensure that there is sufficient air pressure to drive the unit.

2. 0_2 regulators (especially the floating ball type) are often not well calibrated. Start with a flow rate of 10 to 12 mL/min. If mist production seems low increase the apparent flow rate from 10 L/min to 13-14 L/min.

3. Speed of deposition is related to concentration of the solution thus 20 mCi/mL will deposit twice as fast as 10 mCi/mL. As a note of caution, ensure that you start with at least 2 mL of ^{99m} Tc DTPA in the nebulizer to be assured that the volume is sufficient for up to five minutes running time. **Therefore 40 mCi of ^{99m}Tc DTPA in 2 mL should be injected into the radioaerosol kit.**

4. To avoid "Hot Spots" and central deposition keep the inhalation velocity as low as possible by avoiding deep breathing (deep breathing works only if it is controlled and done very slowly). Tidal breathing will assure the best peripheral penetration and distribution.



Suggested Protocol for Pre-Perfusion and Post-Perfusion Studies for the Medi/Nuclear Radioaerosol Delivery System

Pre-Perfusion

1. Follow package insert instructions.
2. Use ^{99m}Tc - DTPA in a 15-20 mCi/mL concentration.
3. Inject a 2 mL volume into the nebulizer.
4. Have the patient inhale until approximately 1 mCi ^{99m}Tc - DTPA is deposited in the patient's lungs. (Depending on the model unit and using a 2 mL volume with a concentration of 20 mCi/mL the dosing time should be within 1.5 to 4 minutes). The approximate dosing time for each unit is: Insta/Vent™ Plus 1-1.5 minutes, Insta/Vent™ 2-3 minutes, Aero/Vent™ Plus 3-4 minutes, Aero/Vent™ MAX 1.5-2.5 minutes, and Aero/Vent™ Jr 1.5-2.5 minutes.

Post-Perfusion

1. Use a reduced perfusion dose of approximately 1 mCi ^{99m}Tc-MAA.
2. Ensure that the ^{99m} Tc-DTPA is in a 30-40 mCi/mL concentration.
3. Inject a volume of 2 mL into the nebulizer.
4. Inhale patient until count rate in the patient's lungs has increased to 2-3 times the residual from the perfusion study. (When using a concentration of 30 mCi/mL, approximately 3.5 minutes of patient breathing time should deposit approximately 3 mCi ^{99m}Tc – DTPA in the lungs.)

Note: Always check your NRC or agreement state license to see if special licensing is required for inhalation lung studies or for the increased dosage required for post-perfusion inhalation lung studies. As with the use of any radioactive material always observe proper radiation safety precautions.

Method of Determining Approximate Activity in Lungs During Aerosol Inhalation Procedure

Figure average time to accumulate usual count on posterior view of Perfusion Lung Scan, ie: 500k counts in 3 min (example).

$$\frac{500{,}000 \text{ counts}}{3 \text{ min.}} = 167{,}000 \text{ c/min}$$

Divide resulting c/min by mCi of MAA administered.

$$\frac{167{,}000 \text{ c/min}}{3 \text{ mCi}} = 55{,}500 \text{ c/min/mCi}$$

Therefore, inhale patient until reaching 55,000 c/min to place approximately 1 mCi in the patient's lungs.
(This would be 5,550 c/6sec. Or 925 c/sec.)

Note: The figures used are for example only. You must use your own time, count and activity.

Experiments in our laboratory using a Searle Pho/Gamma IV camera (small field) with a Div/Con Collimator resulted in approximately 113,000 c/min/mCi.

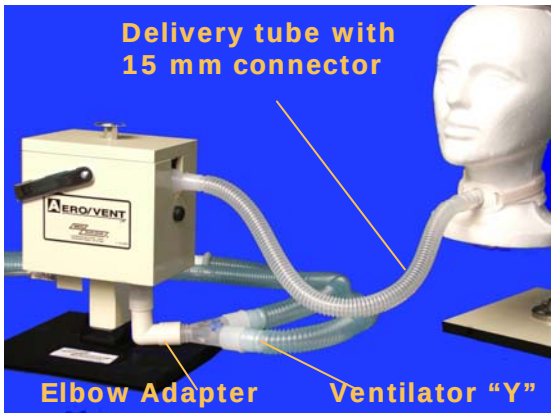
This is, at best, an approximation. It does not take into account size, depth or tissue attenuation. It does provide a quick and easy method to approximate lung activity deposition. However, since most Nuclear Medicine Departments lack the ability to calculate lung volume and attenuation, this method will provide, at least, an approximation of the delivered dose.

New!

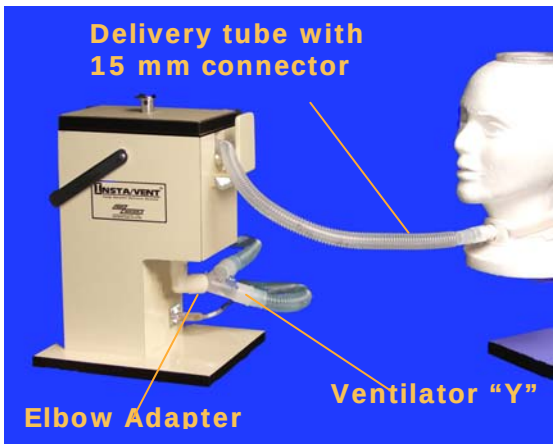
Ventilator Kits

For Medi/Nuclear Radioaerosol Delivery Systems:

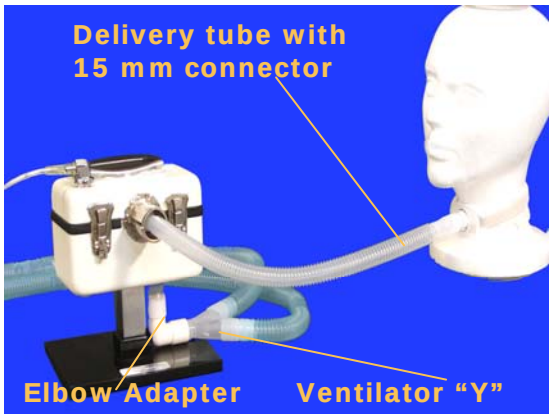
Aero/Vent™ "Jr" Ventilator Kit # AV-100 HV
Insta/Vent™ Ventilator Kit # IV-600 V
Aero/Vent™ Ventilator Kit # AV-400+V



Ventilator setup on Aero/Vent Jr system (tabletop and pole-mount)



Insta/Vent Plus Ventilator Set-up



Aero/Vent +Plus Ventilator Setup

Specially designed radioaerosol imaging kits for patients on ventilators; fits all standard 15 mm endotrachael and tracheostomy tubes.

Easy Setup

- Place delivery system in shield.
- Disconnect ventilator "Y" connector from patient and reconnect it to bottom of HEPA filter using supplied elbow adapter.
- Connect 15 mm tubing coming from lead shield to patient's tracheostomy tube.
- Adjust ventilator tidal volume for increased mechanical deadspace if required (consult respiratory therapist).
- Patient breathing time on system is nominally 3 to 5 minutes.

Mechanical Deadspace

For ventilator adjustments, if needed. The delivery system increases the mechanical deadspace (rebreathed) volume in the ventilator circuit. Aero/Vent Jr and Insta/Vent by 200 mL; Aero/Vent +Plus by 270 mL.

THE WAY'S AND WHEREFORE'S OF 'HOT SPOTS' ON THE RADIOAEROSOL INHALATION LUNG SCAN

Ross Potter, Technical Director, Medi/Nuclear Corp., Inc.

Historically, one of the overriding problems with performance and interpretation of the Radioaerosol Inhalation Lung Scan has been 'hot spots'. What are they? What causes them? What do we do about them?

It has long been thought that 'hot spots' were the result of clumping of particles, particles which were either too large or which were sticking together. I would suggest that neither answer is appropriate.

At Medi/Nuclear Corp. we have been manufacturing radioaerosol inhalation devices for use in Nuclear Medicine for over 20 years. In addition to manufacturing the units, we also have the ability to do our own in-house testing of the units for particle size and distribution as well as nebulizer generation rate. We, like everyone else, depend on some of the major medical centers to provide clinical results.

Because of the hands-on nature of our research and our involvement in the papers presenting the results, we have come to the conclusion that particle size, largely, determines the differential deposition in either the upper or lower respiratory tract. 'Hot spots', rather than being related to particle size, are almost entirely a function of velocity.

This velocity comes about either intrinsically or extrinsically. Intrinsically, it results from conditions within the patient's lungs. This might be mucous plugs, tumor invasion or a narrowing of the passages by any number of disease states. Extrinsically, the cause is uncontrolled deep breathing or tachypnea. In the first instance, as the aerosol passes a narrowing of the breathing passage, it accelerates. Immediately upon passing the narrowing, it decelerates. Upon decelerating, an eddy current is created which deposits the aerosol on the distal side of the narrowing. In the second instance, an uncontrolled deep breath is by its very nature a high velocity breath. In this case, the aerosol will be deposited anywhere a bend is too sharp for the particle's own inertia to allow it to turn. This is usually in the throat or at the carina.

If the trachea is visualized, it generally indicates the presence of excessively large particles, and if these particles are sufficiently large or represent a sufficiently large portion of the particle size distribution, peripheral penetration will be impaired.

Based on the above observations and hypotheses, we set out to redesign our nebulizer to both produce very small particles and to compact the particle size distribution. The results have been presented in papers from Cedars-Sinai Medical Center in Los Angeles. Through incorporation of this unique nebulizer in all of our radioaerosol delivery systems, we feel the optimum in quality of radioaerosol lung imaging has now been achieved. Nebulizer output consists of particles almost entirely (98%) below 1 µM in size.

Troubleshooting Guide When Using A Medi/Nuclear Radioaerosol Delivery System

Oxygen inlet tube blows off.

A. Backpressure in oxygen (or air) supply line is building too rapidly or is excessively high.

B. Turn oxygen (or air) supply to 10 liters/mm more gradually.

C. In rare instances the very small orifice in the nebulizer can become partially occluded thus creating higher than normal backpressure. Use another radioaerosol kit unit.

No counts or slow build-up of count rate in patient

A. Concentration of liquid may be too low. Using the same activity decrease the amount of the volume. Oxygen flow rate may be in error or nebulizer may be malfunctioning.

B. Check the regulator on the air supply tank or outlet. It may require calibration or may read incorrectly if at an angle.[1]

C. See Section "C" above.

D. Check 0_2 hose for leakage.

Post-Perfusion ventilation study unreadable

A. Limit MAA to 1 mCi. Inhale patient until count rate is 2.5 to 3 times that of perfusion study.

Clumping 'Hot Spots'

A. Some form of COPD and/or mucous plugs. See central airways deposition.[2]

Central airway deposition

A. COPD. Patient is on ventilator.

B. Turbulence caused by increased air velocity.

C. Tachypnea.

Very few 'normals'

A. Study is very sensitive to any lung abnormalities which alter airflow; does not need to be symptomatic. Frequently not noted by referring physician.[2]

Count rate falls rapidly

A. Patient is probably a smoker. DTPA clearance rate in smokers can be greatly accelerated.[3]

1. Quality Control in the Production of Radioaerosols. Shuster, et al. JNMT 15: 97. 1987.
2. Clinical Patterns of Radioaerosol Penetration. Collin, et el. JNM 27: P1037 (abs), 1986.
3. Regional Variations In Pulmonary Alveolar/Epithelial (A/V) Permeability in Smokers Studied with Tc^{99m}-DTPA Aerosol. Min et al. JNM 26: P59 (abs), 1985.

Absorbed Radiation Doses

Radiation does received by an adult (70kg) as the result of the administration of 37 MBq (1mCi) 99mTC DTPA via inhalation for ventilation study.

ASSUMPTIONS: 99mTc DTPA lung deposition totally absorbed.
37 MBq (1mCi) 99mTC DTPA retained in lungs.

TISSUE: DTPA absorbed during 3 minute by lung and cleared into circulating blood.[1]

CLEARANCE: Washout Time = 2.31 hours (Normal Subject – Erect)
Washout Time = 1.58 hours (Normal Subject – Supine)

	Erect					Supine			
	2.4 Hours*		4.8 Hours*			2.4 hours*		4.8 hours*	
	R/mCi	mGy/37MBq	R/mCi	mGy/37 MBq		R/mCi	mGy/37 MBq	R/mCi	mGy/37 MBq
Lungs	0.1200	1.20E-06	0.1200	1.20E-06		0.0800	8.00E-07	0.0800	8.00E-07
Bladder Wall	0.0830	8.30E-07	0.1600	1.60E-06		0.0930	9.30E-07	0.1800	1.80E-06
Kidneys	0.0093	9.30E-08	0.0094	9.40E-08		0.0095	9.50E-08	0.0096	9.60E-08
Red Marrow	0.0050	5.00E-08	0.0056	5.60E-08		0.0041	4.10E-08	0.0048	4.80E-08
Ovaries	0.0052	5.20E-08	0.0088	8.80E-08		0.0058	5.80E-08	0.0100	1.00E-07
Testes	0.0035	3.50E-08	0.0060	6.00E-08		0.0039	3.90E-08	0.0069	6.90E-08
Total Body	0.0063	6.30E-08	0.0071	7.10E-08		0.0051	5.10E-08	0.0061	6.10E-08
Thyroid	0.0036	3.60E-08	0.0036	3.60E-08		0.0029	2.90E-08	0.0029	2.90E-08
Trachea	0.3000	3.00E-06	0.3000	3.00E-06		0.3000	3.00E-06	0.3000	3.00E-06

*Bladder Voiding Interval
Note: Bladder wall dose assumes constant

[1]MIRD Dose Estimate Report No. 16- Atkins, et al
Journal of Nuclear Medicine, Vol. 33, No. 9, 1717-1719

New!

INSTA/VENT™ PLUS Radioaerosol Lung Imaging System

Time is power.

- ***Full patient dosing:*** 2 minutes
- ***Patient imaging:*** 1 minute per view
- ***Image quality:*** the industry's highest
- ***Cost:*** same low price as the original Insta/Vent™

Now, that's power.

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New!

INSTA/VENT™ PLUS

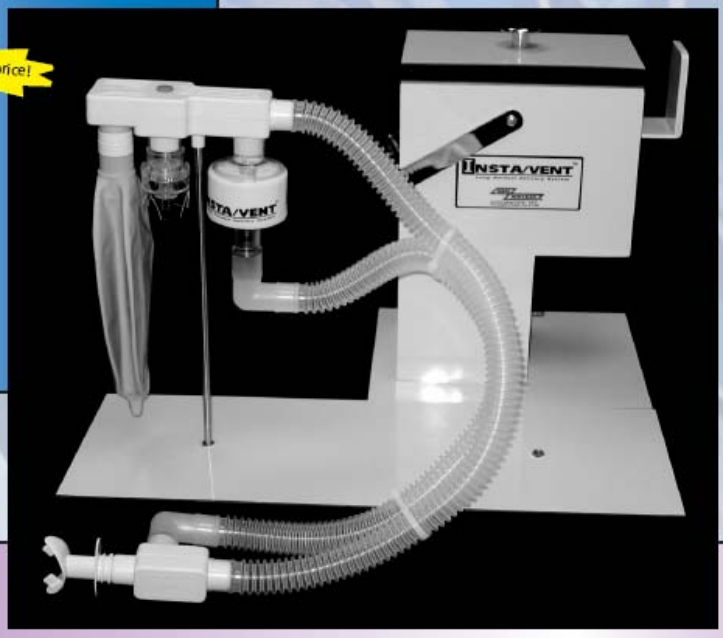
Radioaerosol Lung Imaging System

Products and Accessories

IV600P	Insta/Vent Plus Lung Aerosol Unit
IV600	Insta/Vent Lung Aerosol Unit
IV601	Insta/Vent Aerosol Delivery System Portable Shield
IV603	Insta/Vent Mobile Cabinet only
IV602	Insta/Vent Aerosol Delivery System Complete: Cabinet and Shield

Full line of accessories available. Call for information: 800-321-5981.

Same low price!



"When we compared the Insta/Vent to other systems, we found it to be the superior product. It's fast, and the image quality is very good." *Nora Gurevich, CNMT Chief Technologist, Stanford Hospital, Stanford University Medical Center*

Features

Safety. Exceeds the highest safety standards. Safety Shield™ mouthpiece minimizes potential radiation contamination.

Comfort. No-valve design for unrestricted breathing.

Convenient. Can be carried by hand. Optional mobile cabinet includes extendable shield platform, tabletop workspace, new kit storage, leaded decay storage.

Versatile. Suitable for any patient, infant through adult -- even ventilator-dependent.

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ISO 13488 certified Quality Management System

New!

AERO/VENT™ "Jr"

Radioaerosol Lung Imaging System

Model AV-100 Series

The power of two.

- ***Two*** **tube system**
  (increased speed with *no* loss of image quality)
- ***Two*** **convenient models**
  (pole-mount and table top)
- ***Two*** **times as fast***
  (1.5-2.5 minute full dosing)
- ***Two*** **filters available**
  (Bacteria and HEPA)

No charge loaner shield available.

* as the Aero/Vent™ *Plus*

AV-101 Pole Mount Shield

It's about quality. It's about time.

AV-102 Table Top Shield

Aero/Vent™ "Jr": Our most economical system!

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AERO/VENT™ "Jr"

Features

- Portability and Safety
- Reduced Breathing Time
- Low breathing resistance
- Low deadspace
- Excellent images
- Useful accessories
- Expert customer support

Optional UV-203
Universal Cart

MEDI NUCLEAR® CORPORATION, INC.

For over a decade and a haf, Medi/Nuclear has been dedicated to producing the highest quality radioaerosol lung scanning systems in the field. All of its fine Insta/Vent™ and Aero/Vent™ products offer unmatched image quality as a result of a particle size of 0.3 µm (MMAD). With the same attention to safety, patient comfort and technologist convenience, the Aero/Vent™ "Jr" now offers technologists a very economical 2-tube breathing system that can be used with children as well as adults to reduce deadspace, increase patient comfort and reduce breathing time.

Ordering Information

Product Description	Cat. No.	Packaging
Aerosol Breathing Circuits:		
Aero/Vent™ "Jr" with Bacteria Filter & Rigid Mouthpiece	AV-100B	20/case
Aero/Vent™ "Jr" with Bacteria Filter & Mask	AV-100BM	20/case
Aero/Vent™ "Jr" with HEPA Filter & Rigid Mouthpiece	AV-100H	20/case
Aero/Vent™ "Jr" with HEPA Filter & Mask	AV-100HM	20/case
Shields and Accessories:		
Pole Mount Shield	AV-101	each
Table Top Shield	AV-102	each
Universal Cart	UV-203	each

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New!

AERO/VENT™ MAX

Radioaerosol Lung Imaging System

Model AV-500 Series

It's about time.

- **Two tube system**
  Increased speed with *no* loss of image quality
- **No-charge loaner shield available**
- **HEPA filter standard.**
- **Mask configuration option**
- **1.5-2.5 minute full dosing**

It's about quality.

Model AV-501 Shield

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MEDI NUCLEAR® CORPORATION, INC.

AERO/VENT™ MAX

Features

- Portability and Safety
- Reduced Breathing Time
- Low breathing resistance
- Low deadspace
- Excellent images
- Useful accessories
- Expert customer support

Optional UV-203
Universal Cart
Shown with Aero/Vent Jr

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Ordering Information

Product Description	Cat. No.	Packaging
Aerosol Breathing Circuits:		
Aero/Vent™ "Max" with HEPA Filter & Safety Shield Mouthpiece	AV-500 B	20/case
Aero/Vent™ "Max" with HEPA Filter & Mask	AV-500 M	20/case
Shields and Accessories:		
Table Top Shield	AV-501	each
Universal Cart	UV-203	each

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ISO 13488 certified Quality Management System

MEDI NUCLEAR® CORPORATION, INC.

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