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# Technegas at Last! Implementing Technegas into Clinical Practice in the United States: Considerations, Challenges, and Recommendations

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Technegas, $^{99m}$Tc-labeled aerosolized carbon nanoparticles, has been used internationally since 1986 for pulmonary ventilation imaging. Unlike traditional gases, Technegas exhibits only a gaslike behavior, allowing deep and uniform deposition in the lungs' subsegmental regions. This hydrophobic property minimizes central airway clumping, as is particularly advantageous for patients with chronic obstructive pulmonary disease. Approved by the U.S. Food and Drug Administration in September 2023, Technegas is now available in the United States for diagnosing pulmonary embolism and broader ventilation and airway evaluations. The Technegas Plus system, which produces the radioaerosol onsite by heating [$^{99m}$Tc]sodium pertechnetate in a carbon crucible at ultrahigh temperatures, requires a specific infrastructure, including a 220-volt power supply and an argon gas source. Its rapid administration—often requiring only 1–3 breaths—streamlines workflows while ensuring patient comfort, especially for those with respiratory limitations. Additionally, Technegas supports SPECT and SPECT/CT imaging, enabling sensitivity and specificity superior to those of traditional planar methods. Despite the global adoption of ventilation–perfusion SPECT as the standard for pulmonary embolism diagnosis, its use in the United States remains limited. Now that Technegas is available in the United States, U.S. nuclear medicine departments can transition to advanced ventilation imaging, aligning with international best practices. This paper outlines essential considerations for Technegas implementation: infrastructure requirements, staff training, protocol development, and imaging optimization, including clinical experiences and perspectives from the staff at Barnes Jewish Hospital in St. Louis, Missouri. By integrating Technegas, departments can enhance diagnostic accuracy, improve workflow efficiency, and expand clinical applications, particularly for patients with complex pulmonary conditions.

**Key Words:** Technegas; ventilation; lung imaging; V/Q SPECT; V/Q SPECT/CT

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Technegas (Cyclomedica) was developed in Australia in 1984 and became commercially available in 1986 as a diagnostic tool for ventilation imaging (*1*). Despite its name, Technegas is not a true gas but rather a radioaerosolized particle consisting of ultrafine, $^{99m}$Tc-labeled carbon nanoparticles (*1*). In fact, when Technegas was first created, it was referred to as pseudogas because of its gaslike behavior and distribution in the lungs, allowing for deep distribution where the particles are deposited in the subsegmental regions and retained by surfactant in the alveolar walls (*1*). This radioaerosol is produced by heating [$^{99m}$Tc]sodium pertechnetate within a carbon crucible to approximately 5,000°F for a few seconds within the Technegas Plus (TP) system (*2*).

A major advantage of Technegas is its hydrophobic property, which reduces particle clumping—a common issue with other ventilation agents, particularly in patients with chronic obstructive pulmonary disease (*1*). Although Technegas has been used internationally for nearly 4 decades, it did not receive U.S. Food and Drug Administration approval until September 2023 for diagnosing pulmonary embolism (PE) when combined with perfusion imaging, as well as for the evaluation of ventilation imaging (*2*).

In recent years, nuclear medicine technologists (NMTs) have adapted to a growing range of novel radiopharmaceuticals used in imaging and therapy. Technegas differs from other radiopharmaceuticals in that it requires in-house preparation inside the TP system before administration. Previously published Technegas articles have comprehensively addressed the fundamentals of production and administration; however, this article will examine key considerations for integration into clinical nuclear medicine department

workflows from real-world experiences using Technegas in clinical practice in the United States.

## BACKGROUND

Pulmonary ventilation–perfusion (V/Q) scintigraphy is one of the oldest procedures in nuclear medicine. Planar V/Q imaging was the standard of care for evaluating patients with suspected PE until the 1990s, when CT pulmonary angiography (CTPA) gained prominence (*3*). CTPA's 3-dimensional imaging capability provided enhanced sensitivity and specificity for PE detection, leading to its widespread adoption (*3*).

In the United States today, CTPA is the primary imaging choice for suspected PE because of its increased diagnostic accuracy compared with planar V/Q imaging, greater availability (including 24-h CT staffing), and relative ease of use (avoiding delayed diagnosis because of lack of radiotracer availability) (*3*). Therefore, V/Q scintigraphy in the United States has been reserved mainly for specific patients, particularly those with contraindications to CTPA, such as allergies to iodinated contrast medium, difficult intravenous access, or severe renal impairment, as well as in patients thought to have a low likelihood of PE (*3*).

Globally, V/Q scintigraphy is more frequently used for PE diagnosis, partly because of the adoption of SPECT for V/Q imaging, with SPECT showing greater sensitivity and specificity than CTPA, especially in detecting subsegmental PE (*3*). In the United States, however, the adoption of SPECT or SPECT/CT for lung imaging remains limited, with only 32.1% of nuclear medicine facilities reporting its use (*4*). This rate contrasts with higher adoption rates in countries such as Australia (93.3%), Canada (91.8%), France (99.2%), and Germany (96.2%), according to a recent observational study in *Clinical Nuclear Medicine*. The study, conducted before Technegas became available in the United States, suggested that limited access to Technegas may have contributed to lower use of SPECT for lung imaging (*4*).

Internationally, both the European Association of Nuclear Medicine and the Canadian Association of Nuclear Medicine recognize V/Q SPECT or V/Q SPECT/CT as the standard of care for diagnosing acute PE, as well as recognizing Technegas as the preferred ventilation imaging agent (*5,6*). Although the Society of Nuclear Medicine and Molecular Imaging lung scintigraphy guidelines have not been updated since 2012, they noted even then the potential advantages of SPECT for lung imaging, along with the even distribution characteristics of Technegas, despite its unavailability in the United States at the time of publication (*7*).

## IMPORTANT CONSIDERATIONS FOR TECHNEGAS IMPLEMENTATION

### Production Requirements

Technegas is generated within the TP system, and once prepared, NMTs have a 10-min window to administer it before the system shuts down, requiring a new crucible and activity to be added. The system is designed with this safeguard because over time the particles will start to attract one another, making them larger and less desirable for adequate ventilation imaging. Although the TP system is on wheels and can be rolled to any room to administer Technegas, ideally it should be housed in a designated area within the department and equipped with the 220-volt, 20-amp electrical outlet that is required to reach the high temperatures necessary for production. Departments without an existing 220-volt outlet should consult with biomedical engineering to facilitate installation. The TP unit footprint is not much different from that of xenon delivery systems.

### Argon Gas Supply

Argon gas is an inert, nonflammable gas required for producing the Technegas aerosolized particles. Although argon is less commonly used in nuclear medicine than in other departments such as interventional radiology, it is typically available through the hospital's contracted gas supplier. High purity (>99.997% pure) is required. Departments should confirm with the air gas supplier or respiratory departments whether an argon supply contract is in place. The designated area for the TP system should be large enough to accommodate both the TP unit and the argon gas cylinder. A large T-cylinder should last for approximately 90–100 patient studies before a replacement tank is required.

It is important for departments to have a protocol in place for argon tank exchanges because, for different suppliers, inert-gas tanks can vary in color and type of gas. The nuclear medicine division at Barnes Jewish Hospital was mistakenly delivered a helium tank instead of an argon tank. Both gases come in brown inert-gas tanks from the gas vendor, and when the delivery person attached the tank to the holder on the wall, the label was not visible. The helium did not damage the TP system or reach the patient, but this error revealed the importance of having the NMTs and delivery personnel verify the tank workflow before use. Training of NMTs on how to hook up and operate the large T-cylinder tank is essential.

### Ethanol Use

A small amount of nondenatured ethanol (>95%) is used to coat the carbon crucible before adding [$^{99m}$Tc]pertechnetate, ensuring optimal Technegas production. Given the minimal volume required, a pint-sized vial of ethanol should be sufficient for extended use. It is advisable to source ethanol from the in-house pharmacy if available, but it can also be purchased from an external pharmacy if necessary.

### Installation and Training

The TP system is supplied by Cyclomedica USA and delivered in a large wooden crate, typically a few days before installation. The Cyclomedica service engineers handle the onsite installation, including argon gas setup and system testing, which typically takes a few hours. After installation, a clinical applications specialist conducts onsite training sessions for the NMTs in small groups of 2–3 individuals. The clinical applications training covers an overview of system use, hands-on instruction, and troubleshooting. Training typically lasts 2–3 h

in a hands-on learning environment, but the application specialist remains onsite for observation of the initial Technegas V/Q studies to support staff NMTs with clinical cases.

## IMPORTANT CONSIDERATIONS FOR TECHNEGAS VENTILATION IMAGING

### Considerations for Prescribed Activity

The U.S. Food and Drug Administration label indicates an activity range of 400–1,000 MBq (10.8–27.0 mCi) of [$^{99m}$Tc]$NaTcO_4$ to be used inside the TP system. The most important consideration for the activity is ensuring that the volume is under 0.13 mL because of the small size of the carbon crucible. To achieve this low volume, a high concentration of sodium pertechnetate is required, and that must be communicated to the commercial pharmacy for Technegas unit doses. Additionally, it is critical for the pharmacy to provide the activity for Technegas production in a 1-mL syringe without a removable needle (the same as aliquots for lymphoscintigraphy studies). Our team found that an insulin syringe works best. This is critical in preventing residual activity from remaining in the syringe or needle after activity is added to the system. Pre- and post-syringe assays are strongly recommended to determine the net activity added to the carbon crucible.

### Considerations for Patient Dose

Regardless of the activity of [$^{99m}$Tc]$NaTcO_4$ added to the carbon crucible, patients receive a fraction of that activity as their actual dose, as for other radioaerosols. Imaging with Technegas is recommended at 1,500–2,500 counts/s (CPS) on the posterior image on the P-Scope. Technegas is specific to patient condition and breathing, but typically only 1–3 breaths are required to reach a minimum of 1,500 CPS. The effective dose resulting from an estimated inhaled activity of 40 MBq (1.08 mCi) in adults is 0.6 mSv (*2*). When using dual-technetium tracers for V/Q imaging, a recommendation of a 3–4 times higher activity on the perfusion imaging is essential for diagnostic-quality perfusion imaging (*7*). If the current prescribed [$^{99m}$Tc]macroaggregated albumin is less than 111 MBq (3.0 mCi), one should consider discussing dosing modifications to perfusion imaging to ensure diagnostic quality. The protocol at Barnes Jewish Hospital requires a 185–222 MBq (5–6 mCi) [$^{99m}$Tc]macroaggregated albumin dose, administering both tracers with the patient supine.

### Considerations for Administration

Administering Technegas in the imaging room with the patient at the distal end of the table gantry is preferred. This makes it easy to slide the patient under the detector to evaluate whether an appropriate CPS has been achieved. After 1–2 breaths of Technegas, the patient is placed directly under the camera detector, arms above head, to determine whether sufficient activity is present for ventilation imaging. If the CPS on the detector imaging the posterior lungs are at least 1,500, SPECT or SPECT/CT imaging can begin. However, if the patient's posterior lung CPS are under 1,500, the patient should be pulled back out to the far end of the gantry table and administered another breath of Technegas before the process is repeated to evaluate for appropriate activity (CPS) in the lungs.

### Considerations for Location of Technegas Administration

Although Technegas administration is rather quick, it has come to our attention that some camera systems have a fan in the detector head that can pull airborne Technegas into the detector head from a patient who is not able to maintain a tight seal around the mouthpiece and result in detector head contamination. Therefore, practicing the delivery of Technegas and assessing patient compliance with maintaining a tight seal around the mouthpiece are crucial. As mentioned previously, administration at the distal end of the camera gantry (patient supine, head out) can be used to maximize the distance between patient and detector; however, if noncompliance is suspected after practice breathing, a full mask (as used for xenon or anesthesia) can be incorporated into the administration tubing to prevent leakage and assist in maintaining a seal.

### Technegas Camera Acquisition and Reconstruction Parameters

An advantage of Technegas ventilation is the ability to perform planar, SPECT, or SPECT/CT imaging. In sites already performing SPECT perfusion imaging, this may prove to be a smooth transition to add on another SPECT or SPECT/CT for the ventilation portion. In sites that are still performing V/Q planar imaging, it is recommended that the specific camera vendor be contacted to optimize the imaging and reconstruction protocols for the camera system.

### Additional Important Imaging Considerations

Transitioning from V/Q planar to SPECT imaging may take some acclimatization by both the NMTs learning a new workflow and the interpreting physicians if they are not familiar with SPECT or SPECT/CT lung imaging.

*NMTs.* Time should be allowed for NMTs to adjust to new workflows, including optimizing their time during the Technegas preparation, which takes about 6 min. This allows the NMT to provide a thorough explanation of the ventilation procedure, to have the patient practice breathing, and to assess patient compliance in maintaining a tight seal during those practice breaths.

*Interpreting Physicians.* The lung scintigraphy publications of both the European Association of Nuclear Medicine and the Canadian Association of Nuclear Medicine offer guidance on interpretation criteria for acute PE and other nonembolic conditions (*5,6*).

*Ordering Physicians.* Ordering physician groups should be made aware of the change to Technegas because many like to review the images and may be familiar only with planar xenon or [$^{99m}$Tc]Tc-diethylenetriaminepentaacetic acid V/Q studies. Having a meeting between the nuclear medicine physicians and referring physicians may be helpful in reviewing different images.

## BILLING, CODING, AND REIMBURSEMENT

The purpose of Centers for Medicare and Medicaid Services pass-through is to allow a temporary transitional period of payment during which the Centers for Medicare and Medicaid Services separately reimburses hospitals for a specific drug for a specified time. This process improves patient access to new or expensive drugs and allows the Centers for Medicare and Medicaid Services and other private insurance companies the opportunity to gather information and clinical utility and negotiate reimbursement costs after pass-through expires.

As of July 1, 2024, the Centers for Medicare and Medicaid Services has approved pass-through status for the Technegas kit, reimbursed at $328.60 per unit for 3 y. The consumables kit is billed under drug code A9506 as a single unit per patient.

## SAFETY AND REGULATIONS

Since Technegas is not a true gas, no special ventilation or negative pressure rooms are required for administration. The Nuclear Regulatory Commission reviewed Technegas and the TP system shortly after its approval and determined that radiation safety concerns associated with Technegas aerosol are like those for other unsealed byproduct materials used for imaging studies for which a written directive is not required. As such, they recommend that Technegas be licensed under title 10 of *Code of Federal Regulations*, section 35.200 (*8*).

## CONCLUSION

The introduction of Technegas into clinical practice in the United States brings an exciting opportunity to significantly advance ventilation imaging capabilities. With decades of successful use worldwide, Technegas stands out for its unique ability to mimic gaslike behavior in the lungs, providing uniform particle distribution—a clear benefit for patients with conditions such as chronic obstructive pulmonary disease. Because the delivery of Technegas typically requires only 1–3 breaths to obtain sufficient imaging activity within the lungs, this quick administration not only can increase workflow productivity once NMTs are proficient but also, more importantly, can provide ease of delivery for patients. In addition, allowing the entire V/Q procedure to move to 3-dimensional imaging is associated with improved sensitivity and specificity along with expanded indications for use.

Given that this radiopharmaceutical is produced onsite within a TP system, special considerations for NMTs, administration, management, and biomedical engineering are essential to ensure its smooth implementation. These include locating a home for the TP unit, securing appropriate electricity, and securing a supply of argon gas and ethanol. Additionally, if a department is transitioning from V/Q planar imaging to V/Q SPECT or V/Q SPECT/CT, staff must discuss the imaging protocol and scanning equipment, as well as reconstruction parameters, billing, and interpretation criteria, in preparing for and optimizing the clinical integration of Technegas, thus maximizing its potential to improve patient care and diagnostic accuracy in ventilation lung imaging. Information on Technegas leasing can be obtained by contacting info@technegas.com.

## DISCLOSURE

Tina Buehner is employed by Cyclomedica USA as the Director of Clinical Affairs. No other potential conflict of interest relevant to this article was reported.

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