

Features and Benefits of Technegas and the TechnegasPlus Generator

These pages highlight some of the major features of the Technegas system and the advantages and benefits derived from them.

FEATURE	ADVANTAGE	BENEFIT
Scan imparts low radiation burden	Sensitive tissue and organs spared excessive radiation dose	Physician can perform scan with confidence Follow up scans to monitor disease progress may be performed safely
Technegas behaves like a gas	Penetrates to the alveolus and is trapped there	Image is a true reflection of lung ventilation
Technegas is trapped in the alveolus	SPECT imaging may be performed	SPECT imaging permits the physician greater diagnostic flexibility
More than 20 years and 2 million scans experience	Clinical track record and demonstrated efficacy over a long period of time	Physician confidence that Technegas can be used in all patients
Technegas does not cross into the blood stream	Ventilation images reflect lung function	Physician acquires clear, unambiguous scans
Available 24/7	Scanning can be performed readily	Outpatients and Emergency patients can be scheduled without delay
Technegas readily penetrates to the alveolus	One or two breaths sufficient to acquire required counts	Improves patient compliance and gentle on ill patients
Sensitivity, Specificity, Accuracy and NPV equivalent of CT	Provides a viable alternative to CT	Physician has interpretive confidence, first time, every time which imparts less radiation burden
Non-invasive	Kinder on the patient	Improves patient compliance and comfort
True screening test	Can be used safely on most patients without resort to in-depth work-up	Provides physician with confidence that the study is safe to perform on all patients presenting for PE
SPECT images provide a simple answer to a simple question	Yes or No answers can be obtained speedily	Allows accurate and quick decisions

FEATURE	ADVANTAGE	BENEFIT
Long residence in the lung and no redistribution	Allows acquisition of high quality SPECT images	Indeterminate scans may be reduced to less than 5%
Acquisition of high quality SPECT images	Images may be acquired on multiple projections	Improves identification of mismatching defects
Specific activity of Technegas can be varied	Provides greater flexibility	Specific activity can be increased to cater for comatose and compromised patients
Hydrophobic particulate	Does not absorb water in the humid atmosphere of the airways	Travels right to the alveolus and is trapped on the mucous surface
Technetium-99m is trapped in a pure, inert carbon matrix	Trapped and remains at the alveolar mucous surface	Provides a true reflection of activity at the alveolar surface
Deep penetration into lung segments	Can detect subsegmental emboli	Confidence that all emboli detected

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The following text is sample presentation that outlines the Features and Benefits of Technegas. It covers all the salient points that should be presented to an audience in order to advance Technegas as a diagnostic tool.

THE UTILITY OF TECHNEGAS IN THE DIAGNOSIS OF PULMONARY EMBOLISM.

No single diagnostic modality has impacted as severely on the V/Q scan for Pulmonary Embolism (PE) detection as Computed Tomography Pulmonary Angiography (CTPA), sometimes known as Multi-Detector Computed Tomography (MDCT).

While there have been a number of ventilation agents used in nuclear medicine departments for diagnosing PE, Technegas, for the past twenty years, has established itself as a valuable diagnostic agent possessing characteristics and advantages over such competitors as Krypton, Xenon and DTPA. These observed advantages have been addressed in detail elsewhere. This table provides a summary.

SUMMARY OF VENTILATION AGENTS

Ventilation Agent	Xe-133	Kr-81	Aerosols	Technegas
Ease of Admin	Mod	Mod	Low/Mod	Very easy
Patient comfort	Mod	Mod	Low	High
Cost	Mod	Very high	Mod	Mod
Availability	Variable	Variable	Always	Always
Rad dose to patient	High	Very low	Mod	Mod
Rad dose to staff	Medium	Negligable	Mod/High	Low
Image quality	Poor	Good	Variable	Good
Affinity for H ₂ O	N/A	N/A	Hydrophilic	Hydrophobic
Energy kEv	81	190	140	140
Half life	5.24 days	13.1 sec	6 hours	6 hours
B-energy kEv	350	N/A	N/A	N/A

It is not the intent of this paper to address the issue of competition between the various ventilation agents. Rather, as CTPA is the predominant threat to V/Q imaging, particularly as it affects Technegas use, this paper will highlight the evidence supporting the contention that V/Q SPECT with Technegas is a superior and safer first line diagnostic option than CTPA.

What is Technegas?

Technegas is a unique ventilation agent. It is a microaerosol of 20nm by 3nm thick hexagonal platelets containing Tc 99m completely encapsulated within a pure graphitic surface (1). It is produced within a Technegas generator at high temperatures. While technically an aerosol, Technegas exhibits many of the transport characteristics of a true gas

(2). What sets Technegas apart from other aerosols is its hydrophobic particulate nature (2-4). It is this characteristic which allows Technegas to penetrate deep into the lungs without adsorbing water in that humid atmosphere to reach the alveoli where the Technegas is trapped on the mucous surface. It does not cross the alveolar membrane into the pulmonary circulation (5).

Imaging of the 140KeV gamma ray from the 99mTc Technetium 99m encapsulated in a pure, inert carbon surface thereby provides a true reflection of activity at the alveolar surface. This is then compared to with an image obtained using macro-aggregated albumin (MAA) of activity in the pulmonary circulation. MAA is the actual determinant of PE, since upon injection intravenously, it is itself around 1 million 'micro-emboli', obstructing about 1% of the pulmonary microcirculation. As it is also labelled with 99mTc, a gamma camera image reflects the pulmonary blood flow throughout the lung. Any pre-existing embolus upstream registers as a defect in the image. However, in 40-80% of patients (depending on a range of living conditions), other pathology can also create blood flow defects, usually as a consequence of prolonged exposure to inhaled dusts and toxins. Thus there is inevitably a matching ventilation defect with perfusion defects from non embolic causes. It is the mismatch with an MAA perfusion image which displays the patency of blood supply in the pulmonary circulation that provides the definitive diagnosis of PE.

V/Q planar imaging with Technegas in the hands of experienced physicians has resulted in excellent results and reporting to referring physicians (6). However, the series of PIOPED studies and probabilistic reporting using an inferior ventilation agent, Xenon -133, and emanating from the United States has severely misrepresented the utility of V/Q imaging (7). Additionally, reports coming from the United States have compared state of the art 64 slice CT to planar V/Q. It is little wonder that the utility of V/Q imaging has been reported as inferior and its viability as a diagnostic tool called into question.

V/Q SPECT imaging with Technegas, however, has demonstrated accuracy, specificity, sensitivity and negative predictive value results which are AT LEAST the equivalent of CTPA (7,8,9,10).

COMPARISON OF CTPA , V/Q SPECT AND V/Q PLANAR

	Planar	SPECT	CTPA
SENSITIVITY	76%	97%	86%
SPECIFICITY	85%	91%	98%
ACCURACY	81%	94%	93%
N.P.V.	81%	98%	90%
P.P.V.	80%	90%	97%

Multi-Detector Computed Tomography

The utility of multi-slice CT (MDCT) in the diagnoses of many disease conditions, is unquestioned. Improvements in imaging technique, sensitivity and specificity has resulted in significant advances in tumour detection and many other anatomical abnormalities providing informed diagnosis and specific treatment translating into improved patient quality of life.

In a matter of seconds many images can be generated. In the case of imaging for a PE query, the radiologist may acquire all the images he needs in seconds compared to 20 minutes for a V/Q SPECT acquisition. Additionally, asymptomatic co-existing conditions may be detected.

Every major hospital and private practice Radiology clinic has at least one CT machine though not all have nuclear medicine departments.

Most hospitals provide some form of 24 hour on-call service while not all hospitals offer 24 hour nuclear medicine service.

Referrers want the confidence of a binary report. CT will provide a yes or no answer. Traditional probabilistic reporting in nuclear medicine practices means that a large percentage of patients will be classified in an indeterminate category requiring further investigation. In a life-threatening condition such as PE, the referrer needs a quick and accurate diagnosis so he can initiate or withhold treatment.

It is little wonder that V/Q imaging, particularly planar imaging, has been pushed into the background and its continued utility questioned. Many of the early comparative studies did indeed demonstrate the superiority of CTPA compared to V/Q. In such cases it is invariably observed that state of the art CT has been compared to planar V/Q using Xenon-133, which is limited to a single posterior view.

Surprisingly, it is this very popularity, increasing numbers of slices acquired and limitations which have produced the chinks in CTPA armour. A positive diagnosis can be missed simply through the physician not scanning each and every slice.

RADIATION DOSE

While CT constitutes about 13% of all examinations in the U.S., it contributes 30% of the total patient radiation dose from the use of medical X-rays and rising (11). Other countries mirror these figures (12,13). This is of particular concern in the case of PE where the female breast may receive 10mGy per breast, fully 40 times that of a V/Q scan (14,15).

The implication of this is that such high doses, particularly in proliferating breast tissue, will result in an increase in breast cancer incidence (16,17). While this has been noted as a theoretical increased incidence (9) it has already been confirmed in at least one study (18).

There is little to no such risk with Technegas as the dose to breast tissue is much less than CT.

RESULTS

V/Q SPECT, using Technegas, provides diagnostic results (see table 2) AT LEAST the equivalent of CT (7,8,9,10).

SPECT imaging allows the nuclear medicine physician quickly to accurately detect mismatches even at the subsegmental level. The positive scan also allows the treating physician to obtain a base-line scan against which the efficacy of subsequent treatment can be measured (15).

So many images are obtained with a CT scan and so busy are the scanners that it is often not possible to review every study slice by slice. This results in the radiologist often reviewing slices 3 or 4 at a time. The implication is obvious.

Even when a positive scan is detected the patient is often sent to nuclear medicine to obtain a base line image!!

PIOPED II showed that 1 in 6 CT scans were indeterminate often necessitating a V/Q scan to confirm the diagnosis (7).

The argument is also often made that CT provides a binary answer and additional information. But there is not much advantage in gaining additional information for an asymptomatic condition if you do not rule out PE in the first instance. V/Q SPECT with Technegas allows the nuclear medicine physician to report confidently yes or no answers, provides a base line image and minimises the radiation burden inflicted upon the patient in accordance with ALARA principles (12,19,20).

CONTRAINDICATIONS

In over 20 years of experience with Technegas and over 2 million scans in 50 countries worldwide, RARELY has an adverse event has been documented and confirmed. Therefore, Technegas can be used for the diagnosis of suspected PE in most patients.

Contrast this with the precautions which must be exercised BEFORE a CTPA can be performed on a patient presenting with a life-threatening condition:

- 1) Is the patient a diabetic on Metformin?
- 2) Is the patient allergic to contrast media?
- 3) Is the patient comatose?
- 4) Is the patient suffering from heart failure?
- 5) Is the patient renally compromised?
- 6) Is the patient a young child?
- 7) Is the patient a female of child bearing age?

Hypothetical Case History.

A female patient walks into the emergency department of a hospital or into the surgery of her G.P. She complains of non-specific chest pain, dyspnoea, tachycardia, etc. After the physician rules out a cardiac event and on negative chest X-ray, the physician is faced with the decision to rule out PE.

Decision 1 – Go to V/Q SPECT.

No major complications or adverse side effects would be expected.

Test is non-invasive.

Low radiation burden.

Yes or No answer in 20 minutes.

Scan provides a base line against which therapy can be measured.

Accuracy, Sensitivity, Specificity and NPV all around 95%.

Decision 2 – Go to CTPA

Careful patient screening to rule out a number (see above) of contraindications.

Invasive.

Weigh up risk of inflicting large radiation dose to female breast tissue.

1 in 6 scans indeterminate requiring further test and potential for additional radiation.

Often need a base line scan requiring further test and potential for additional radiation.

Subsegmental emboli may be missed.

Can take time to get a report back.

CONCLUSION.

Technegas has withstood the test of time and advancing diagnostic challenges. Its efficacy as a diagnostic modality and clinical track record have established Technegas as the lung ventilation imaging agent of choice.

“V/Q SPECT with Technegas is the only logical choice as a screening test for the potentially life-threatening condition of Pulmonary Embolism”.

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