Other Uses for Technegas (Part 2)

In the last issue of the Crucible a brief overview of the usefulness of ventilation scans using Technegas in the workup of chronic obstructive pulmonary disease (COPD) was presented. In this issue the utility of ventilation/perfusion (V/Q) scans in a few other clinical scenarios like congenital diaphragmatic hernia (CDH) and patients undergoing radiotherapy for bronchogenic carcinoma will be outlined.

CDH remains one of the most common life-threatening congenital abnormalities in the neonatal period. While advancement in therapeutic strategies e.g. lung protective ventilation with permissive hypercapnia, extracorporeal membrane oxygenation (ECMO), delayed surgical repair, pulmonary vasodilators and maintenance of right-to-left shunting in cases of severe pulmonary hypertension have led to improved survival rates beyond the newborn period, long-term survival may be associated with increased pulmonary morbidity and persistent pulmonary hypertension (1).

Björkman et al from Karolinska Institute in Stockholm, Sweden studied postoperative regional distribution of pulmonary ventilation and perfusion in 12 infants with CDH who underwent surgical repair in the newborn period (1). The aims of their study were to determine the lung ventilation and perfusion distribution following surgical repair; the relationship between the degree of ventilation and perfusion abnormalities and clinical disease severity and the role of various risk factors as predictors of subsequent lung function abnormalities.

At the time of the study the patients ranged in age between 3–12 months (average 6 months) and were clinically stable. The hernia was left-sided in 10 and right sided in 2 patients. Six patients required ECMO and eight patients had pulmonary artery hypertension postoperatively. Two patients required supplemental oxygen at the time of the V/Q scan.

The V/Q scan was acquired using Technegas and human albumin macro aggregates as ventilation and perfusion agents respectively. SPECT images were obtained for both phases of the study using a 3 head gamma camera. SPECT data was used to quantify the ratio of the relative distribution of ventilation and perfusion between the ipsilateral and contralateral lungs (Vi/Vc and Qi/Qc respectively). Functional lung volume as a fraction of total lung volume was also quantified for the ipsilateral and contralateral lungs. Neonatal clinical data collected during the patient’s stay in the paediatric intensive care unit was correlated with the SPECT data.

Seven patients had good relative ventilation and perfusion distribution between ipsilateral and contralateral lungs while remaining five patients had significantly compromised ipsilateral lung capacity (defined as <20% of both the total ventilation and perfusion flow to the ipsilateral lung). As a group all twelve patients had an imbalance in the distribution of ventilation and perfusion between ipsilateral and contralateral lungs with ipsilateral lung contributing 30% of ventilation and 28% of perfusion while the contralateral lung...
contributing 70% of ventilation and 72% of perfusion. Interestingly, no significant difference was noted between the relative distribution of ventilation and perfusion within each lung side suggesting that ventilation and perfusion were equally affected. Patients not requiring ECMO, on average, showed ipsilateral to contralateral ratio of ventilation, perfusion and functional volume ratios closer to 1 than patients requiring ECMO. When various clinical parameters at the time of repair were correlated with V/Q scan data, days on ventilator, days on ECMO and presence of pulmonary hypertension in the post-operative period linearly correlated with the quantified parameters.

Discussing their results, authors pointed out that the presence of considerable variation in ventilation and perfusion characteristics in studied infants, was not evident from other investigations e.g. growth, chest radiographs, or clinical evaluation of respiratory status at follow-up as all subjects at the time of imaging were clinically stable. Children appearing well with clinically normal respiratory parameters (respiratory rate, oxygen saturation, work of breathing) could, hence, have relatively severe abnormalities in ipsilateral ventilation and perfusion and could depend almost completely on gas exchange from the contralateral lung. Such children may have limited functional reserve and can be very susceptible to infection or other complications.

Moreover, the presence of marked ventilation and perfusion abnormalities months later in infants who required ECMO treatment earlier, possibly points to role of these abnormalities in pathophysiology of CDH. Authors hypothesized that abnormal ipsilateral V/Q distribution may indicate a lack of normal postnatal lung growth during the first year. It was concluded that V/Q scans could provide information useful for clinical management.

Munawar et al. from University of Western Ontario, Canada in a small group of 10 patients with stage III non-small cell lung carcinoma investigated the impact of ventilation SPECT in intensity modulated radiation therapy (IMRT) planning process (2). The aim of the study was to define well ventilated lung regions and then try to avoid these regions using inverse-planned IMRT and beam angle optimization in hoping to minimize the risk of both acute and late complications of radiotherapy.

Patients who were treated with curative intent chemoradiotherapy and underwent four dimensional simulation CT and pulmonary V/Q SPECT on the same day were retrospectively identified for the study. Attenuation corrected ventilation scans were imported into the treatment planning system to be registered with the planning CT. The gross tumour volume (GTV), clinical target volume (CTV), planning target volume (PTV), spinal cord, esophagus, heart and evaluable lung defined as lung-CTV were delineated on the planning CT. Two separate functional lung volumes were automatically segmented. These included i) vv50 defined as volume containing all voxels with a SPECT intensity ≥50% of the maximum and ii) vv70 defined as volume containing all voxels with a SPECT intensity ≥70% of the observed maximum SPECT ventilation intensity. These volumes served as surrogates for the well ventilated lung and were subsequently used as avoidance volumes in inverse IMRT treatment planning. The mean ventilated lung dose (MvLD) was mathematically computed based on the dose distribution of a treatment plan and the ventilation SPECT counts. For each patient, three separate IMRT plans were generated. The first plan used nine equally spaced beams to avoid total lung only i.e. avoidance of bulk lung volume without any deliberate avoidance of the ventilated lung. The second plan used nine equally spaced beams to avoid vv50 and vv70 only, while the third plan used three beams with beam directions chosen to minimize the mean ventilated lung dose. Resulting dose volume histogram indices were calculated for each plan and were compared with respect to calculated SPECT-based ventilation parameters in order to quantify the potential utility of ventilation SPECT in this setting.

After analysis of the data, authors concluded that incorporation of ventilation SPECT data could be used to reduce the mean lung dose and dose to the functional lung in a subgroup of patients. In other patients, sparing of the functional lung was not possible without compromising the planning tumor volume (PTV). Authors emphasized the need for further studies in a larger group of patients to help guide further implementation of SPECT ventilation imaging in the chemoradiotherapeutic management of lung cancer.

References:


Rashid Hashmi (Retired)
Nuclear Medicine Physician and Radiologist currently working at UNSW as Associate Professor.
Dear Colleagues in Nuclear Medicine

After over thirty years at its present home at Lucas Heights, Cyclomedica will be relocating to a new premises in the second half of 2016. In 1994, Tetley Industries, manufacturers of the Technegas generator, moved from Resolution Drive in Caringbah to the current site in Technology Park. Over the next thirty or so years, and after three name changes (Tetley Industries, Vita Medical Australia and Cyclomedica Australia) the company has outgrown its current home.

The new site at Kingsgrove will provide Cyclomedica with much larger premises and much needed room for expansion to cope with increasing global demand for TechnegasPlus generators (TG’s) and Patient Administration Sets (PAS). As you may know, each TP, carbon crucible and PAS are made in-house. The current manufacturing facility which was producing about 1,000 boxes of PAS thirty years ago, is now bursting at the seams to produce and store almost 4,000 boxes of PAS annually and sufficient TP’s to satisfy global demand. The problems have been compounded by purchase and storage of componentry and parts required to manufacture these products and have inventory to keep more than 1,000 Technegas generators (TG’s) optimally functioning around the world.

I would like to reassure all of our customers that a smooth transition is planned and no disruption to supply anticipated. However, the less we have to transport from Lucas Heights to Kingsgrove the better, particularly the TP’s. I have received many requests for quotes over the past year or so. Can I ask you to revisit your need for upgrading your generator from a TG to a TP, particularly if you have a TG which is fifteen years or older (a lot are over twenty years old)? It is becoming increasingly difficult to keep these generators operational as parts have become obsolete and we are relying on trade-ins for parts.

This edition’s lead-article by Associate Professor Rashid Hashmi, continues the story of Chronic Obstructive Pulmonary Disease (C.O.P.D.) and considers the utility of Technegas as the Ventilation agent in other clinical conditions. Rashid’s summary and Bill Burch’s reporting on some of the presentations appearing at the recent Asia Pacific Society of Respirology (A.P.S.R.) meeting in Kuala Lumpur, continue the story of C.O.P.D. and the prevalence of co-morbid disease underlying the condition and confusing the diagnosis. Three recent abstracts were submitted at the A.P.S.R., two were submitted to the Japanese Society of Pulmonary Functional Imaging (J.P.S.R.) as well as two poster presentations. ALL were accepted and received great interest.

Charles Buttigieg
Asia-Pacific Marketing & Sales Mgr
Cyclomedica

Help add to the World Knowledge Base

Could I once again ask you to submit any ‘unusual’ cases for inclusion in our lung atlas? The better this is populated the more meaningful it will become.

Its aim is to provide cases which physicians around the world can refer to when they are confronted by particularly baffling images.

Hopefully, someone else has already gone down this track and their experience will help not just physicians better diagnose the problem but also provide patients with improved diagnostic outcomes and accurate treatment.

Charles Buttigieg
Asia-Pacific Marketing & Sales Mgr
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See submission details on page 4.

Daily Technegas Operation.

The Technegas generator should be plugged in first thing in the morning and turned on during the working day. This is sufficient to charge the main battery. It should be turned off at the end of the day and NOT left on overnight. Nor should it be left on over the week-end. If the Technegas generator is left continually on there is a possibility that spikes in the power grid may affect the Technegas generator resulting in it failing to operate correctly.

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SPECTlung visitor statistics for 2015

Even though we have not had any more cases supplied for our educational website for some time, it is pleasing to note from the user statistics that the site is being used much as we had hoped it would, namely a study reference point for PE interpretation.

Overall there were 3006 visitors to the site from a total of 102 countries, but the most significant visitors were listed as from Russia (21%) followed closely by USA (19%) with Australia third (16%). These named country addresses can be misleading since many folks choose to use international home URLs for economy and convenience. Just out of interest, the remainder of the top 10 reads: UK - 8.5%; Brazil - 5%; Canada – 3.3%; Ireland – 2.4%; India – 1.3%; Italy -1.2%; Sweden -1.1%.

Especially pleasing was the high incidence of returning visitors (366), and the length of time they spent on average on the site, namely 3.8 minutes. The new visitors spent an average of 1.8 minutes. It was of interest to note that 85% of all visitors were on desktop machines rather than tablets or mobile units. In a further breakdown of what was actually being read, 12% of visitors spent an average of 2.5 minutes on the ‘imaging issues’ page; almost all the case studies averaged over 1 minute per visit. It is difficult to interpret the abnormal figures for case study #30 (7.5min) and #40 (4min). It may be something to do with them being the last study on each page, although the rarity of #40 as video presentation, could explain that one.

In summary, the site seems to be getting regular usage, the hit rate pulses higher around the time of conferences, but over a yearly period, the mean level has not dropped off. But nor has it risen, and I am sure it would benefit from more case studies. Please, anyone who has a particularly interesting or difficult case – especially if you got the diagnosis wrong, AND KNOW WHY! - it would enhance the teaching value of SPECTlung.com for you to offer it for display.

An extensive review of the technical field of V/Q imaging has recently been published. (Artifacts and Anatomical Variants Affecting Ventilation and Perfusion Lung Imaging. Schembri GP, Roach PJ, Bailey DL, Freeman L. Semin Nucl Med 45:373-391 2015). It is a very comprehensive report, and should be mandatory reading for all those new to the field, as well as a handy refresher for the more experienced. The only significant omission, although present by implication in the properties of aerosol behaviour, was to expressly state that Technegas is hydrophobic, a unique attribute, and that the usual ‘wet’ aerosols like DTPA, no matter how small they are initially, will grow in a matter of milliseconds once they get into the supersaturated regions of the bronchial tree, and that is only 3 branches down out of 23 in the lung.

Another point I observed doing 81mKr studies in London in 1984, was that there is a tendency for this 13 second half-life gas to deposit less activity in the lower lung regions, since with the conflicting priorities of minimising lung movement, and getting good penetration, the intermixing process with multiple breaths takes too long in this region, resulting in lower count densities in the lung bases.

In summary, the site seems to be getting regular usage, the hit rate pulses higher around the time of conferences, but over a yearly period, the mean level has not dropped off. But nor has it risen, and I am sure it would benefit from more case studies. Please, anyone who has a particularly interesting or difficult case – especially if you got the diagnosis wrong, AND KNOW WHY! - it would enhance the teaching value of SPECTlung.com for you to offer it for display.

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A few interesting presentations exploring role of pulmonary scintigraphy in the workup of patients with chronic obstructive lung disease (COPD) were made in the 20th Congress of Asia Pacific Society of Respirology held in Kuala Lumpur, Malaysia in early December 2015.

Huang et al from Shanghai Changzheng Hospital, Shanghai, China in their paper entitled “Clinical utility of tomographic pulmonary scintigraphy in diagnosing lung obstructions in COPD patients and associated disease comorbidities”, presented their experience using hybrid V/P SPECT/CT in a group of 70 patients. Aim of the study was to evaluate V/P SPECT to diagnose COPD and its associated comorbidities. Using pattern of uptake on V/P SPECT they reported presence of left heart failure, pulmonary congestion and pulmonary embolism in 61, 13 and 12 patients respectively. Given that these changes were not detected by conventional lung function testing, they concluded that V/P SPECT can reveal heterogeneity of COPD and suggested that it could become a diagnostic tool in identifying comorbidities associated with COPD.

In another presentation entitled “Use of ventilation/perfusion single photon computed tomography (V/P SPECT) for assessment of ventilation in COPD”, Bajc et al from Skåne University Hospital, Lund, Sweden presented their study on possible role of technique in 66 patients who were diagnosed with COPD based on GOLD criteria. They classified air flow limitation on the deposition and peripheral penetration pattern of Technegas in three grades. Grade 1 when slightly uneven deposition with minor reduced penetration was seen, grade 2 when deposition in intermediate and large airways with diminished penetration was seen and grade 3 when deposition in large airways and major lung areas with reduced or abolished ventilation was seen. These were then compared with airflow limitation (FEV1/FVC) and ventilation capacity (FEV1) evaluated by spirometer, and symptoms measured in COPD assessment test (CAT). They found that patients with grade 3 obstruction on ventilation SPECT had FEV1/FVC and FEV1 values indicating GOLD stage III-IV and CAT 23±4% while those with grade 2 obstruction of ventilation SPECT had FEV1/FVC and FEV1 values indicating GOLD stage II and CAT 19±4%. It was concluded that these findings could have bearing on the patients undergoing treatment for COPD as better penetration of Technegas into smaller airways may indicate efficacy of anti-inflammatory and bronchodilator drugs.

These presentations provide an insight into possible role of pulmonary scintigraphy in work-up, diagnosis and management of patients with COPD in future. However, there findings need to be corroborated by other investigators interested in this subject.
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About 1/7th of breast tissue exposure

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