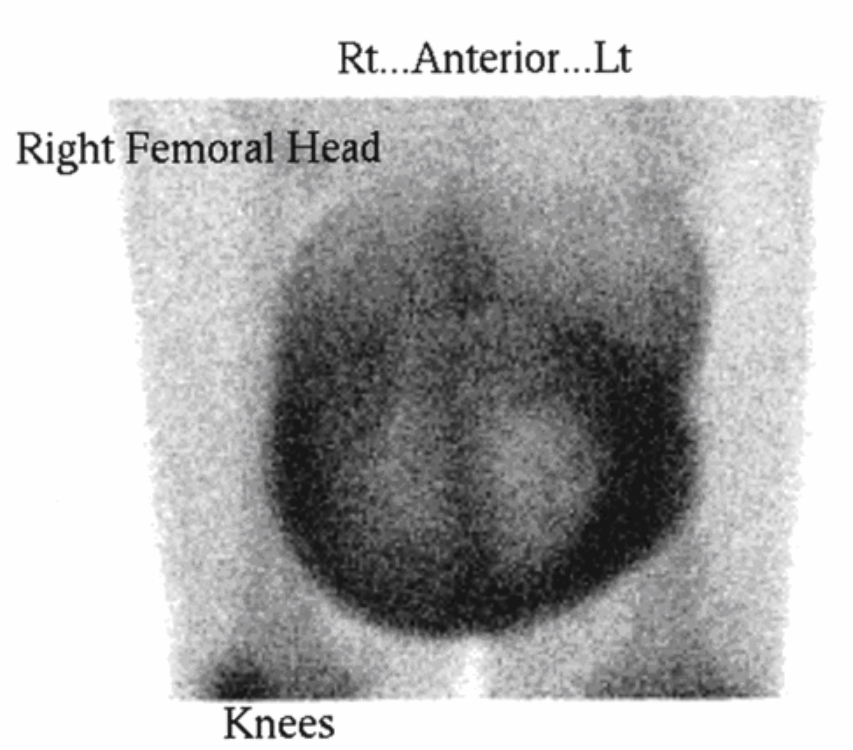
E Pluribus Unum
out of many, one

seasonal rains
RURAL ALLIANCE IN NUCLEAR SCINTIGRAPHY

Volume 2, Number 1 SUMMER EDITION 2008

99mTc MDP Blood Pool Study



The official quarterly newsletter of the Rural Alliance In Nuclear Scintigraphy

www.rains.asn.au

EMAIL CONTACT
Newsletter: seasonal@rains.asn.au
Membership: membership@rains.asn.au
Other: enquiry@rains.asn.au

POSTAL
PO Box U102
Wagga Wagga
NSW 2678

Introduction

The Australian health care system has been described or defined by the 'inverse care law'; those Australians in the most need of health services receive the least. This might equally reflect life for rural Nuclear Medicine professionals; those with the greatest need for support and representation actually have the least. It is true that the rural Nuclear Medicine professional develops unique skills and capabilities not generally manifest in metropolitan counterparts; an evolutionary adaptation ('survival of the fittest'). Despite these attributes, rural Nuclear Medicine professionals are confronted with professional isolation that fosters a number of inequities:

- Professional representation at state and federal level.
- Accreditation and continuing professional development (CPD).
- Diffusion of innovation, technology and techniques.
- Support for training, leave (illness or recreation) and workload.
- Career development pathways.

RAINS aims to quench the thirst of rural Australia left parched by professional under representation.

RAINS Committee

President's Report

Welcome to the first edition for 2008 of Seasonal RAINS.

RAINS is an alliance of rural Nuclear Medicine professionals and was spawned at the Adelaide ANZSNM ASM in 2007 due to growing concern over equity issues. This quarterly newsletter represents a key strategy in tackling the challenges of rural practitioners.

I would like to welcome all our new members and encourage each of you to participate in RAINS based CPD activities in 2008. Those who participated in RAINS CPD activities in 2007 should have received a CPD statement just prior to Christmas. I invite all of you to offer review articles, interesting images or cases and the like for inclusion in *Seasonal RAINS*. The ongoing success of *Seasonal RAINS* will require contributions from the broader membership.

We also hope to circulate early in the new year a CPD CD containing CE powerpoint presentations with narrations. Please ensure you update your email and post details annually to avoid missing out on CPD opportunities or your CPD statement.

Finally, the November CPD conference in Wagga Wagga in 2007 was a great success. We were fortunate to have high quality speakers and excellent sponsorship and support. There were 60 qualified technologists in attendance, 40 students and several physicians. The CPD conference will run again in 2008 during November so keep your diaries open.

Pete Tually

Visit our website:

http://rains.asn.au

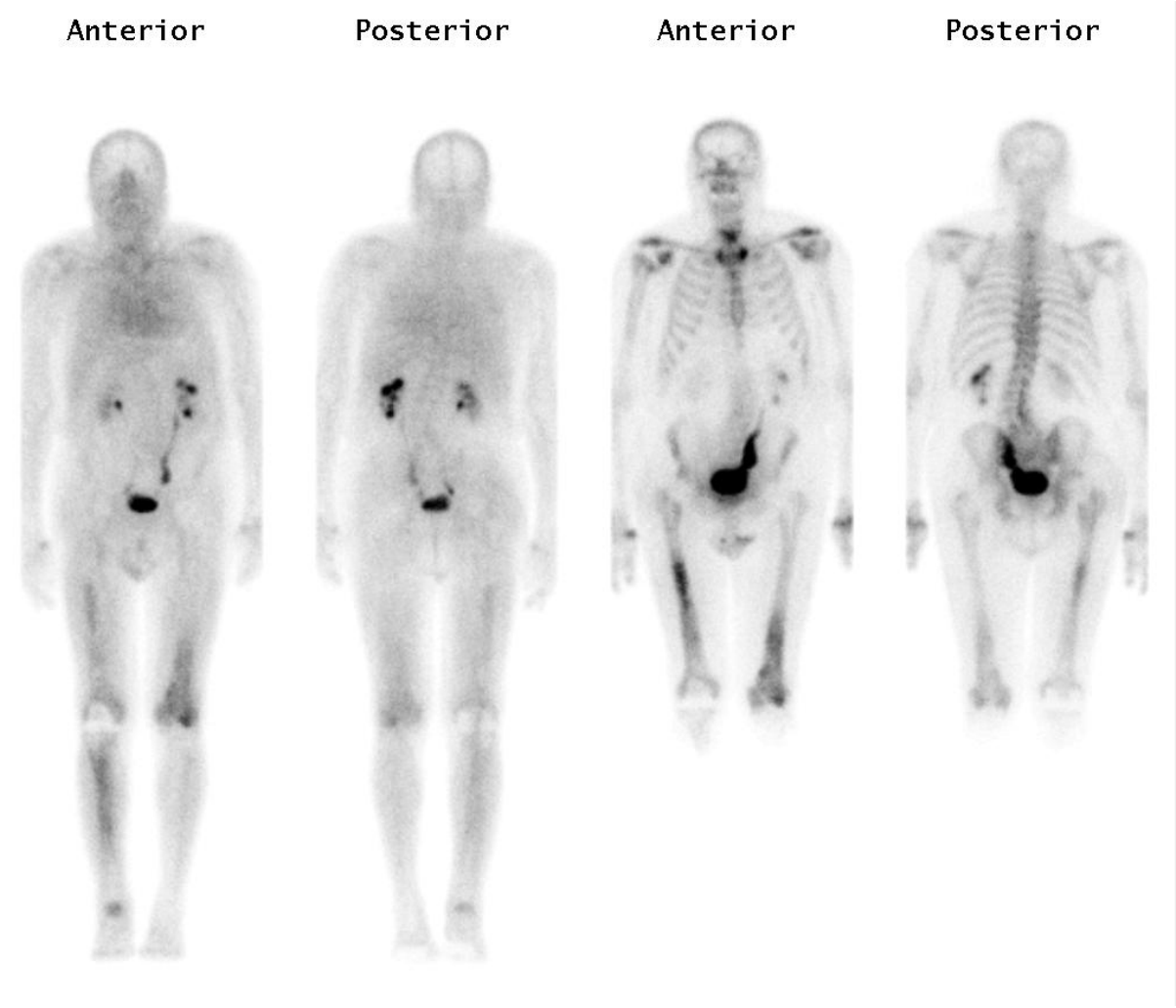
Start Collecting Your 2008 CPD Points With RAINS Now!

Interesting Image

Bone Lymphoma

Annah Skillen

Hunter New England Imaging, Nuclear Medicine and PET, Newcastle.



A 78 year old male presented to our department with a history of Paget's disease within his right distal femur and knee. A 2004 Bone Scan confirmed this diagnosis; however atypical radiological findings were more suggestive of an underlying infiltrative process such as infection or tumour. Infection of the then recent right total knee replacement was excluded in early 2005, and due to a slightly raised serum alkaline phosphates (ALP) level the patient was diagnosed and treated for Paget's disease over the next two years. Early 2007 saw this patient return to his specialist for review as he was suffering from a new pain in his left distal femur and knee and associated effusion to the area. A firm submandibular swelling on the patients left neck was also noted. The previous pain experienced within the patient's right leg was resolving with treatment. The patient was referred to our department for investigation of his new pain.

Routine three phase bone scanning demonstrated increased blood flow and pooling within the distal femurs, right tibia and talus (Figure above). Delayed wholebody and static imaging showed patchy areas of increased uptake within these areas and mild degenerative changes within several joints (Figures above). Findings were consistent with Paget's disease. Due to inconsistencies in the patient's history a bone biopsy of the patient's left femur was performed. This biopsy confirmed a diagnosis of primary lymphoma of the bone (PLB). An ^{18}FDG PET scan was performed for disease staging. ^{18}FDG gave a diagnosis of a stage IV PLB.

PLB is an exceptionally rare disease accounting for 1-3% of primary malignant bone tumours (Barbieri et al 2004). 94% of cases are non-Hodgkin's Lymphoma (NHL), representing less than 1% of all NHL cases and 5% of extra-nodal disease (Barbieri et al 2004). PLB results in osteoclast stimulating factors causing lytic bone destruction (Barbieri et al 2004).

This patients PLB was misdiagnosed on three separate occasions (initially in 2004, and twice in our department (report was co-signed)). The treatment of Paget's disease results in the patchy appearance of tracer uptake demonstrated on this patients bone scan, so the images are in fact consistent with the initial diagnosis. The key factor in this case is that Paget's disease will almost never spread to another area of the body whilst a patient is undergoing treatment. This is what occurred in this patient and upon this realisation, the initial diagnosis was questioned.

Despite the similar appearance of the two diseases in this case, bone scanning has been proven to be useful in the diagnosis and staging of PLB (O'Connor et al 2007). However, it is important to remember that bone tracer uptake is proportional to the change in the osteoblastic activity due to disease presence, rather than the actual disease itself. This has also been reported to be the case for several other imaging techniques for the diagnosis of PLB (Baar et al 1993). So rather than imaging changes within the bone structure, we need to image the disease itself. ^{18}FDG PET imaging has proven itself to be the superior imaging modality (Park et al 2004). This is largely due to its ability to distinguish between tumour activity and bone remodelling, or osteoblastic activity. Although we have this knowledge, other imaging modalities should never be excluded. It is the changes in osteoblastic activity, such as that demonstrated on a bone scan; which may in fact indicate early disease presence before it is metabolically active enough to demonstrate FDG uptake (as demonstrated in this patients right talus).

This case has demonstrated that Paget's disease and PLB have similar appearances on a ^{99m}Tc Bone scan. Whilst it is not essential to review past cases of Paget's disease after learning of this, it is important that PLB be considered in the differential diagnosis of Paget's disease.

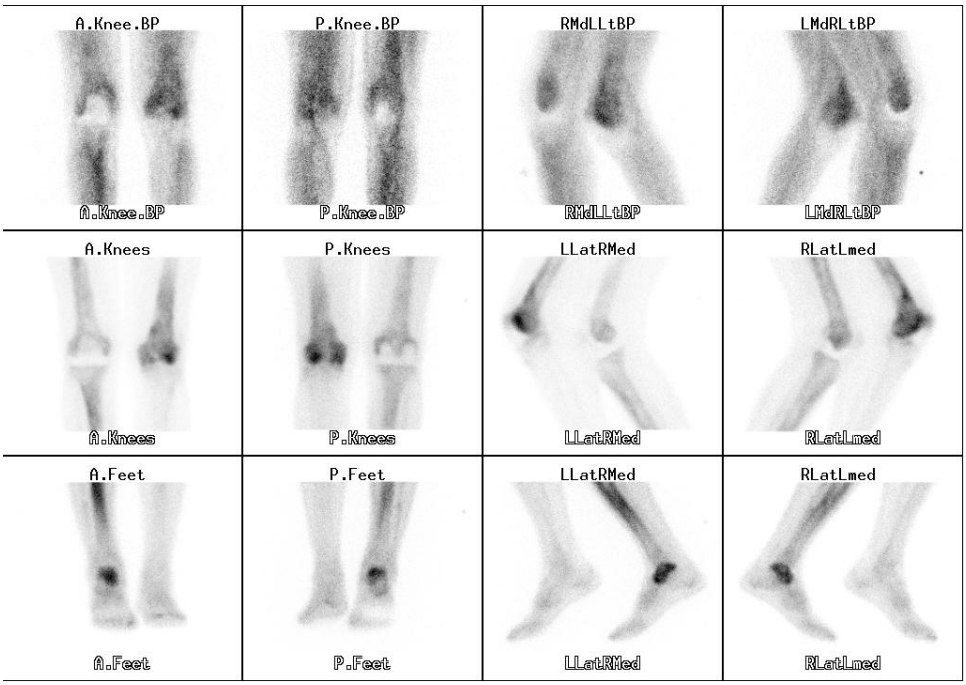
References.

Baar J, Burkes R, Bell, R et al. Primary non-Hodgkin's lymphoma of Bone. *Cancer* Feb 15 1994; 73(4):1194-9.

Barbieri E, Cammelli S, Mauro F, et al. Primary non-Hodgkin's lymphoma of the bone:treatment and analysis of prognostic factors for Stage I and Stage II. *Int J Radiat Oncol Biol Phys*. Jul 1 2004;59(3):760-4.

O'Connor A, Birchall J, O'Connor S, et al. The value of 99mTc-MDP bone scintigraphy in staging primary lymphoma of bone. *Nuclear Medicine Communications* Jul 2007 28(7):529-531.

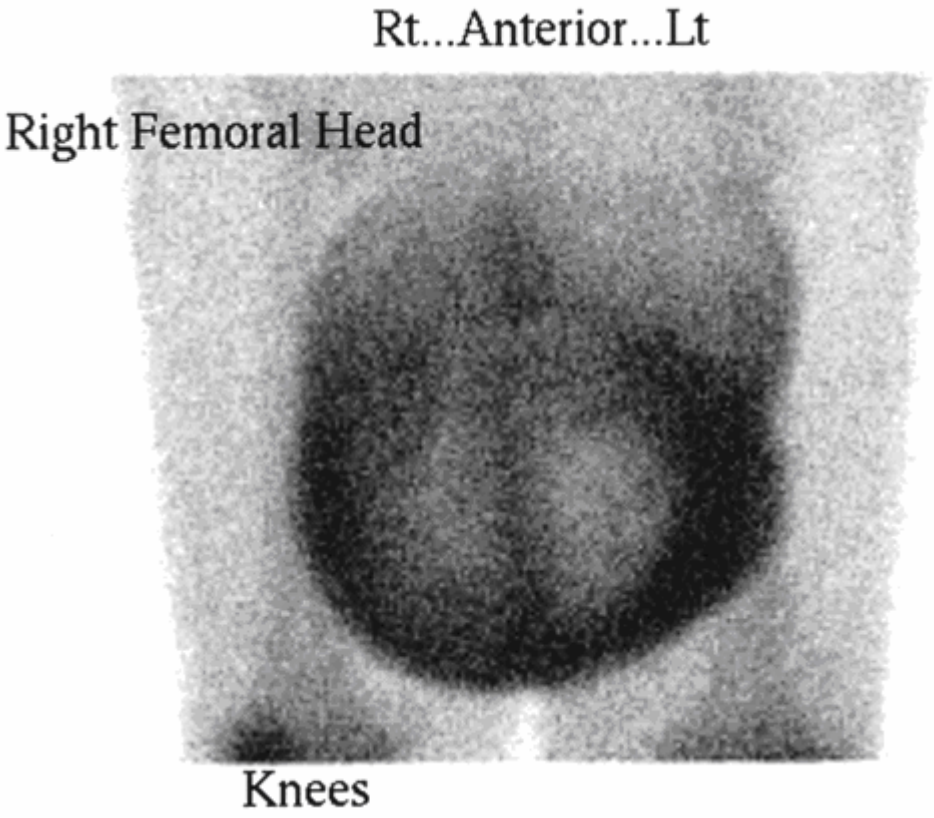
Park Y, Kim S, Choi S et al. Clinical impact of whole-body FDG-PET for evaluation of response and therapeutic decision-making of primary lymphoma of bone, *29th ESMO Conference* Nov 2004, Vienna, Austria.



Do you have an interesting image or case study? Email the image and brief overview with author details to seasonal@rains.asn.au and collect 2 CPD points.

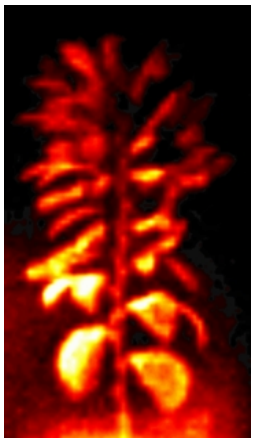
What The ……. ?

The following images were taken with 99mTc MDP (blood pool). What is the pathology? Solution in the next issue.



Send your 'What The …… ?' image, solution and author details to seasonal@rains.asn.au

What The …..? Solution For Spring Edition



99mTc DTPA biodistribution at 1 hour after administration to the root system of a bean plant. Prominent leaf uptake is noted with some stem activity. Incidentally, 99mTc pertechnetate would provide a similar appearance with slightly less prominent leaf and slightly more prominent stem.

The image represent part of some research being undertaken at CSU looking at water management in grape vines

Continuing Professional Development

Exceeding the recommended crucible volumes in the Technegas generator

Geoff Currie, Janelle Wheat and Zoe-Beth Traviss

School of Dentistry and Health Sciences, Charles Sturt University, Wagga Wagga.

ABSTRACT

Introduction: While Technegas generators have been common place within departments for over a decade, misconceptions still exist concerning appropriate volumes used to fill the Technegas crucible. Anecdotal evidence suggests that it is common clinical practice to over fill the crucible as a means of increasing activity without the need for multiple simmer cycles.

Research Question: Is the convex bubble blown off by argon flow? If so, what is the extent of the lost activity? Is over-filling the crucible an effective means of increasing activity without performing multiple simmers?

Methodology: Various volumes of ^{99m}Tc pertechnetate were assayed. Both volume and activity of ^{99m}Tc pertechnetate delivered to the crucible were recorded before the simmer cycle. After completion of the simmer cycle the Technegas crucible was inspected to ensure complete evaporation, and then calibrated to allow calculation of the percentage difference between the expected activity and actual activity.

Results: No statistically significant difference was noted between mean loss for volumes within manufacturer specifications (2.0%) and the mean loss for volumes exceeding manufacturer specifications (2.4%) ($P = 0.62$). Visual inspection of the crucibles immediately following the completion of the simmer cycle demonstrated unevaporated liquid in the crucible 87.5% of assays with volumes greater than or equal to 0.19 ml and no assays within manufacturer specifications.

Conclusion: While the argon purge does not blow off the convex meniscus and there is negligible post simmer loss of activity from the over filled crucible, this practice is not an effective means of avoiding the need for multiple simmer cycles to increase crucible activity.

INTRODUCTION

A Technegas generator is a microprocessor controlled device which produces an ultra fine micro-aerosol of a graphite coated Technetium atom used for ventilation lung scanning (*1*). Recommended crucible loading activity ranges between 400 and 900 MBq of Sodium Pertechnetate in 0.14 ml (*2*). High specific concentrations are not always available due to the decay of eluate and/or the generator bound parent. This decay results in significantly reduced available activity as the day and week progress. This is significant, as not only will the amount of ^{99m}Tc available from the generator decrease throughout the week, but the eluted ^{99m}Tc pertechnetate activity will also decrease throughout the day. Multiple simmer cycles of 6 minutes can be employed to obtain activity suitable for ventilation imaging.

Specific concentration has further ramifications on patient management since it is proportional to the efficiency with which an adequate count rate sufficient to complete the ventilation study is achieved. This may be compounded by the symptoms typical of a patient presenting for pulmonary embolism evaluation (i.e. dyspnea and chest pain) (*1*). Anecdotally, patient compliance tends to decrease as the duration of the ventilation procedure increases, increasing the likelihood that the study will be performed with sub optimal count density and/or room contamination will occur. A high specific concentration should increase the likelihood of obtaining an adequate count rate with minimal inspiration and improved patient compliance.

A number of measures are employed to improve available specific concentrations of ^{99m}Tc, such as, decreasing the volume of saline used to elute the generator or performing additional elutions throughout the day. Nonetheless, specific concentration of ^{99m}Tc eluate is of considerable concern, particularly on days of low activity due to generator decay. Contrary to manufacturer's guidelines (*2*), anecdotal evidence suggests that it is a common practice to increase the ^{99m}Tc pertechnetate volume above the confines of the crucible (convex bubble) to increase activity while limiting the preparation time to a single simmer cycle.

Manufacturer's guidelines (*2*) advise that over filling of the crucible does not contribute to increased generation of Technegas because the argon purge results in bubbled activity being blown off the crucible. This theory is yet to be reported in the literature. Theoretically, since the activity is blown off, it will not be evaporated within the crucible and, will not be converted to Technegas during the burn cycle. Furthermore, this additional activity may actually be heated during the burn stage, resulting in evaporation into the chamber as a wet aerosol of pertechnetate in steam and subsequent degradation in image quality due to rapid lung clearance and

undesirable uptake in thyroid, esophagus and stomach (*3*).

THE RESEARCH QUESTION

Is the convex bubble blown off by argon flow?
If so, what is the extent of the lost activity?
Is over-filling the crucible an effective means of increasing activity without performing multiple simmers?

METHODOLOGY

A standard first generation Technegas generator (Vita Medical, Australia) was used to produce all crucible residues. Volumes in the range 0.05 ml to 0.21 ml of ^{99m}Tc pertechnetate were assayed. A 0.14 ml volume was employed to evaluate the limits of the manufacturer specifications (0.14 ml) while 0.21 ml was the maximum single convex bubble achievable without overflow. Background was noted and accounted for on all dose calibrator assays. For each assay, a new graphite crucible was wetted with ethanol and placed between the electrodes of the generator, rotating gently to ensure good contact.

Activity within a 1 ml syringe was assayed and weighed prior to loading the graphite crucible and recorded as 'pre-activity' in MBq and 'pre-weight' in mg. The ^{99m}Tc pertechnetate was loaded into the crucible. The syringe was assayed to determine the 'residual activity' in MBq and the 'post-weight' in mg. 'Pre-activity' was subtracted from 'residual activity' and recorded as 'expected activity' in MBq. The volume loaded in the crucible was determined as the difference between the pre and post weight (mg) and expressed as mls.

Following the six minute simmer cycle the crucible was inspected to ensure complete evaporation of all activity and the graphite crucible was removed, assayed and recorded as 'actual activity'. All activity assays were background corrected. The percentage difference was calculated between the expected activity and actual activity.

The procedure was repeated for a variety of crucible loading volumes (36 in total). The argon cylinder pressure was considered a possible confounder and, thus, all experimental data was acquired with cylinder pressures ranging between 13000 kPa and 16000 kPa. Similarly, the argon flow rate was considered a possible confounder so all experimental data was acquired with a regulator flow rate of between 16 L/min and 17 L/min.

The differences between independent means were calculated with a 95% confidence interval (CI). The statistical significance was calculated using Student's *t* test for continuous data. A *P* value less than 0.05 was considered significant. Confidence intervals without an overlap were considered to support a statistically significant difference while confidence intervals with an overlap represented differences for which chance could not be excluded as the cause.

RESULTS

A total of 36 assays were performed with a mean crucible volume of 0.165 ml, a median volume of 0.17ml and a range of 0.05 ml to 0.21 ml. The percentage loss of activity from the crucible following the simmer cycle was tabulated (Table 1). The mean percentage loss of activity from the crucible following the simmer cycle was 2.2% (95% CI 1.4 – 3.1%). No statistically significant relationship was detected between the crucible volume and the percentage activity loss ($P = 0.55$).

The mean percentage loss of activity was stratified as those within manufacturers specifications (0.15 ml or less) and those exceeding these specifications. The mean percentage loss for volumes within manufacturer specifications was 2.0% (95% CI, 0.7 - 3.3%) while the mean percentage loss for volumes outside manufacturer specifications was 2.4% (95% CI, 1.3 - 3.5%). The overlap of these confidence intervals supports a lack of statistically significant difference ($P = 0.62$) (Fig. 1).

Visual inspection of the crucibles immediately following the completion of the simmer cycle demonstrated unevaporated liquid in the crucible in 38.9% (14/30) of assays. No unevaporated liquid was noted where the crucible volume of ^{99m}Tc pertechnetate was within manufacturer specifications. Of crucible volumes greater than or equal to 0.19 ml, 87.5% (14/16) had unevaporated liquid. A statistically significant difference was not in the mean crucible volume for those assays with residual unevaporated liquid after the simmer cycle (0.20 ml with a 95% CI of 0.18 - 0.12 ml) compared to those evaporated to dryness (0.14 ml with a 95% CI of 0.13 - 0.16 ml) ($P < 0.001$). No statistically significant relationship was seen between the percentage lost activity and the presence of residual unevaporated liquid post simmer ($P = 0.54$).

The mean percentage loss of activity was also stratified as those less than 0.19 ml and those greater than or equal to 0.19 ml. The mean percentage loss for volumes less than 0.19 ml was 2.2% (95% CI 1.1 - 3.4%) while the mean percentage loss for volumes greater than or equal to 0.19 ml was 2.3% (95% CI 1.0 - 3.5%). The overlap of these confidence intervals supports a lack of statistically significant difference ($P = 0.98$) (Fig. 2).

Table 1: Tabulated summary of actual and expected crucible activities for assays completed employing ethanol preparation of the crucible.

Volume (ml)	Actual Activity (MBq)	Expected Activity (MBq)	% Difference	Unevaporated liquid post simmer
0.05	36	35	2.86	No
0.05	17	18	-5.56	No
0.10	58	59	-1.69	No
0.10	45	45	0	No
0.14	245	248	-1.21	No
0.14	221	224	-1.34	No
0.14	242	251	-3.59	No
0.15	83	85	-2.35	No
0.15	54	57	-5.26	No
0.15	55	54	1.85	No
0.15	47	49	-4.08	No
0.15	50	50	0	No
0.15	48	50	-4	No
0.15	234	248	-5.65	No
0.15	42	42	0	No
0.16	219	225	-2.67	No
0.16	240	245	-2.04	No
0.17	258	270	-4.44	No
0.17	245	247	-0.81	No
0.17	237	250	-5.2	No
0.19	248	251	-1.20	Yes
0.19	222	232	-4.31	No
0.20	267	265	0.75	Yes
0.20	250	248	0.81	Yes
0.20	234	245	-4.49	Yes
0.20	258	270	-4.44	No
0.20	265	266	-0.38	Yes
0.20	81	83	-2.41	Yes
0.20	77	79	-2.53	Yes
0.20	58	61	-4.92	Yes
0.20	105	105	0	Yes
0.20	61	64	-4.69	Yes
0.20	68	66	3.03	Yes
0.20	201	205	-1.95	Yes
0.21	241	256	-5.86	Yes
0.21	242	250	-3.2	Yes

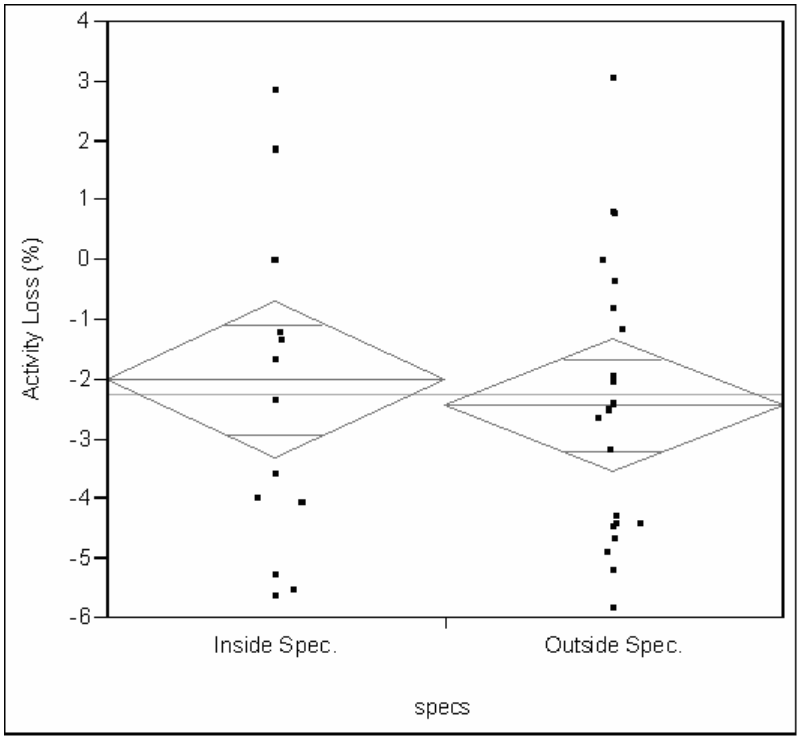


Figure 1: Comparison of the mean percentage differences between the actual activity and the expected activity within the crucible for the results stratified as those within manufacturers specifications (0.15 ml maximum) and those exceeding manufacturers specifications. No statistically significant difference is evidenced by the overlap of the 95% confidence intervals represented by the diamond overlay. This was supported by the student's t test analysis of independent means ($P = 0.62$).

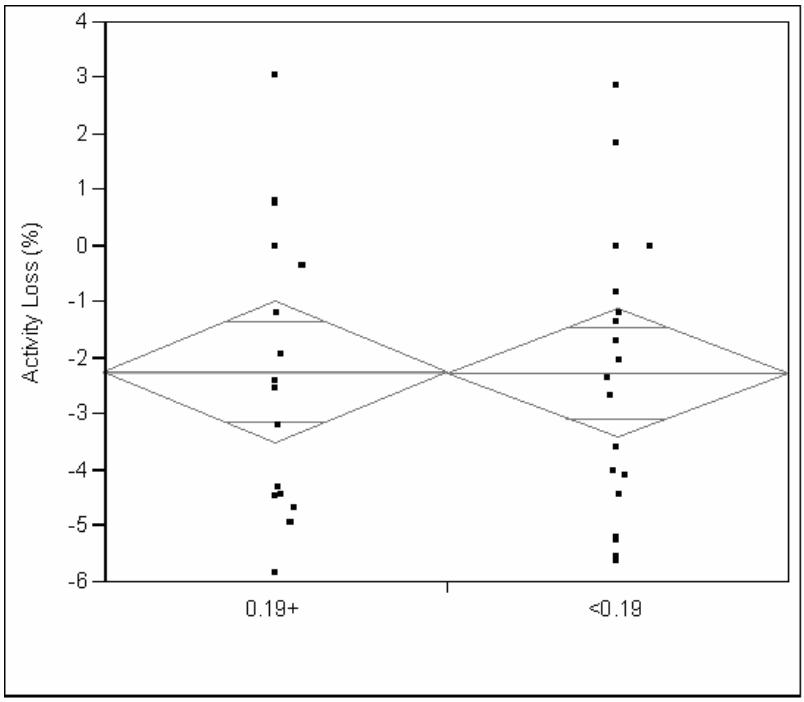


Figure 2: Comparison of the mean percentage differences between the actual activity and the expected activity within the crucible for the results stratified as those volumes less than 0.19 ml and those greater than or equal to 0.19 ml. No statistically significant difference is evidenced by the overlap of the 95% confidence intervals represented by the diamond overlay. This was supported by the student's t test analysis of independent means ($P = 0.98$).

DISCUSSION / CONCLUSION

The Vita Medical Technegas Generator User Manual (*2*) states that if the meniscus activity is above the well of the crucible (Fig. 3), the argon flow during the simmer cycle will blow the ^{99m}Tc pertechnetate out of the crucible into the ashtray. Contrary to this belief, these results demonstrated that the flow of argon during the simmer cycle was not responsible for overflow of ^{99m}Tc pertechnetate into the ashtray. No statistically significant difference was noted between the mean loss of activity for assays within manufacturers specifications compared to those that exceeded these specifications ($P = 0.62$).

While the majority of activity remained within the crucible for the various volumes post simmer cycle, visual inspection of the crucible following the simmer cycle revealed unevaporated ^{99m}Tc pertechnetate for the majority of volumes exceeding 0.19 ml. One might hypothesise that, while the argon flow was not adequate to blow the meniscus into the ashtray, the length and/or temperature of the simmer cycle is not sufficient to fully evaporate volumes of greater than 0.19 ml. After completion of the simmer cycle, the eluant should be evaporated to dryness and leave a white crust of salt and ^{99m}Tc pertechnetate on the graphite (*3*). This white crust was observed on all volumes less than 0.19 ml, with no residual unevaporated ^{99m}Tc pertechnetate evident.

The clinical significance of unevaporated ^{99m}Tc pertechnetate following the simmer cycle is twofold. Firstly, departments over filling the crucible are not making efficient use of available activity, as this extra activity is not converted into Technegas during the burn cycle. The time and resource based theory for over filling the crucible are nullified by these technical difficulties. Secondly, ^{99m}Tc pertechnetate not evaporated during the simmer cycle may produce a wet aerosol of pertechnetate in steam during the burn phase, causing rapid lung clearance and activity in the thyroid and stomach (*3*). ^{99m}Tc pertechnetate which was observed to be unevaporated for the 0.2 ml volumes exceeding 0.19 ml could degrade ventilation image quality due to decreased count density and free pertechnetate uptake in surrounding tissues. It is important, however, to note that no deleterious effects were observed for volumes exceeding manufacturer specifications by less than 0.05 ml.

While no significant loss of activity from the confines of the crucible was demonstrated with increasing volumes of ^{99m}Tc pertechnetate, the practice of over filling the crucible to improve efficiency of the ventilation process, particularly in the presence of poor specific concentrations of pertechnetate, is not recommended. Exceeding a crucible volume of 0.19 ml leaves unevaporated ^{99m}Tc pertechnetate post simmer which may decrease count density, increase the time required to ventilate patients and degrade image quality. Crucible volumes in the range 0.14 ml to 0.19 ml do not exhibit these deleterious effects but also fail to provide significant benefit to preparation time since the maximum increase in crucible activity will be 36% (0.19 ml). While the argon purge does not blow off the convex meniscus and there is negligible post simmer loss of activity from the over filled crucible, this practice is not an effective means of avoiding the need for multiple simmer cycles to increase crucible activity. Alternative strategies to increase crucible activity / time efficiency may include; adjusting the simmer temperature to ensure evaporation to dryness of 0.20 ml crucible volumes, reloading the crucible after a short aborted initial simmer, or utilising a crucible oven (built into the new generation systems).

REFERENCES

1. Christian, P, Bernier, D & Langan, J 2004, *Nuclear Medicine and PET: Technology and Techniques*, 5th edn, Mosby, Philadelphia.
2. Vita Medical Limited 1997, *Technegas Generator User Manual*, Revision H, Australian English Version, Vita Medical Ltd, Sydney.
3. Fawdry, R, Bernier, A & Gruenwald, M 1988, 'Initial Experience with technegas – a new ventilation agent', *Australas Radiol*, vol.32, no.2, pp. 232-238.

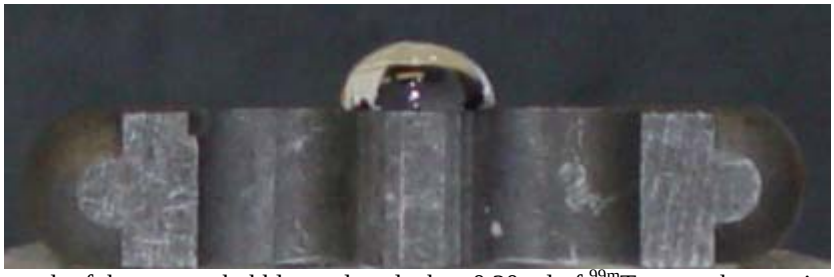


Figure 3: A photograph of the convex bubble produced when 0.20 ml of ^{99m}Tc pertechnetate is added to the crucible well.

Continuing Professional Development – Question and Answer Sheet

Article title: Exceeding the recommended crucible volumes in the Technegas generator.

Your name: _____

RAINS Member Number: _____

Answer the following questions and return the completed sheet before the middle of the month to: RAINS
PO Box U102 or
Charles Sturt University seasonal@rains.asn.au
Wagga Wagga NSW 2678

1. What is the recommended Technegas crucible activity and volume?

2. What does the manufacturer suggest will occur to the bubble during simmer if the crucible is over filled (two words)?

3. What alterations to biodistribution might indicate that the above (question 2) has occured?

4. What did this investigation actually demonstrate caused the altered biodistribution associated with wet aerosol formation?

5. What crucible volume limit was determined by this study?

6. What adjustment to the Technegas generator might allow the use of volumes greater than the maximum outlined above (question 5)?

7. What other strategies might provide more effective means of improving activity/time efficiency?

Do you have a CPD review article in mind or in progress? Email the final draft with author details to seasonal@rains.asn.au and collect 3 CPD points.

The Doctor of Health Science

Introduction
The Doctor of Health Science (DHlthSc) at CSU is a professional doctorate that allows candidates to pursue a research higher degree of the same standard as the PhD but within a structure that is aimed at improving professional practice. Specifically, it offers a research based approach for provision of solutions relevant to the professions and industry.

Professional doctorates aim to provide a tool for advanced research enabling candidates to contribute in a significant way to the knowledge and practice in their profession or discipline area. Consequently, candidates enrolled in professional doctorates tend to be more intrinsically motivated aiming to improve professional practice and enhance job satisfaction.

Course Structure
The DHlthSc is offered by part-time distance education mode and is composed of coursework and an applied research/professional component. Student's progress through the research/professional component of the DHlthSc is monitored by the requirement that students complete subjects in sequence thus meeting pre-defined milestones. The applied research/investigation allows students to develop a research question or topic for investigation by conducting an intensive literature review, critique and reflecting on their professional practices.

The DHlthSc culminates in a professional portfolio (including an exegesis), which integrates the research/investigation within their professional practice. The professional portfolio incorporates reports, papers and publications prepared throughout the course with an exegesis to link the results back to the profession and professional practice, and original question on which the research or investigation is based. The professional portfolio with exegesis is subjected to external examination in accordance with University regulations.

The duration of the DHlthSc is the equivalent of 4.5 years part time enrolment.

Enrolment Pattern
HSC700 Research Critique and Publication
HSC701 Reflective Practice in Health Science
HSC702 Proposal For Applied Research
HSC703 Research Project and Report 64 Points
HSC704 Health Science Portfolio / Exegesis

CHARLES STURT
UNIVERSITY

Admission Requirements
For admission to the DHlthSc applicants would need to demonstrate that they:

- are working in an appropriate field within, or relevant to, the Health Professions and can demonstrate they have the opportunity and facilities to complete the applied research/investigation components of the course; and
- have had a minimum of five years of relevant professional and/or vocational experience (with relevance being determined by the DHlthSc Course Coordinator in conjunction with the proposed principal supervisor); and
- normally hold a Masters degree or equivalent (by coursework) in an approved area of Health Sciences, with credit grades or above in all subjects undertaken.

Course Aims and Objectives
The DHlthSc promotes an advanced, critical reflection on professional practice in the health sciences and aims to:

- provide opportunity for the candidates to continue lifelong learning in keeping with the university's mission statement;
- satisfy the educational needs of professionals working in or aspiring to work in the most senior tiers of the health sciences and related sectors;
- promote the acquisition of advanced analytical and problem solving skills and conceptual insights that enhance the capacity of the candidate to undertake positions of significant responsibility in the health sciences;
- encourage excellence in scholarship and focused research within the candidates discipline area.

Course Coordinator
Dr Janelle Wheat
Senior Lecturer, Faculty of Science
Telephone: 61 2 69332750
Email: jwheat@csu.edu.au

For all inquiries please contact info.csu on:
Telephone: 1800 334 733 (free call within Australia)
Telephone: 61 2 6338 6077 (outside Australia)
Email: inquiry@csu.edu.au
Web inquiry: www.csu.edu.au/student/contact

Continuing Professional Development

Gated myocardial perfusion SPECT quality control

Janelle Wheat[1], Geoff Currie[1] and Ben Ramsay[2]

[1] School of Dentistry and Health Sciences, Charles Sturt University, Wagga Wagga.
[2] Department of Nuclear Medicine, The Canberra Hospital, Canberra.

ABSTRACT

Introduction: While the functional data of gated SPECT is valuable, its collection should not compromise the perfusion data. Failure to detect patient motion or gating errors may result in the generation of a perfusion artefact. This possibility was thought to be more likely when the perfusion data was generated by summation of the reconstructed gated slices.

Methods: This study was a retrospective cross sectional study of 35 patients undergoing gated myocardial perfusion SPECT. The rotating cinematic display and sinograms for the gated and ungated datasets were visually assessed for the presence or absence of patient motion and/or gating errors. In three normal studies, a variety of motions were artificially introduced to produce 18 studies for random evaluation with 12 motion free studies.

Results: Only 51.1% and 34.9% of studies identified on ungated data as having gating errors and patient motions respectively demonstrated a corresponding finding on the gated data. Motion correction software effectively corrected for patient motion in 80% of the ungated data sets and 0% of the gated data sets. In detecting introduced motion, ungated data provided an accuracy of 100% compared to just 80% for the gated data. The ROC analysis provided evidence that visual assessment of the ungated sinogram is preferable to the gated sinogram for detecting patient motion.

Conclusion: Producing the ungated perfusion data set for qualitative assessment from a summation of previously reconstructed gated slices means routine post acquisition quality assurance is performed on a single count deficient gate interval. All gated myocardial perfusion SPECT studies should be ungated to ensure the efficacy of post acquisition quality control.

INTRODUCTION

Gated SPECT provides important diagnostic and prognostic information over SPECT alone by utilising electrocardiographically linked myocardial perfusion images to provide ventricular wall motion and thickening information. This additional information allows both regional perfusion and global function to be assessed simultaneously at no extra cost and with no extra acquisition time (*1*).

A recent (2004) industry survey indicated that 31.1% of departments employ a gated myocardial perfusion SPECT reconstruction strategy that generates the ungated short axis, horizontal long axis and vertical long axis slices by simply summing the gate intervals of the reconstructed gated data (*2*). Intuitively, there are a number of potential problems arising from this strategy:

1. Perfusion data may be over filtered due to summation of low count filtered data causing possible false negative results.
2. Visual examination of raw data for patient motion, gating errors or other artifacts (e.g. incidental radiopharmaceutical accumulation in thorax outside reconstruction window) will rely on the poor count gated data.

The former is a significant problem, particularly for small and non transmural defects, and has been investigated by this group. In unpublished data by this author, a statistically significant decrease in both defect extent and severity was noted using this reconstruction method. The latter may be more problematic if motion or gating errors escape detection and are, thus, included in the reconstructed perfusion data.

The first rule of performing gated myocardial perfusion SPECT is that, while the functional data is valuable, its collection should not compromise the perfusion data. Failure to detect patient motion and, therefore, omitting a repeat motion free study may result in the generation of artefact that could mimic coronary artery disease. A number of investigators have examined the incidence of patient motion in ungated data sets with Wheat & Currie (*3*) reporting a 36% incidence of visually detectable motion, Botvinick et al. (*4*) reporting 25% and Prigent et al. (*5*) reporting the 26%. One suspects the presence of visually detectable patient motion is somewhat more difficult to reliably detect when examining the sinogram and cinematic display of a low count gate interval.

Gating the SPECT data requires implementation of a strategy to deal with arrhythmia with particular attention focussed on ensuring the ungated perfusion data is not compromised. Rejecting ‘bad beats’ using a narrow window means that perfusion data is lost unless all ‘rejected’ counts are acquired in an additional 9th bin / interval for subsequent summation into the ungated data set (*6*). Paul and Nabi (*7*)

recommend a 20% acceptance window and DePuey (*8*) indicated that 25% to 35% is typical in clinical practice. The American Society of Nuclear Cardiology (ASNC) (*8*), however, recommend a 100% window so the functional information is not acquired at the expense of the perfusion data. That is, a 100% window will accept all beats. Only 20.9% of departments employ a 9th interval for rejected beats yet only another 22.0% abandon gating in arrhythmia (*2*). Not surprisingly then, Nichols et al. (*9*) reported that only 26% of gated myocardial perfusion SPECT patients had data sets free of gating errors.

METHODOLOGY

The aim of this investigation was to compare the accuracy and appropriateness of assessing the sinogram and rotating cinematic display on the gated versus ungated raw data for identification of patient motion or gating errors that may have deleterious effects of the reconstructed data. Can the gated raw data sinogram and cinematic display be relied upon to identify data sets requiring repeat scanning?

Study Population Demographics

This study was a retrospective cross sectional study of 35 patients undergoing gated myocardial perfusion SPECT. The study population consisted of 70 myocardial perfusion studies (35 rest and 35 stress). The age of the study population was normally distributed ($P = 0.20$) with a mean of 68.5 years, a median age of 72 years and the age range was 46 to 84 years. The study population consisted of 18 (51.4%) males and 17 females (48.6%) ($P = 0.87$).

Study Protocol

All data were acquired following two day stress/rest (34.3%) or two day rest/stress (65.7%) myocardial perfusion SPECT protocols ($P = 0.06$). All myocardial perfusion SPECT studies employed a 740 MBq dose of ^{99m}Tc tetrofosmin (Nycomed-Amersham, Amsterdam). A triple detector gantry was used to acquire all patient data. All data acquisitions employed low energy, high resolution collimation with step and shoot mode, elliptical orbits and a 64x64 matrix. The zoom was 1.23 and projections were acquired at three degree intervals for 20 seconds per projection to provide a total acquisition time of 15 minutes. All patients were positioned supine with their feet into the gantry for an eight interval gated SPECT acquisition. The gating window was variable with a narrow window (20%) being preferable where the patients rhythm permitted. The window was expanded to as much as 100% as deemed necessary to eliminate potential loss of perfusion data due to gating errors.

Clinical Evaluation

The raw gated SPECT dataset for each study (rest and stress) was converted from an eight interval gated study to an ungated dataset by summation of the eight intervals for each projection. The rotating cinematic display and sinograms for the ungated datasets were visually assessed by two experienced technologist observers independently from one another and blinded to both the second observers' responses and the clinical outcome of the study. Each study was assessed for the presence of visually detectable motion and the presence of gating errors. Each was reported on a five point scale; definitely present, probably present, equivocal, probably absent and definitely absent. After completion of the analysis of all 35 patients' ungated data, the gated studies were evaluated in a similar fashion. This order insured any bias associated with remembered information would benefit the gated study assessment. The end diastolic gate interval was used for all evaluations of the gated data.

All data was presented and assessed using a grey scale (16 bit, 64000 shades). The presence of motion on the cinematic display and the sinogram was indicated by the identification of an obvious disruption to their smooth progression. It has been reported in the literature that motion less than one pixel is not likely to be detected visually (*10,11*). Gating errors were characterized by horizontal bands of low counts relative to adjacent projection data.

Motion Correction

A motion correction algorithm was applied to each set of gated and ungated myocardial perfusion SPECT studies where the ungated data was deemed to 'definitely' contain motion and the corresponding gated data was deemed to either 'definitely' or 'probably' contain motion. Ten studies were identified to satisfy this criteria (seven stress, three rest, six male and four female). The motion correction algorithm corrects for both 'x' and 'y' axis motions and uses parabolic interpolation for fractional shifts. The algorithm re-projects reconstructed data to their original angles to produce a reference for the true projection data and motion estimation (*12*).

A window of interest and thresholding allowed the limitation of the region of comparison to the organ of interest and thus, improving the success rate of motion correction. The motion correction algorithm was applied to corresponding pairs of gated and ungated data. The corrected gated data was subsequently ungated to provide an equitable comparison with the corrected ungated data. Each corrected rotating cinematic display and sinogram were visually examined for motion and reported on a five point scale; definitely present, probably present, equivocal, probably absent and definitely absent.

Motion Simulation

During the evaluation of patient studies outlined above, three studies were selected to have motion artificially introduced. Only the stress studies were utilized for motion simulation to capitalize on the superior heart to background count ratio and heart to liver count ratio (compared to the rest studies). All three patients were also lean to reduce the possibility of physiological artifacts. Cooperative evaluation of the patient studies indicated both to be motion free and without other technical errors (e.g. gating errors). Two patients were male and one was female.

Vertical patient motion was simulated using software to shift the selected projections in the gated stress studies. In essence, vertical motions were simulated by relocating the original motion free projection. Bounce motion was simulated by upward vertical shifting of the raw projection data in a returning pattern while abrupt motion used a non returning pattern. That is to say, shift for bounce simulation only required relocation of three projections while abrupt motion required all subsequent projections represented per detector to be relocated. There were a number of variables that were considered in simulating motion in the studies including:

- Type of motion; vertical bounce and abrupt,
- Direction of motion; vertical motions were simulated in an upward direction,
- Magnitude of motion; two pixels (abrupt) and four pixels (bounce) – this is the minimum for each that will create an artifact (*11*),
- Duration of motion; three frames (bounce) or 20 frames (abrupt),
- Location of motion; RAO 45, LAO 45 and LPO 45.

A total of 18 motion simulation studies were produced as a result of combining these variables for the three patients. A further 12 studies were produced from the original motion free study of each patient; one as raw data and three modified in appearance by count truncation, temporal smoothing and a combination of truncation and temporal smoothing. Thus, a total of 30 gated files required ungating to produce 60 patient files for visual evaluation for motion. The cinematic display and sinogram were randomized for visually inspection and reported on a five point scale; definitely present, probably present, equivocal, probably absent and definitely absent.

Statistical Analysis

The statistical significance was calculated using Chi square analysis for nominal or ordinal data and Student's *t* test for continuous data. A *P* value less than 0.05 was considered significant. The X^2 Pearson Chi Sqaure test was employed for categorical data with normal distribution and the G^2 Likelihood Ratio Chi-Square test for categorical data without normal distribution. Confidence intervals (CI) were employed with 95% confidence. Relative risk (risk ratio) was used to determine the strength of association between exposure and outcomes with a risk ratio of 1.5 indicative of the exposure of interest being 1.5 times more likely to result in the outcome of interest. Receiver operating characteristic (ROC) analysis was performed using JROCFIT software version 1.0.2 developed by Dr John Eng at Johns Hopkins University (Baltimore, USA) as a translation of the ROCFIT program developed by Dr Charles Metz at the University of Chicago (USA).

Data collection and analysis was approved by the Charles Sturt University School of Clinical Sciences, Ethics in Human Research Committee.

RESULTS

The inter-observer correlation for visually detected motion was excellent with a 96% correlation between observers for the presence or absence of visually detectable motion. Similarly, excellent inter-observer correlation was noted for the presence or absence of gating errors with a 94% correlation between observers.

Gating Errors

No statistically significant difference was noted in the presence of gating errors between genders (P = 0.54), age (P = 0.09), study type (rest or stress) (P = 0.32) or protocol (rest/stress or stress/rest) (P = 0.22). For stress studies, 42.9% (15/35) of studies demonstrated 'definite' gating errors and for rest studies, 54.3% (19/35) of studies demonstrated 'definite' gating errors. A further 25.7% (9/35) of stress studies and 11.4% (4/35) of rest studies 'probably' contained gating errors. Only 31.4% (11/35) of patients showed 'definite' gating errors in both rest and stress studies although 48.6% (17/35) of patients had both rest and stress studies classified as either 'definitely' or 'probably' containing gating errors. This translates to 65.7% (23/35) of patients 'definitely' exhibiting gating errors in at least one of their studies which increases to 85.7% (30/35) when 'definite' and 'probable' gating errors are pooled.

Table 1 provides an overview of the gated data versus the ungated data for the presence or absence of gating errors. The highlighted row and column (bold border) demonstrate a predominance of 'definitely present' observations for gating errors on the ungated data with 'probably absent'

predominating the gated data. The G^2 Likelihood Ratio Chi-Square test revealed a statistically significant difference between gated and ungated data ($P < 0.001$). The confidence with which gating errors are detected deteriorates in 61.8% (21/34) of studies where a definite gating error was noted on the ungated data set. Similarly, 92.3% (12/13) of studies where the ungated data determined a 'probably present' gating error were interpreted as 'probably absent' on the gated data set. Furthermore, only 51.1% (24/47) of studies identified as having gating errors ('definitely' or 'probably' present) on ungated data were identified as having gating errors on the gated data. Relative risk suggests assessing the raw sinogram and cinematic display on the ungated files detects twice the incidence of gating errors than the gated files. Less significantly, the confidence with which observers could exclude the presence of gating errors was also lower for the gated data with 70% (7/10) of ungated data receiving a 'definitely absent' response also receiving a 'probably absent' response on the gated data.

Patient Motion

A statistically significant difference was noted in the presence of patient motion between genders ($P = 0.03$) with males more likely to exhibit patient motion. No statistically significant difference was noted in the presence of patient motion for age ($P = 0.25$), study type (rest or stress) ($P = 0.08$) or protocol (rest/stress or stress/rest) ($P = 0.48$). For stress studies, 42.9% (15/35) of studies demonstrated 'definite' patient motion and for rest studies, 44.1% (15/34) of studies demonstrated 'definite' patient motion. One of the rest studies was excluded due to a gating error corrupting the data. A further 17.1% (6/35) of stress studies and 20.6% (7/34) of rest studies 'probably' contained patient motion. Only 29.4% (10/34) of patients showed 'definite' patient motion in both rest and stress studies although 47.1% (16/34) of patients had both rest and stress studies classified as either 'definitely' or 'probably' containing patient motion. This translates to 58.8% (20/34) of patients 'definitely' exhibiting patient motion in at least one of their studies which increases to 76.5% (26/34) when 'definite' and 'probable' patient motions are pooled.

Table 2 provides an overview of the gated data versus the ungated data for patient motion. The highlighted cells (bold border) demonstrate a predominance of 'definitely present' observations for patient motion on the ungated data with 'equivocal' increasing substantially on the gated data. The G^2 Likelihood Ratio Chi-Square test revealed a statistically significant difference between gated and ungated data ($P = 0.03$). The confidence with which patient motion is detected deteriorates in 90.0% (27/30) of studies where a definite patient motion was noted on the ungated data set. Moreover, only 34.9% (15/43) of studies identified as having patient motion ('definitely' or 'probably' present) on the ungated data were identified as having patient motion on the gated data. Relative risk suggests assessing the raw sinogram and cinematic display on the ungated files detects 2.9 times the incidence of patient motion than the gated files. It is also worth noting that 23.2% (16/69) of gated data was deemed equivocal for detection of patient motion compared to just 2.9% (2/69) for the ungated data.

Patient Motion Versus Gating Errors

Not surprisingly, 46.4% (32/69) of studies exhibited both patient motion and gating errors. Perhaps patient motion was sufficient to alter heart rate enough to cause beat rejection. More importantly although of minor significance in this cohort, difficulty in assessing for patient motion resulting in an 'equivocal' classification was always associated with gating errors (2/2). The relative risk of having a gating error in the presence of patient motion is 1.5.

Motion Correction

All 10 ungated data sets demonstrated an improvement in the severity of patient motion while three (30%) of the gated studies demonstrated a worsening of the motion severity after application of the motion correction algorithm. The motion correction algorithm effectively corrected for patient motion in 80% (8/10) of the ungated data sets and 0% of the gated data sets.

Motion Simulation

As illustrated in table 3, there were no false positive or false negative results for the ungated data while the gated data produced an 11.1% (2/18) false negative rate and 33.3% (4/12) false positive rate. Both the sensitivity and specificity for detection of patient motion in the ungated data set was 100% which compared favourably with the 88.9% sensitivity and 66.7% specificity in the gated data set. The predicted value of a positive result (PVP) was 80% for the gated data and 100% for the ungated data. Similarly, the predictive value of a negative result (PVN) was 80% for the gated data and 100% for the ungated data. Note surprisingly then, a statistically significant difference was noted for responses between gated and ungated data ($P < 0.001$) (table 4).

ROC analysis (Fig. 1) demonstrates that assessment of the ungated raw data sinogram and cinematic display is superior to the same assessment on the corresponding gated data for detection of patient motion. The ROC area under the curve for the gated data, defined by the solid line in figure 1, was 0.889. By comparison, the ROC area under the curve for the ungated data, defined by the broken line in figure 1, was 1.00.

Table 1: Contingency table of the evaluation confidence for gating errors in the gated data by the ungated data.

		GATED					
		Definite	**Probably**	**Equivocal**	**Probably Not**	**Definitely Not**	
UNGATED	**Definite**	13	10	1	10	0	**34**
	Probably	0	1	0	12	0	**13**
	Equivocal	0	0	0	0	0	**0**
	Probably Not	0	0	0	6	7	**13**
	Definitely Not	0	0	0	7	3	**10**
		13	**11**	**1**	**35**	**10**	**70**

Table 2: Contingency table of the evaluation confidence for patient motion in the gated data by the ungated data.

		GATED					
		Definite	**Probably**	**Equivocal**	**Probably Not**	**Definitely Not**	
UNGATED	**Definite**	3	7	5	15	0	**30**
	Probably	0	5	2	6	0	**13**
	Equivocal	0	0	1	1	0	**2**
	Probably Not	0	0	7	12	0	**19**
	Definitely Not	0	0	1	3	1	**5**
		3	**12**	**16**	**37**	**1**	**69**

Table 3: Contingency table of the evaluation confidence for patient motion versus the ungated and gated data. False positive and false negative results are highlighted by bold borders.

		REST					
		Definite	**Probably**	**Equivocal**	**Probably Not**	**Definitely Not**	
No motion	**gated**	0	4	0	4	4	**12**
	ungated	0	0	0	5	7	**12**
Motion	**gated**	12	4	0	1	1	**0**
	ungated	17	1	0	0	0	**5**
Total	**gated**	**12**	**8**	**0**	**5**	**5**	**30**
	ungated	**17**	**1**	**0**	**5**	**7**	**30**

Table 4: Contingency table of the evaluation confidence for patient motion in the gated data by the ungated data. False positive and false negative results are highlighted by bold borders.

		GATED					
		Definite	**Probably**	**Equivocal**	**Probably Not**	**Definitely Not**	
UNGATED	**Definite**	12	4	0	0	1	**17**
	Probably	0	0	0	1	0	**1**
	Equivocal	0	0	0	0	0	**0**
	Probably Not	0	2	0	3	0	**5**
	Definitely Not	0	2	0	1	4	**7**
		12	**8**	**0**	**5**	**5**	**30**

DISCUSSION

This investigation reported the presence of gating errors in between 65.7% and 85.7% of gated studies. This is concordant with Nichols et al. (*9*) who reported that only 26% of gated myocardial perfusion SPECT patients had data sets free of gating errors. While gating errors are evident from visual examination of the raw data sinogram, visual detection does not actually translate to the introduction of artefact that may undermine diagnostic integrity. While one might expect that severe gating errors would undermine the diagnostic integrity of the perfusion data (Fig. 2a), one might also presume minimal impact from more subtle gating anomalies (Fig. 2b).

Only 51.1% of studies identified as having gating errors on the ungated data were identified as having gating errors on the gated data. Similarly, only 34.9% of studies identified as having patient motion on the ungated data were identified as having patient motion on the ungated data. The higher count ungated data provides greater accuracy and confidence for decisions about the presence or absence of patient motion and gating errors over the low count gated data (Fig. 3 and 4). A fairly intuitive outcome, especially in Nuclear Medicine where a ‘counts count’ philosophy is the cornerstone of quality imaging. With an eight fold increase in counts per pixel, the ungated data provides greater statistical certainty than the gated data equating to a 2.9 fold decrease in sampling error.

The motion simulation study allowed qualification of the relationship between ungated and gated data with ROC analysis. The ROC analysis provided evidence that visual assessment of the ungated sinogram is preferable to the gated sinogram for detecting patient motion. Both the sensitivity and specificity for detection of patient motion in the ungated data set was 100% which compared favourably with the 88.9% sensitivity and 66.7% specificity in the gated data set. In detecting known patient motion, ungated data provided an accuracy of 100% compared to just 80% for the gated data. One might imagine that this figure could be substantially worse if motions were introduced toward the lower end of visual detection (i.e. one pixel). The motions that were simulated were known to be of a magnitude and duration sufficient to cause a perfusion artefact (*3*). Thus, failure to detect the motion on the gated data set may translate to an artefact that mimics coronary artery disease, undermining diagnostic integrity. It is crucial that such motions are detected in routine post acquisition quality assurance so that the study can either be corrected, repeated or considered during interpretation. Unfortunately, in the event that motion is detected on the gated data, motion correction is eliminated as an option because the lower count statistics undermines the algorithm accuracy (Fig. 5).

CONCLUSION

Producing the ungated perfusion data set for qualitative assessment from a summation of previously reconstructed gated slices is fraught with danger. This strategy requires routine post acquisition quality assurance to be performed on a single count deficient gate interval. The associated lack of statistical certainty may permit patient motion and gating errors to go undetected. While the presence of patient motion and/or gating errors does not necessarily render the data set worthless, it is important for the reporting physician to consider their presence carefully. All gated myocardial perfusion SPECT studies should be ungated to ensure the efficacy of post acquisition quality control.

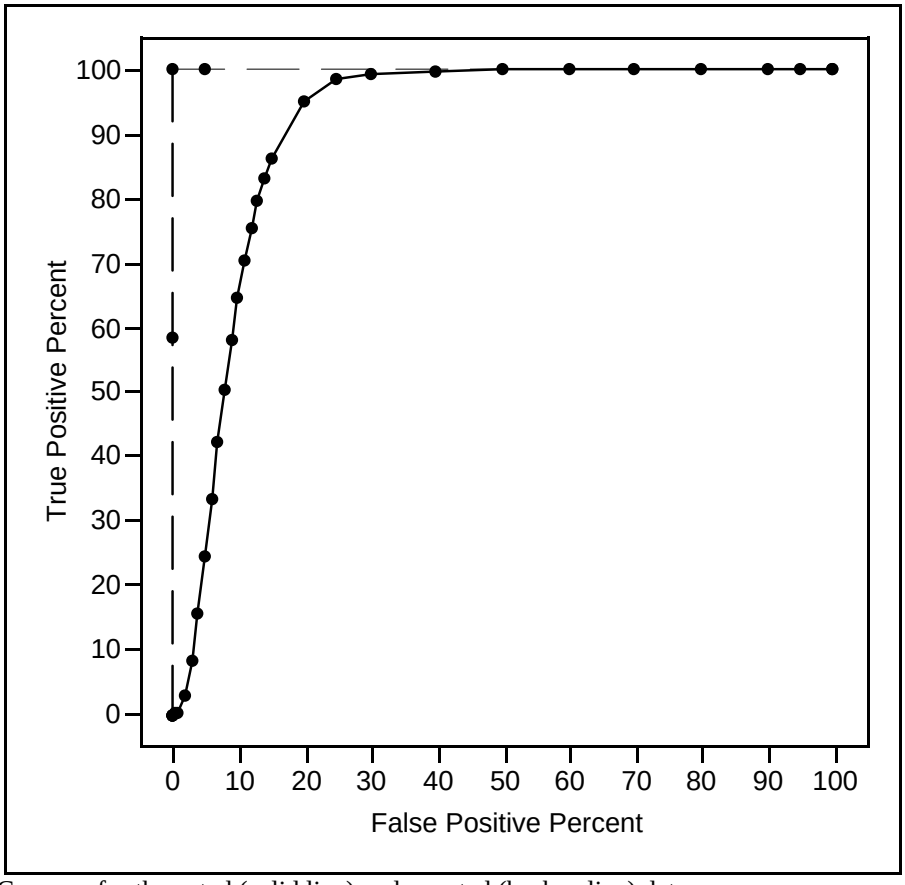


Figure 1: ROC curves for the gated (solid line) and ungated (broken line) data.

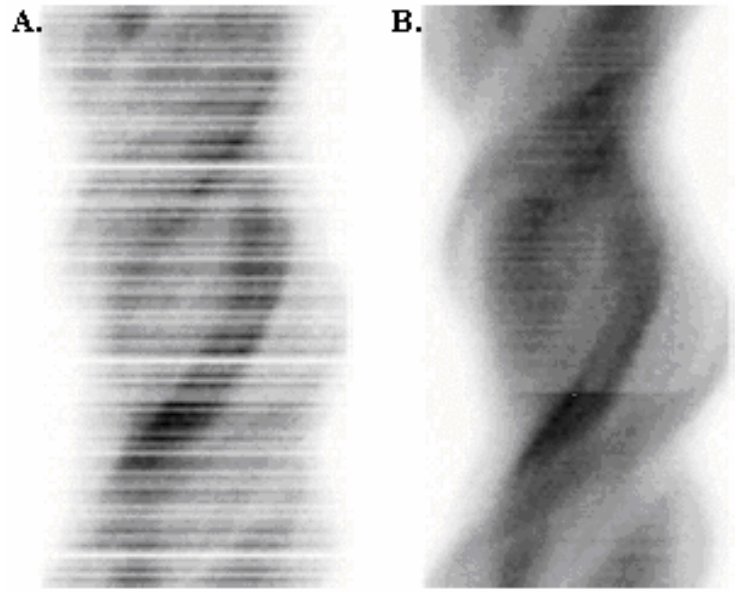


Figure 2: Raw data sinograms providing clinical examples of marked gating errors (A) and subtle gating errors (B).

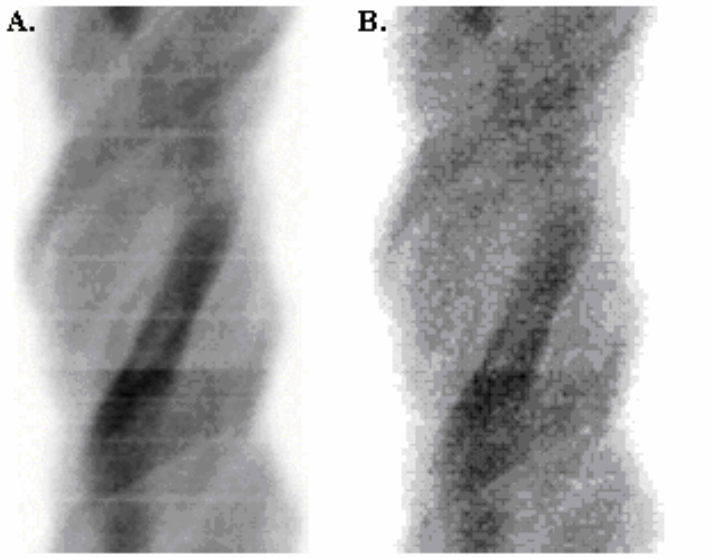


Figure 3: Raw data sinograms providing clinical examples of an obvious gating error on the ungated data (A) which is not obvious on the corresponding gated data (B). gating errors are seen as horizontal count deficient strips.

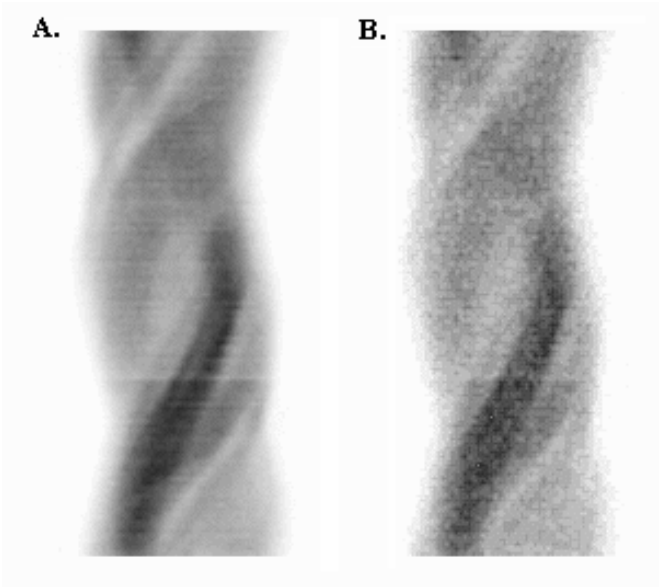


Figure 4: Raw data sinograms providing clinical examples of obvious multiple small motions on the ungated data (A) seen by tracing the right edge of the cardiac sinogram. This motion is not obvious on the corresponding gated data (B).

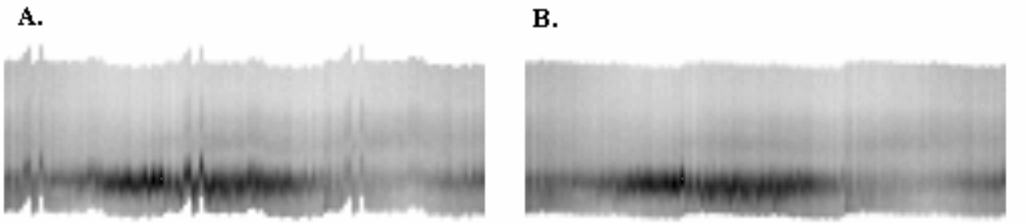


Figure 5: Raw horizontal sinograms post motion correction. Motion correction performed on the gated data (subsequently ungated for display) is illustrated on the left (A). Motion correction applied to the ungated data is seen on the right (B). The superior and inferior edges provide a map of the actual corrective motions applied to the raw data. The relatively subtle corrections determined by analysis of the ungated data eliminated visually detectable patient motion (B). Conversely, the gated correction introduced marked deviations that corresponded to a worsening of motion in the data (A).

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RAINS CPD Initiatives.

The following initiatives have been developed by RAINS to facilitate achievement of the 30 CPD points for RAINS members. These are proposed activities that mirror activities approved by the ANZSNM with some modification for more ready use in the rural environment.

Activity	Description	CPD Points
E-Journal Club	RAINS members can submit a power point presentation of a relevant journal article in Nuclear Medicine of 20-30 minutes. View, read and submit review questions (80% pass mark).	2 presenter points 1 attendee point
E-Grand Rounds	RAINS members can submit a power point presentation of one or more clinical cases. Content should include patient history, scan methodology, other imaging procedures, relevant technical information, final report and patient outcomes of 20-30 minutes View, read and submit review questions (80% pass mark).	2 presenter points 1 attendee point
Continuing Education Articles and Tests	Each issue of Seasonal RAINS will contain 1 or more continuing education articles with tests. Completion of the tests and submission back to RAINS with an 80% pass mark will attract CPD points.	2 per test
Writing CPD articles/tests	RAINS members are encouraged to write fully referenced and scientific continuing education articles accompanied by 10 'test' questions and submit for distribution in Seasonal RAINS.	3 per article published
Short Courses and workshops	CSU in conjunction with RAINS and the ACT Branch of the ANZSNM organise an annual 2 day CE workshop in Wagga.	4 points
In-service Education	Provide 30 minute power point presentation with narration for inclusion on CPD CD, including written question). View, read and submit review questions (80% pass mark).	2 presenter 1 attendee
Book or journal article(s) review	Write a considered book review or review of a journal article (nuclear medicine) for inclusion in Seasonal RAINS (1 page).	2 points
Research	Principle or co-investigator in a research project.	up to 15 per 3 years; 10 as principal & 5 as co-investigator
Publication	Principle or co-author of a published paper.	up to 5 per 1 yr

Continuing Professional Development – Question and Answer Sheet

Article title: Gated myocardial perfusion SPECT quality control.

Your name: _____

RAINS Member Number: _____

Answer the following questions and return the completed sheet before the middle of the month to: RAINS
PO Box U102 or
Charles Sturt University seasonal@rains.asn.au
Wagga Wagga NSW 2678

1. How might summing reconstructed gated data to produce slices for perfusion assessment (ungated) impact on the integrity of study QC?

2. What is the first rule of performing gated SPECT?

3. How should 'bad beats' ideally be handled in gated myocardial SPECT?

4. What does ROC analysis stand for?

5. What proportion of studies contain gating errors?

6. What proportion of ungated studies showing gating errors failed to show gating errors in examination of the gated data?

7. What proportion of ungated studies showing patient motion failed to show gating errors in examination of the gated data?

Do you have a CPD review article in mind or in progress? Email the final draft with author details to seasonal@rains.asn.au and collect 3 CPD points.

RAINS Report - 2007

Geoff Currie[1], Matt Ayers[2], Pete Tually[3], Russell Pearce[4], Michael Crook[5], Narelle Harrison[6], Carla Robertson[7] and David Grimmond[8]

[1] Charles Sturt University, Wagga Wagga, NSW 2678 Australia
[2] Mid North Coast Diagnostic Imaging, Port Macquarie, NSW 2444 Australia
[3] Imaging the South, Perth, WA 6007 Australia
[4] Gosford Nuclear Medicine, Gosford, NSW 2250 Australia
[5] Toowoomba Nuclear Imaging, Toowoomba, QLD 4350 Australia
[6] Central Gippsland Health Service, Sale, VIC Australia
[7] Griffith Nuclear Medicine, Griffith, NSW 2680 Australia
[8] Federal Committee, ANZSNM, Australia

SUMMARY

Membership during the first six months of operation:

- 97 members,
- 52.6% female ($P = 0.612$),
- 71.1% technologists, 22.7% students, 5.2% physicians/radiologists and 1.0% in sales,
- 82.7% (excluding students) are also ANZSNM members,
- 12.0% (excluding students) are Australian Institute of Radiography (AIR) members,
- dual ANZSNM/AIR memberships was held by 9.3% (excluding students),
- distribution by state includes; New South Wales (57.7%), Victoria (14.4%), Queensland (12.4%), Australian Capital Territory (8.2%), Tasmania (3.1%), Western Australia and Northern Territory (both 2.1%) ($P = 0.298$),
- 88.9% of AIR members where in NSW (11.1% in VIC),
- 88.9% employed in private Nuclear Medicine departments.

With respect to ordinary members:

- 90.9% are technologists and the remainder physicians/radiologists,
- 47.3% are female ($P = 0.686$),
- 81.5% have ANZSNM membership,
- 16.7% AIR membership,
- state distribution includes New South Wales (49.1%), Victoria (18.2%), Queensland (20.0%), Tasmania (5.5%), Western Australia and Northern Territory (both 3.6%),
- 94.2% employed in private Nuclear Medicine departments.

With respect to associate members:

- 100% are technologists,
- 59.5% are females ($P = 0.216$),
- 90% have ANZSNM membership,
- 0% AIR membership,
- state distribution of members includes New South Wales (55.0%), the Australian Capital Territory (35.0%) and Victoria (10.0%),
- 75.0% are employed in private Nuclear Medicine departments.

CPD point accrual was evaluated with respect to qualified technologists only and limited to RAINS specific CPD activities:

- 65.2% of technologists received CPD points from RAINS,
- 10.5% of associate members did not receive any RAINS based CPD points while 44.0% of ordinary RAINS members accrued zero RAINS CPD points,
- the mean CPD point accrual was 7.4 with a range of 2 to 21 and a median of 7,
- ANZSNM members accrued a mean of 7.7 points while those without ANZSNM membership only accrued a mean of 5.5 points ($P = 0.205$),
- AIR members accrued a mean of 5.7 points while those without ANZSNM membership only accrued a mean of 7.7 points ($P = 0.248$),
- the mean points accrued by males was 7.7 compared to 7.2 for females ($P = 0.674$),
- the mean CPD points was highest for New South Wales (8.6) followed by Queensland (7.5), Western Australia (6.0), Victoria (5.3) and Australian Capital Territory (4.9) ($P = 0.092$),
- no statistically significant difference was noted in the mean CPD points accrued between the public (6.0) and private (7.1) sectors ($P = 0.498$),
- no statistically significant difference was noted in the mean CPD points accrued between the ordinary members (7.2) and associate members (7.8) sectors ($P = 0.631$).

Conclusion

It is clear that RAINS activities extend advantage to regional and metropolitan based practitioners; particularly with respect to CPD. The importance of associate members can not be over stated. This

analysis suggests that associate members tend to join RAINS specifically for the CPD opportunities. For ordinary members, CPD is just one of several key motivations for RAINS membership; issues of isolation and lack of representation. CPD activities have been prominent in the early achievements of RAINS so 2008 will see emergence of strategies geared toward non CPD issues confronting rural practitioners including, but not limited to:

- Provide a voice and representation.
- Overcome barriers to training, recruitment and continuing education.
- Promote equity of service provision in rural areas.
- Undertake research on rural issues.
- Provide a network for support and collaboration.
- Integrated approach to student clinical placements.
- Lobby professional bodies on rural issues.
- Promote Nuclear Medicine services in the rural health sector.
- Inform and lobby, where appropriate, legislative and regulatory processes impacting on rural Nuclear Medicine.

CPD will continue to be an important priority in 2008 and will include opportunities for point accrual well in excess of the requirements for ANZSNM re-accreditation including, without being limited to:

- Two CPD articles per quarter in *Seasonal RAINS* (8 points annually with additional points available for authors).
- CPD CD distributed with 6 narrated powerpoint presentations (12 points annually with additional points available for presenters).
- Annual November CPD conference (4 points with additional points available for presenters).
- Journal or book review published in *Seasonal RAINS* (2 points per review).
- Collaborative publications on rural issues (2 points annually for participants).
- RAINS based research projects across rural departments (5 points over 3 years for participants).

A proactive approach to equity issues in CPD has provided a cost effective solution in rural Australia for a problem that continues to burden regional and metropolitan colleagues. The initial six months of operation for RAINS has provided a sound platform to build a productive future for rural Nuclear Medicine and CPD more generally.

Strategic Alliance of Rural ResearcherS – STARRS

The lure of private practice or rural life often attracts highly skilled Nuclear Medicine professionals away from teaching hospitals. The opportunity for networking with colleagues is limited and can be prohibitive of research participation. Private and rural practice often fall short of providing the critical mass of patients, staff, expertise or resources required to complete clinically relevant research. Despite this, those of us isolated professionally are often in the best position to convolve projects that will directly impact on our patients or the way we perform our duties. It may simply be a lack of confidence in tackling a research idea in isolation that is prohibitive of development of projects aimed at solving our key clinical issues.

A key platform of RAINS is to facilitate strategic networking opportunities amongst members. In 2007, this networking was successful in a number of areas including; locum relief, representation and shared collective knowledge. In 2008 we aim to further develop the support network developed by and for RAINS members. Research is a key component of that plan because collaborative research activity meets a number of RAINS objectives:

- CPD points for participation and publication.
- Targets the sense of professional isolation that can impact on staff retention.
- Exploits and showcases the unique capabilities of rural practitioners.
- Provides an opportunity to address unique needs of rural patients.
- Strengthens the support network amongst rural practitioners.
- Provides an informed foundation for lobbying legislative or regulatory bodies.
- Strengthens the position of RAINS within industry which provides a greater strength for professional representation.
- Provide an established network of research participants that provides both a ready made multi-centre structure for research and collectively provides the critical mass of patients, expertise and resources.

In 2008, RAINS will launch a special interest group, STARRS, for those members keen to participate in research at any level. Opportunities will evolve for active and passive participation. Actual roles and degree of participation in any given project will vary depending on an individuals interest and expertise; roles within a project will be tailored to complement the skills and interests of individuals. The specific goal of RAINS is to create an alliance of researchers with complimentary skills and interests. Collectively amongst the team of RAINS members working on any given project, all of the skills and expertise to conduct and disseminate research will be available.

Research is an easy and enjoyable path to satisfying CPD. You can claim up to half of the CPD point requirement from being a researcher with 10 points per 3 year cycle for principle investigators and then another 5 points per 3 year cycle for projects where you are a co-investigator. Then, of course, the results need to be disseminated and you can claim another 5 points per year for a mix of principal author (5 points per paper) or co-author (2 points per paper).

If you are interested in contributing to research in any capacity from assisting with project conception, data collection, through data analysis, manuscript preparation to team leader, please register your interest by contacting:

Geoff Currie
Convenor, RAINS STARRS
gcurrie@csu.edu.au

Please be assured that the STARRS convenor and his University colleagues are already entitled to claim the full 30 points available through research and publication. The STARRS initiative offers no CPD benefit to these parties. This initiative is squarely aimed at facilitating research for RAINS members and at strengthening the RAINS network.

All RAINS members are also welcome to register their research ideas or suggest issues that might need some attention from STARRS. Ideas may be focussed on rural issues or may have broader validity.

There are currently 3 research projects being developed for 2008.

JOIN RAINS STARRS NOW

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Book Review

A Clinician's Guide to Nuclear Oncology

2007, Alazraki, Shumate & Kooby, SNM Publishing.

This book is written with the express interests of clinicians caring for cancer patients in mind. Nuclear medicine plays a key role in diagnosis, staging and response to therapy for many types of cancer yet the actual use varies from site to site due to, among other factors, availability of nuclear medicine services and awareness / education of medicos caring for cancer patients. This book aims to provide cancer clinicians with a resource outlining the availability of procedures, appropriateness of procedures and alternative modalities in a variety of cancers.

The book also includes radionuclide therapies. The book provides a simple overview of the use, appropriateness and radiation safety issues surrounding the more common radionuclide therapy procedures. Unfortunately this section is included as a brief appendix which understates both the current importance and future directions of radionuclide therapy. A greater emphasis on efficacy of radionuclide therapy options might have provided clinicians with more useful information.

Perhaps the edge that this book provides is an attempt to integrate nuclear oncology into the molecular imaging domain. Clearly nuclear medicine plays a key role in any molecular imaging clinical algorithm, however, this book provides concise delineation of the practical applications of molecular imaging in a variety of clinical situations.

A limitation is the lack of demarcation between standard nuclear medicine and PET techniques. While obvious to a nuclear medicine professional, the target audience of the book may lack sufficient knowledge/understanding to massage the book applicability depending on the local availability of PET. While PET and PET/CT represent a significant component of molecular imaging, broader validity of this book requires greater emphasis on currently available standard nuclear medicine options. This is important in rural Australia where the bulk of the books content promotes the use of technology not readily available. More importantly, perhaps, is the accompanying understatement of the clinical utility of standard nuclear medicine procedures that are available in sites without PET.

Each chapter provides information on epidemiology, advances, staging, clinical indications, radiopharmaceuticals, procedural overview and review of treatment options. Generally, chapters focus on specific cancer groups including:

- lung,
- breast,
- prostate,
- colorectal,
- lymphomas,
- melanoma,
- neuroendocrine,
- oesophagus and stomach,
- pancreatic and biliary,
- soft tissue sarcoma,
- thyroid,
- other head and neck,
- paediatric,
- germ cell,
- gynaecologic,
- renal and bladder,
- brain.

Additionally, a chapter is dedicated to providing an overview of PET and PET/CT with FDG.

All of that information in less than 200 pages provides an indication of the depth of information. Indeed, it is difficult to see the usefulness of the book to the target audience. Any clinician managing cancer patients should have far greater depth of understanding of the bulk of the content while the nuclear medicine information really provides insufficient detail on which to base a decision to change current management strategies. It might be useful as an introductory guide to the oncology resident.

It does, however, provide a very useful resource for the Nuclear Medicine Technologist with readily available summaries of key epidemiological and pathophysiological information for a variety of cancers. An insight into the clinical role of nuclear medicine in oncology, in the Australian setting, might also be gleaned.

Geoff Currie
School of Dentistry and Health Sciences,
Charles Sturt University, Wagga Wagga.

Do you have a book review in mind or in progress? Email the final draft with author details to seasonal@rains.asn.au and collect 2 CPD points.

Journal Article Review

The Role of V/Q Scanning in PE

The Journal of Nuclear Medicine (JNM) has sparked some debate over recent editions on the role that the V/Q scan plays in pulmonary embolism (PE). In an *invited perspective* in the September 2007 edition of the JNM, Strashun (*1*) argued the 'unclear medicine' perspective, highlighting the difficulties encountered when trying to detect 'cold' lesions. Strashun argues that the poor specificity and variable sensitivity of the V/Q scan resulted in the subjective interpretation criteria that provides 'shades of grey' rather than more definitive 'black and white' diagnostic reports. He further argues that these deficiencies combined with the high frequency of severe PE and the associated (30%) mortality rate plus the non specific clinical presentation of patients has driven clinicians to seek out alternative diagnostic tools. The article provides a brief insight into the PIOPED I criteria and suggests the lack of 'binary' (yes/no) outputs has paved the way for the emergence of CT angiography in PE. This introduction fails to provide any insight into the favourable positive and negative predictive power of the V/Q scan or indeed the evolutionary steps taken in the interpretation criteria. That is, PIOPED I provides a very rudimentary base for more advanced interpretation criteria. This is especially true in Australia where Technegas is in widespread use. PIOPED was based on 133Xe single projection inspiration/washout ventilation studies and makes no account of the improved diagnostic integrity associated with multi-projection ventilation scanning using either 99mTc based aerosols or Technegas. Despite the merits of V/Q scanning that were not addressed by Strashun, he indicates that in the USA centres with availability of multi-detector CT angiography (MDCTA) have broadly abandoned the use of the V/Q scan in PE. Anecdotally, Australia has seen a similar pattern although one suspects this is more related to marketing than to actual diagnostic integrity.

Strashun (*1*) provides a very brief overview of the MDCTA results of PIOPED II suggesting that these results leave a very limited role for the V/Q scan. Interestingly, the author argues that MDCTA has only been competitive in the face of recent technological advances in CT yet overlooks the impact of advances in scintigraphy; Technegas (perhaps due to its limited use in the USA) and SPECT. Further, a major reason cited for choosing MDCTA over V/Q in PE was the ability of CT to detect other causes of symptoms. Not withstanding the requirements for a chest xray to be performed on all V/Q scan patients, the introduction of SPECT/Ct with associated attenuation correction not only improves diagnostic integrity, beyond MDCTA in some reviews, but also affords the opportunity for detection of incidental pathology.

Perhaps the biggest issue in the V/Q versus CT debate in PE was only briefly addressed by Strashun (*1*); cost and radiation burden. Furthermore, the risks of CT contrast induced renal failure are sufficiently high to warrant a glomeruli filtration rate (GFR) below 30 ml/min as the cut-off below which CT should not be performed. Considering the co-morbidities associated with and risk factors for developing PE, one suspects that the absence of routine GFR determination using an accurate method of calculation (eg. DTPA) rather than a simple estimation (eg. based on creatinine) sees many departments 'running the gauntlet' with the health and wellbeing of patients. We should not forget that there are also significant inherent risks associated with both ionic and non-ionic contrast media.

The additional radiation burden to the patient having MDCTA is alarming. Strashun (*1*) indicates that the increase in radiation dose compared to the 99mTc MAA perfusion study is as much as 178 fold (500 mGy to 0.28 mGy). Moreover, the risk of breast cancer increases by as much as 1 in 500 highlighting the role the very high positive and negative predictive value of the V/Q scan plays in the diagnostic workup in PE. That is, V/Q should be the first line procedure, particularly in females or those with co-morbidity, and MDCTA should be used only in cases where the V/Q is 'intermediate probability'; an outcome significantly reduced with the use of Technegas. Strashun (*1*) appears to concede that the limitations MDCTA (risks and radiation burden) are prohibitive of complete displacement of the V/Q scan but concludes that MDCTA is a superior diagnostic tool. This is despite the omission of consideration of the previously mentioned advances in scintigraphy and the failure to disclose that PIOPED II excluded 40% of patients from undergoing MDCTA on the basis of renal impairment, allergy or ill health.

It was not entirely surprising that Strashun (*1*) was taken to task by a group led by Australian nuclear physicians. Led by A/Prof Roach (*2*), a keynote speaker at the recent RAINS CPD conference in Wagga Wagga (November 2007), surprise was expressed at the omission of V/Q SPECT from the Strashun (*1*) article. Roach et al. (*2*) reminded readers that V/Q SPECT has been validated as being superior to both planar V/Q scanning and MDCTA in PE with consistent improvements in both

sensitivity and specificity. This is clearly discordant with the opening approach of Strashun (*1*). Moreover, SPECT V/Q has further reduced 'intermediate probability' results (after Technegas improvements) to less than 5% which might argue for a very limited role for MDCTA since it is best reserved for this sub group of patients. Roach et al. (*2*) points out that MDCTA, even with recent advances, misses 1 in 6 PE diagnoses; a failure rate well below V/Q scanning. Roach et al. (*2*) glean contrasting figures from the PIOPED II report that provide a stark contrast to the positive view of MDCTA provided by Strashun (*1*). Roach et al. (*2*) conclude that the use of MDCTA should be limited on the basis of its poor sensitivity, not just risks and radiation burden, highlighting the 98.5% negative predictive value of V/Q SPECT in PE.

It is clear that the role of V/Q scanning in PE will vary based on the procedures adopted. The difficulties faced in nuclear medicine practice is that high profile journals like the JNM may have a significant influence on referral patterns despite having limited validity in this country. The superior methods employed for V/Q scanning in Australia (SPECT and Technegas) over the USA in particular provides an excellent example of this phenomena. Freeman (*3*) in the January 2008 JNM articulates the political momentum behind the emergence of MDCTA in PE; radiologists and clinicians are more comfortable with an anatomic demonstration of the presence or absence of a clot. Freeman (*3*) intimates that the limitations outlined by both Roach et al. (*2*) and Strashun (*1*) can not be mitigated and, thus, the role of the V/Q scan in PE remains secure and 'front line'.

Despite the 65 to 250 fold increase in radiation dose to the chest reported by the American College of Radiology between the V/Q scan and MDCTA, the key considerations when deciding on the use of MDCTA and V/Q appears to be (*3*):

- clinical efficacy (V/Q superior based on PIOPED II),
- out of hours availability (MDCTA more readily available),
- interpretive expertise of physician (will depend on whether the V/Q is reported by a nuclear physician or radiologist).

While Freeman (*3*) argues that the V/Q scan should be the front line procedure in the assessment of suspect PE, he recognizes that in many institutions the decision to move toward MDCTA has been made and is irreversible in the short term. Despite this, Freeman (*3*) highlights the role that V/Q might play in centres where MDCTA remains the front line procedure:

- A baseline V/Q scan should be performed to allow follow-up in all patients with a MDCTA positive for PE.
- A basline V/Q scan should be performed on all patients with known deep vein thrombosis (DVT) to detect 'silent' PE (38% incidence).

The above perhaps provides a strong argument for using V/Q scan as the first line tool since:

- all positive MDCTA patients will go on to have a V/Q anyway (only intermediate probability V/Q scans would go on to have MDCTA if V/Q was font line tool) and
- it offers a clear argument that the risks and radiation burden of MDCTA are too great for it to be used as a screening tool where a 62% of subjects would be negative.

The authors of this review concur with the sentiments of Roach et al. (*2*) and the conclusion of Freeman (*3*); that the trend toward the use of MDCTA in PE must be reversed.

References

1. Arnold M. Strashun. A Reduced Role of V/Q Scintigraphy in the Diagnosis of Acute Pulmonary Embolism, *J Nucl Med*, 2007; 48: 1405-1407.
2. Paul J. Roach, Paul Thomas, Marika Bajc, and Bjorn Jonson. Merits of V/Q SPECT Scintigraphy Compared with CTPA in Imaging of Pulmonary Embolism, *J Nucl Med*, 2008; 49: 167-168.
3. Leonard M. Freeman. Don't Bury the V/Q Scan: It's as Good as Multidetector CT Angiograms with a Lot Less Radiation Exposure, *J Nucl Med*, 2008; 49: 5-8.

Janelle Wheat and Geoff Currie
School of Dentistry and Health Sciences,
Charles Sturt University, Wagga Wagga.

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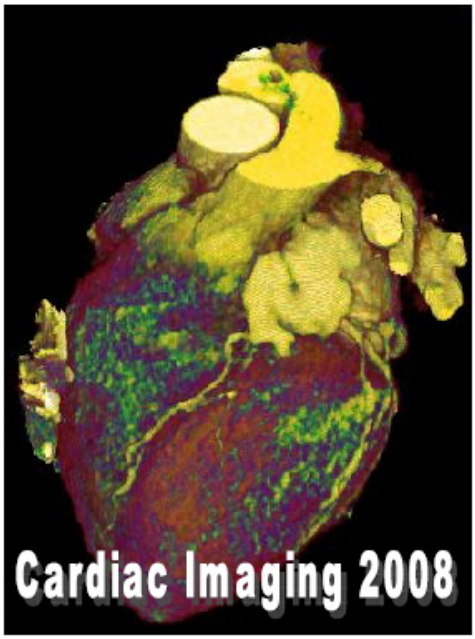

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Seasonal RAINS will be sent to RAINS members during Summer, Autumn, Winter and Spring.

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All submissions will be reviewed for appropriateness and accuracy (where relevant). Inclusion in Seasonal RAINS remains the discretion of the editorial board. Preference will be given to submissions consistent with the philosophy and purpose of RAINS.

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300-500 word limit.

Interesting Image

1 JPG image and 300 word limit case presentation.

What The … ?

1 JPG image and 100 word limit solution.

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Summary of recent or upcoming events. Update RAINS member achievements; publication, conference presentation or scholarship.

Book or Journal Article(s) Review

Review of a recently released nuclear medicine text or journal article(s) related to nuclear medicine. Minimum of 1 page.

E-Journal Club

20-30 minute power point presentation of a relevant journal article in Nuclear Medicine. Submissions should include written text and discussion for each slide plus 10 test questions.

E-Grand Rounds

Submit a 20-30 minute review summary and presentation (power point) of one or more clinical cases. Content should include patient history, scan methodology, other imaging procedures, relevant technical information, final report and patient outcomes. Submissions should include written text and discussion for each slide plus 10 test questions.

In-Service Education

Seminars should be submitted as power point presentations with audio narration. Audio recordings should be embedded in the power point presentation (not linked) using a radio quality setting (22kHz, 16 bit, mono). Ensure sound quality is suitable for circulation. Valuable presentation might only be included if narration is re-recorded. Accepted presentations will be included on the RAINS CPD in-service CD. All presentations should be accompanied by 10 review questions. Presentations should be sent by mail to: The Editor, PO Box U102, CSU, Wagga Wagga, 2678.

CPD Articles

Submissions should provide an educational review of an area of interest. The reviews should be well researched and present all valid perspectives. CPD articles may be accepted after review by the editorial board. Alternatively, the submission may be accepted with some suggested revision or deemed not suitable for the purpose intended (CPD). All submission must adhere to the guidelines provided by the *Journal of Nuclear Medicine Technology*; available on the SNM web site (www.snm.org).

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Rural Alliance In Nuclear Scintigraphy - (RAINS)

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There are no membership fees for RAINS in 2007.

Please send complete forms to:
RAINS
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I wish to apply for membership to RAINS and, if accepted as a member, I undertake to comply with the RAINS Charter.

See membership guidelines (please tick):

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Professional Category (please tick):

Technologist/Scientist …….	☐	Physician ……...	☐
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