SPECIAL CONTRIBUTION

The Proficiency Testing Program of the American College of Nuclear Physicians

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One of the ways the nuclear medicine community meets the challenge of managed health care is through participation in the Proficiency Testing Program (PTP) under the guidance of the American College of Nuclear Physicians (ACNP). This self-assessment program offers education opportunities to technologists and physicians, evaluates scintillation camera performance and offers techniques to optimize equipment efficiency and improve image quality. Subscriber PTP results have been instrumental in identifying areas where participants need additional information to maintain practice efficiency in nuclear medicine. The PTP is easy to participate in and is cost effective. It is the only nuclear medicine program available that provides a comprehensive assessment of quality using phantoms developed to simulate various clinical imaging situations that allow participants to compare their results with those of their peers.

Key Words: Proficiency Testing Program; quality control; image quality; clinical imaging; proficiency testing; phantoms

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The Proficiency Testing Program (PTP) is designed to evaluate and improve quality in nuclear medicine. This program uses imaging phantoms to assess image acquisition, processing and interpretation of images. Typically, the phantoms are of various organ systems and are designed to assess certain types of imaging studies. In addition, specialized phantoms designed for greater understanding of SPECT imaging, quality control and image perception are periodically distributed. The types of phantoms produced and distributed depends on the needs and interests of the imaging community.

The PTP is an educational program for physicians and technologists that is designed to complement a nuclear medicine department's quality assurance program. The PTP provides phantoms that simulate clinical imaging situations and didactic material to assist in fulfilling the educational objectives of the exercise. These materials can also be used to train residents and student technologists who are learning the basics of nuclear medicine. Some of the phantoms developed by the PTP can be incorporated into the laboratory's quality control program, especially in the complex area of SPECT imaging.

The PTP produces phantoms twice yearly for assessment of practice proficiency in nuclear medicine. Refining and maintaining the skills required to achieve an acceptable level of performance are necessary components of developing proficiency in nuclear medicine imaging and interpretative skills. The ability to respond to the current emphasis on quality assurance and the associated documentation is critical for nuclear medicine in this evolving managed health care environment.

Subscribers are exposed to a variety of image acquisition protocols, processing techniques, interpretative situations and quality control procedures. This helps subscribers become familiar with the rationale for these techniques and to qualitatively and quantitatively observe the impact on image quality and interpretability when various imaging parameters are changed from the standard protocols used in the laboratory. Participating in the PTP is an opportunity to compare how your laboratory evaluated the unknowns in each phantom to the results from other program participants.

This program is a unique opportunity for your laboratory to assess its ability to acquire and process images from a standardized phantom and provide an interpretation of the results. Your results are objectively evaluated and provided to your laboratory with the statistical results of all subscribing laboratories. There is no other program in nuclear medicine that provides such a comprehensive assessment of quality.

ORGANIZATIONAL BACKGROUND

The PTP was begun by the College of American Pathologists (CAP) in 1973 as part of its interlaboratory comparison program to evaluate and accredit pathology laboratories and to promote quality. The program was jointly sponsored by the CAP, the American College of Nuclear Physicians (ACNP)

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and the Society of Nuclear Medicine (SNM). Scientific and technical components of the program were administered by the Joint Nuclear Medicine Imaging Committee, made up of members of these organizations and technical and scientific consultants.

In 1993, the CAP decided it was not feasible to continue this program, in large part because there were now so few pathologists practicing nuclear medicine. The ACNP agreed to manage the program since they felt it was extremely valuable to the nuclear medicine community. The structure of the program has remained unchanged, however, membership of the Joint Nuclear Medicine Imaging Committee has been expanded to include the Technologist Section of the SNM and liaison from the American College of Radiology (ACR).

With the aid of the ACNP's Corporate Committee, marketing of the PTP has greatly expanded. In 1995, the committee sold 459 phantom exercises. There has been considerable interest in the program from nuclear medicine sections outside the U.S. and distribution of the PTP has become international.

The Joint Imaging Committee meets twice yearly. At each two-day meeting, the committee determines what phantom will be developed for each exercise, develops the objectives for each exercise, reviews the status of the phantoms being produced and analyzes the results of the most recent exercise.

Phantoms are developed based upon input from the subscribers and advice from experts in nuclear medicine. Each phantom exercise takes at least two years to develop, which includes phantom design, extensive testing and imaging by committee members, phantom production and preparation of written materials. When possible, VOICE and CME accreditation for the exercise is obtained.

THE PROGRAM

The PTP subscriber receives a phantom, instruction manual and response form to complete. The response form is used to provide information on the scintillation camera used, quality control data collected and the acquisition and processing parameters used to image the phantom. In addition, questions are asked regarding the images and data obtained as a result of imaging the phantom. Completion of the PTP is a joint effort among the nuclear medicine technologists and physicians. When possible, materials will be included so VOICE and CME credits may be obtained.

Subscribers should submit one primary response for each exercise. Usually up to five additional responses may be submitted from the same institution so that the phantom can be imaged using different scintillation cameras, different technologists performing the imaging procedure, different acquisition and processing parameters, different physicians interpreting the results or any combination of these options. Additional submissions may be made for a modest fee. When the submission is completed, the subscriber is encouraged to retain the phantom and use it in their training and/or quality control programs.

To have their results included in the data analysis, subscribers must complete the exercise by the deadline that is typically four to six weeks after shipment of the phantom. Analysis of the results is performed by the Nuclear Medicine Imaging Committee and a statistical consultant. A critique of the results is produced that discusses the goals of each imaging exercise and the overall results based on all subscriber submissions with a statistical analysis. This allows each subscriber to evaluate their own results in comparison to the entire group of subscribers. This is a unique opportunity. There is no other nuclear medicine imaging program in which results of imaging a known phantom are compared with results from other institutions. Subscribers also gain information regarding various techniques and develop a better understanding of why certain techniques may be helpful or are preferred in certain clinical situations.

The committee extracts additional data regarding the types, age and vendors of scintillation cameras used in the exercises, the acquisition and processing parameters used by the subscribers and other relevant parameters. These data are used to make recommendations and comments on the results submitted to the subscriber. For example, it might be statistically shown that to obtain results above the 25th percentile for a certain clinical study, the camera used should have certain performance characteristics and be of a certain temporal vintage.

The cost of the PTP is currently $495 for each phantom, which includes shipping costs within the U.S. To obtain additional information on the PTP program or to subscribe contact:

ACNP
Proficiency Testing Program
1200 19th Street, NW
Washington, DC 20036
Phone 800-447-2267 or 202-857-1135.

Please contact the ACNP office if you wish to obtain more information on an exercise that has already been distributed. The most recent phantoms may be available along with the instruction manual and final report.

PAST, PRESENT AND FUTURE PHANTOMS

In the past, the committee has distributed mostly transmission phantoms. The transmission phantoms were imaged using a ^{57}Co sheet source or a fillable flood phantom containing ^{99m}Tc. At present, however, the majority of phantoms are of the emission type. One or more cavities in the emission phantoms are filled with radioactivity by the subscribers and imaged in either planar and/or SPECT mode. Each of the emission phantoms is leak tested before shipping.

The phantoms developed by the imaging committee try to simulate a clinical imaging situation. Many of the clinical exercises are repeated using a different phantom to represent another aspect of the clinical study. This allows the subscriber to assess the ability of the scintillation camera and the technologist and physician to perform the exercise and privately compare their results to other subscribers who participated in the exercise. The 1994 IM-A geometric receiver operator curve (ROC) study and the 1995 IM-A SPECT quality control phantom were designed as quality control and didactic exercises

TABLE 1
Past, Present and Future PTP Phantoms

Year	Phantom	Year	Phantom	Year	Phantom
1973A	Geometric	1981B	Brain	1990 IM-A	Cardiac (segmental, akinesis, hypokinesis)
1973B	AP liver	1982A	Thyroid	1990 IM-B	Renal
1874A	LL brain	1982B	Myocardium	1991 IM-A	Pelvis
1974B	AP liver	1983A	Liver	1991 IM-B	Hepatobiliary (GBEF)
1975A	AP thyroid	1983B	Myocardium	1992 IM-A	Cardiac-arrythmia
1975B	AP + PT thorax	1984A	Head and neck	1992 IM-B	Geometric-SPECT and planar
1976A	Geometric	1984B	Myocardium	1993 IM-A	Lung V/P study
1976B	LL brain	1985A	Gallium	1993 IM-B	Brain SPECT (coronal)
1977A	AP liver	1985B	Ejection fraction	1994 IM-A	Geometric ROC study
1977B	AP pelvis	1986A	Geometric ROC study	1994 IM-B	Cardiac SPECT
1978A	AP liver	1986B	Ejection fraction	1995 IM-A	SPECT QC
1978B	AP thyroid	1987A	Liver ROC study	1995 IM-B	Spinal bone-SPECT and planar
1979A	Liver	1987B	Cardiac-arrythmia	1996 IM-A	Rest/stress myocardial perfusion study
1979B	Brain	1988A	Feet AP + lat. ROC study	1996 IM-B	SPECT/planar renal exercise
1980A	Liver	1988B	Cardiac-cardiomyopathy	1997 IM-A	Skeletal study-SPECT and planar
1980B	Brain	1989A	Cardiac-tachycardia	1997 IM-B	Medium-energy SPECT
1981A	Liver	1989B	Renal		

relating to specific aspects of imaging, as will the 1997 IM-B medium-energy SPECT phantom. Table 1 lists the phantoms distributed by the committee since 1973. Several of the past, current and future phantoms are described below, along with some of the knowledge gained by these PTP exercises.

1994 IM-A Geometric ROC Study

This transmission phantom was shipped in the spring of 1994. The phantom consisted of a grid containing 100 squares, some of which contained a lesion that was hot or cold. Lesion contrast ranged from high to low. The objective of this exercise was to assess the ability of the scintillation camera at each participant's laboratory to define simulated lesions, as well as the skill of the observer to detect them.

The subscriber was asked to image this phantom as though a bone scan was being performed. Participants used different collimators and collected a wide range of counts ranging from 300,000 to more than 2,000,000 counts. The majority of participants collected between 500,000 and 1,000,000. The acquisition matrix varied from 64 × 64 to 1028 × 1028, with the majority of respondents using either a 128 × 128 or 256 × 256 matrix. These uncontrolled variables increased the difficulty when comparing the results of one subscriber to the group average. From this exercise, it was learned that acquisition and processing variables in future exercises had to be restricted so that proper analyses of data could be performed.

The analyses were performed using ROC, which compares the true-positive rate (TPR, or sensitivity) to false-positive rate (FPR, or specificity). ROC analysis of the test pattern quantitates both sensitivity and specificity, and fully assesses combined instrument and observer performance. Figure 1A shows a typical image; Figure 1B shows the grid values; Figure 1C is a sample report.

1995 IM-A SPECT Quality Control Phantom

This emission phantom was shipped in May 1995 as a SPECT quality control phantom. Among the quality control parameters this phantom was designed to measure were uniformity, linearity and resolution for SPECT, as well as acquisition protocols, reconstruction software and attenuation algorithm. Figure 2 shows this phantom positioned for imaging.

This phantom consisted of three regions. The first region was an object-free space that could be used to determine uniformity when filled with a radioactive solution. The second region contained an orthogonal hole plate that consisted of 37 holes, each with a diameter of 14 mm. When the phantom was filled with a radioactive solution and imaged, it demonstrated a pattern of 37 hot regions that were circular and arranged in 7 rows with a center-to-center hole distance of 28 mm. This region could be used to demonstrate linearity, uniformity of spatial resolution throughout the imaging volume, the ability of the imaging system to reproduce the shape of an object and the effect of attenuation on object contrast between holes from periphery to center.

The third region contained two triangular test objects in which one quadrant had been cut at a 45° angle so that the maximum width could be measured when viewed in the sagittal and coronal planes. This region could be used to check pixel size and the reorientation algorithm. Figure 3 presents images of the various regions of the phantom.

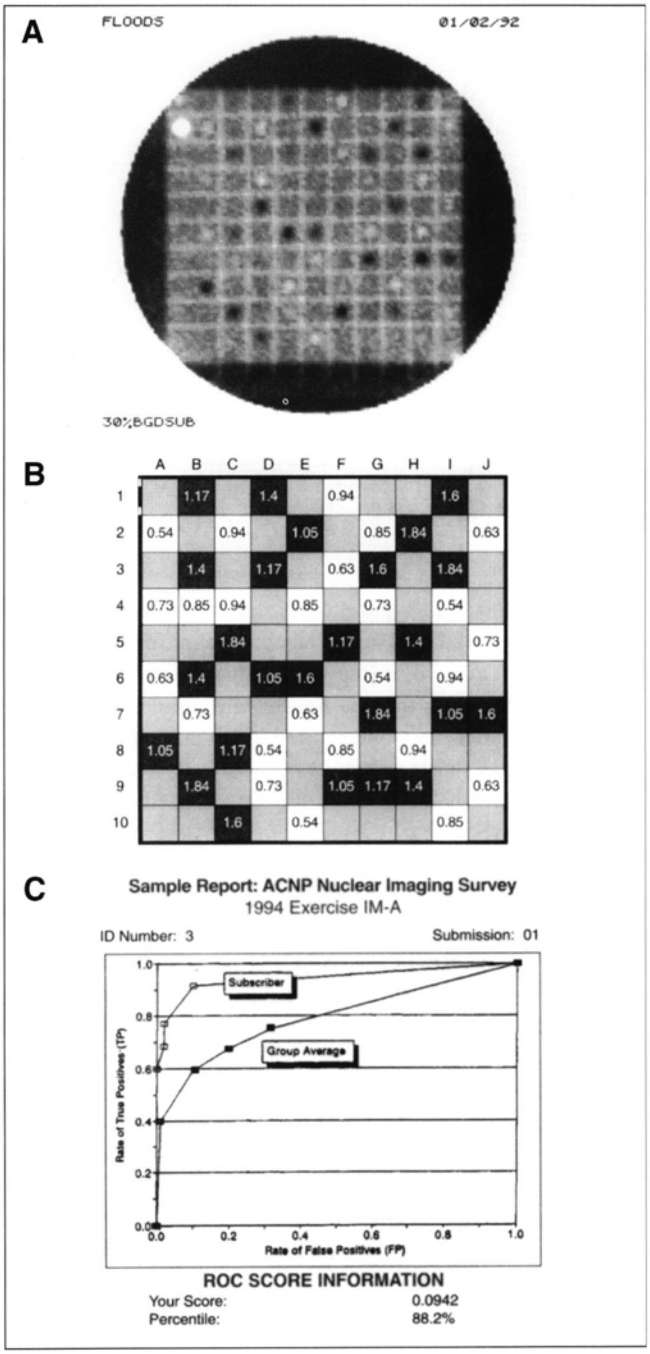

FIGURE 1. (A) Typical image of the grid submitted by a subscriber. (B) A graphic representation of the hot and cold lesions in the phantom. The numbers in the blocks represent the target-to-background ratios. The higher the number, the hotter the target; 1.00 is background. (C) A sample report sent to a subscriber.

This exercise differed considerably from previous exercises. Rather than evaluating proficiency of acquisition and interpretation using a well-known procedure, it presented a number of procedures that gave the participant variations in both acquisition and processing to demonstrate the advantages and limitations of different procedures. As such, this exercise contributed more to the subscriber's learning process than previous exercises.

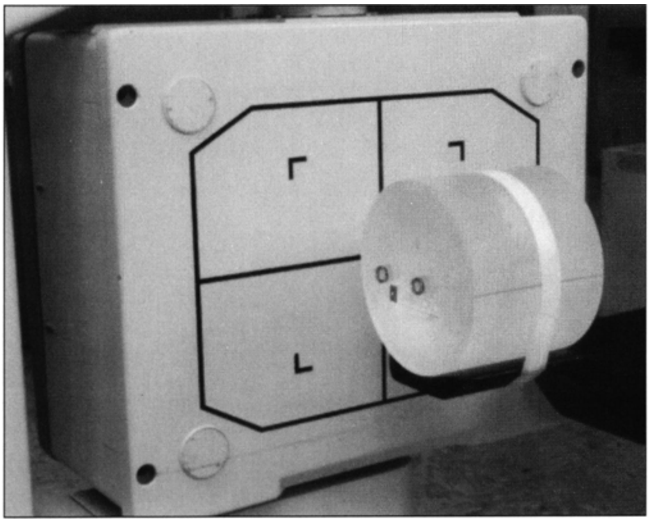

FIGURE 2. ACNP's 1995 IM-A SPECT Quality Control Phantom positioned on the head holder of a scintillation camera ready for imaging.

The results of this exercise demonstrated a wide variation of responses to the various measurements requested and the committee identified several areas in which many participants need additional information. These are among the problem areas where additional needs were identified and will be addressed in future exercises:

1. Some of the routine filters that were not available were the ramp and Hamming. Nomenclature and terminology differed significantly among the manufacturers and the accessibility of the parameters was difficult for many participants.

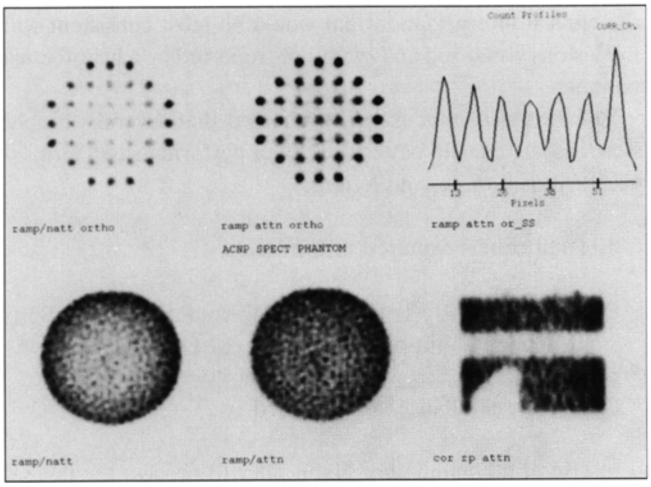

FIGURE 3. Images of the ACNP SPECT Quality Control Phantom. Upper left: 14-mm orthogonal hole plate reconstructed without attenuation correction. Upper center: 14-mm orthogonal hole plate reconstructed with attenuation correction. Upper right: profile through center row of 14-mm orthogonal hole plate reconstructed with attenuation correction. Lower left: uniform section reconstructed without attenuation correction. Lower center: uniform section reconstructed with attenuation correction. Lower right: coronal section reconstructed with attenuation correction.

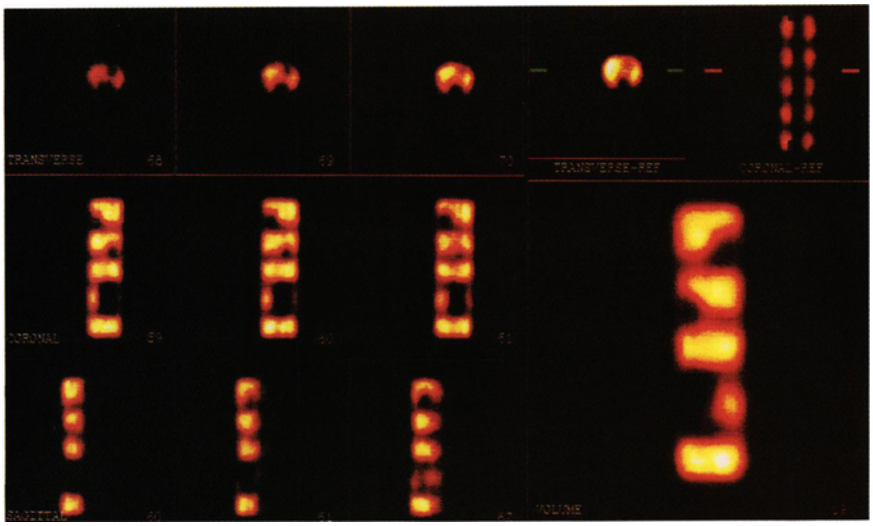

FIGURE 4. Images of 1995 IM-B spinal bone study. Top row, first three images: transverse sections through phantom. Top row, fourth image: transverse section reference image. Top row, fifth image: coronal section reference image. Center row, first three images: coronal sections through phantom. Bottom row, first three images: sagittal sections through phantom. Lower right large image: volumetric presentation.

2. Determination of pixel size was difficult for a significant number of the participants.

3. Attenuation correction procedures were not easily accessed in many of the computer systems.

1995 IM-B Spinal Bone: Planar and/or SPECT

This emission phantom was shipped in September 1995 to evaluate the subscriber's ability to use their scintillation camera to detect three cold lesions of varying dimensions located within a phantom that simulated the five vertebrae (L1-L5) of the lumbar region of the spine. Images of this phantom are shown in Figure 4. The phantom was designed to reflect the essential features of an actual clinical case provided on film by a member of the committee. The subscriber was asked to identify the locations of any lesions detected and to indicate the clinical interpretation that would be most consistent with the lesions visualized and symptoms reported by a hypothetical patient.

The results of this exercise indicated that several variables were associated with better subscriber performance in terms of visualizing all three cold lesions:

1. Total counts acquired in the study.

2. Availability of a low-energy, high-resolution (LEHR) or low-energy, ultra-high resolution (LEUHR) collimator.

3. Age of scintillation camera used.

4. Use of a Hamming or Hahn filter to process the images.

1996 IM-A Rest/Stress Myocardial Perfusion Study

This emission phantom was shipped in April 1996 to test the ability of the subscriber to detect and localize myocardial perfusion defects and determine the clinical significance of these defects. Myocardial perfusion imaging was performed using two cardiac phantoms: one simulating the heart after stress and one simulating the heart at rest. A photograph of the phantom is shown in Figure 5. The phantom was designed to reflect the essential features of an actual clinical case provided by a member of the Joint Imaging Committee. After acquiring, processing and displaying the images, the subscriber identified the abnormalities and determined their clinical significance using the clinical history provided.

Most nuclear medicine laboratories prefer SPECT imaging over planar. The reasons for this preference are that SPECT imaging improves contrast between the heart and other tissues of the body and allows the heart to be visualized in multiple cross-sectional views.

A second objective of this exercise was to have the subscribers submit key quality control data, such as high-count integral flood-field uniformity and center-of-rotation (COR) of the scintillation camera. SPECT imaging is susceptible to artifacts resulting from nonuniformities in response and incorrect COR adjustments. An important part of the final critique, generated by the committee, was a summary of the quality control data from the scintillation cameras used and a report to the participants of these findings.

The committee found there was a significant variance in the frequency of performing high-count floods: 27% daily, 38% weekly, 19% monthly and 16% at other time intervals. The

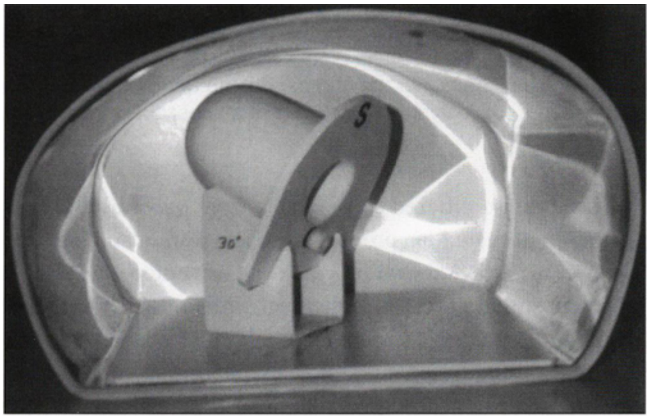

FIGURE 5. Photograph of the 1996 IM-A cardiac phantom.

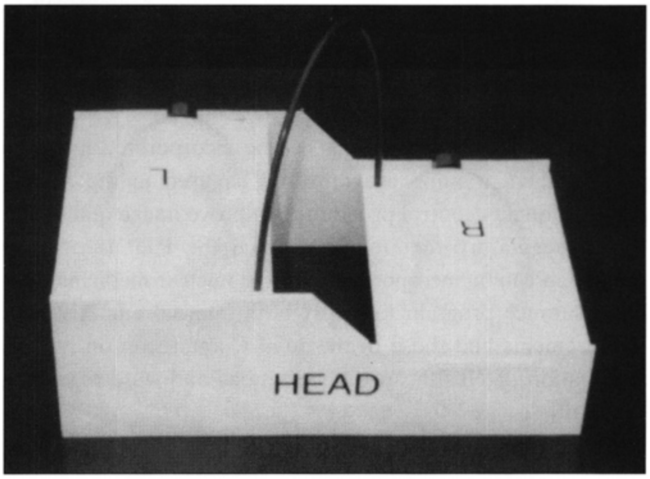

FIGURE 6. The renal phantom with the left kidney more anteriorly positioned than the right. The black caps at the inferior edge of each kidney are the fill ports into which the radioactive solution is placed.

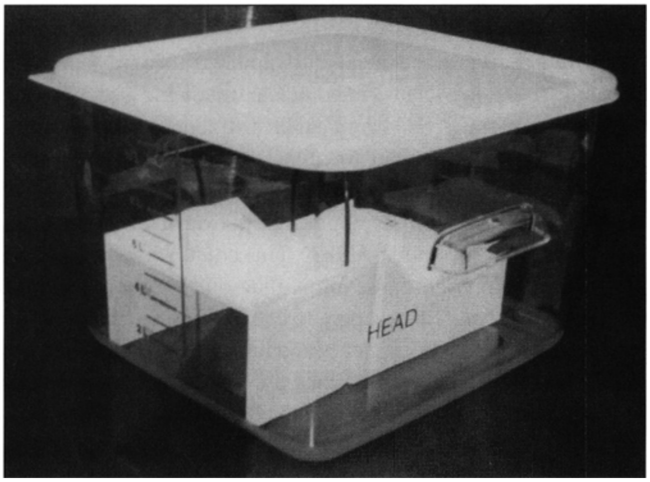

FIGURE 7. The renal phantom in the covered imaging tank that is filled with water to simulate tissue and the resultant photon attenuation.

total counts collected also varied with 38% collecting 10 to 15 million, 34% collecting 30 million and the balanced ranged from less than 5 million to 200 million. The acquisition matrix was uniformly divided among the four matrices from 64×64 to 512×512. The majority reported integral uniformity from 2% to 6%, basically independent of total counts collected. Among the recommendations were that subscribers who reported integral uniformity above 4% should determine the reason for these high values that may indicate collecting too few counts, using an inappropriate protocol to quantitate integral uniformity or there may be a problem with the camera. Other findings and recommendations made were with respect to COR determination, use of the appropriate filter during image reconstruction, variations in processing the acquired data and recognition of peri-infarct ischemia.

1996 IM-B SPECT/Planar Renal Exercise

This emission phantom was distributed in September 1996 and was designed to be imaged in either planar or SPECT mode. Kidneys were positioned at different depths from an anterior-posterior perspective. Each kidney was filled with radioactivity and may have contained one or more lesions of various sizes or shapes. A clinical history was presented to give the participant an indication of the clinical status of this simulated patient's kidneys. Photographs of the renal phantom are shown in Figures 6 and 7.

The first objective of this exercise was to measure the ratio of activity in the left and right kidneys. This was done by anterior and posterior imaging, drawing ROIs and calculating the activity in each kidney by the arithmetic and geometric mean methods. These calculated values were compared to the actual values and evaluated to determine which method more closely approximated the true value.

The second objective was to determine the presence, number and size of the lesions in the kidneys by planar and/or SPECT imaging techniques. If SPECT imaging was performed, the participant was asked to provide the acquisition and processing parameters. This allowed the committee to compare the various techniques used and correlate these data with the results obtained from the images.

1997 IM-A Skeletal Study

Scheduled for the spring of 1997, this phantom is designed to test the subscriber's ability to detect, localize and measure simulated skeletal abnormalities. The exercise also will include a patient's history, which subscribers will use to determine the clinical significance of the findings.

Subscribers may image the skeletal phantom using SPECT and/or planar imaging. Subcribers will be able to evaluate their ability to identify and quantify defects using alternative acquisition and processing protocols. Subscribers will be provided with detailed information about the use of image reconstruction filters and the quantitative measurement of defects.

1997 IM-B Medium-Energy SPECT Phantoms

This phantom will be distributed in the fall of 1997 to evaluate the performance of the scintillation camera equipped with the appropriate collimator to perform SPECT imaging of radionuclides such as ^{67}Ga and ^{111}In. These radionuclides emit medium-energy photons, as well as two or more photons of different energies. Image quality, spatial resolution, uniformity, both integral and reconstructed, will be evaluated both qualitatively and quantitatively. These results will be compared with those obtained when ^{99m}Tc is imaged under equivalent conditions. This comparison will demonstrate to the subscriber the variation in scintillation camera performance over a wide energy range.

The phantom will consist of a right cylinder with an inside diameter of eight inches and approximately five inches tall. To facilitate filling the phantom, there will be two fill ports. There will be a thick plate containing a pattern of holes of varying sizes and a region of uniform activity within the phantom. The holes will appear as hot-spots as might be seen in hot-spot imaging of metastatic disease.

BENEFITS

There are several technical and administrative ways in which technologists, physicians and nuclear medicine sections may benefit from the PTP. From an instrumentation standpoint, these exercises allow you to objectively evaluate the performance of your scintillation camera within your department and in comparison with other departments from from both intra- and interlaboratory perspectives. This could provide objective evidence to your administration that one or more cameras needs to be replaced or upgraded to perform quality studies. Optimizing equipment efficiency and improving image quality can speed patient throughput and increase sensitivity and specificity.

This program provides an objective, confidential self-assessment of the diagnostic skills of the physicians, based on the interpretation of the images generated from these phantoms as judged by imaging specialists. The subscriber also is provided with the results of the other subscribers across the country that allows a comparison of interpretative skills. In addition, when more than one physician interprets studies in the section, these results may be compared and studied to minimize interobserver variability.

Many of the PTP phantoms can be incorporated into your department's training program and be used in the SPECT imaging quality control program to improve image quality and satisfy regulatory requirements. Since the PTP is peer reviewed, it can be incorporated into the nuclear medicine quality assurance program to satisfy both internal administrative requirements and those of the Joint Commission on the Accreditation of Healthcare Organizations and state regulatory authorities.

Finally, many of the current and future PTP exercises are being designed so technologists and physicians can earn VOICE and CME credits, respectively. This is not only an educational benefit, but also a financial benefit.