Computed Tomography in the 21st Century

Changing Practice for Medical Imaging and Radiation Therapy Professionals

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Introduction

Since Godfrey Hounsfield's development of the first head CT scanner based on x-ray computed tomography in 1967, CT scanning has come a long way in a relatively short period of time. The first CT scanners were installed in the United States in 1973, and in 1980 approximately 3 million CT examinations were performed. By 2005, the number had increased to more than 68 million CT examinations and continues to rise.[1] The rapid rise in use of CT is not by accident — CT technology has transformed much of medical imaging. The cross-sectional images afforded by CT scanning have allowed visualization of anatomical structures with improved detail.[2,3]

Increased availability of CT scanners and faster scanning times, enabled by the new multislice scanners, have led to increased use of CT examinations in emergency departments and as a replacement for other imaging examinations.[4,5] The increasingly sophisticated technology has expanded CT use in both routine diagnostic procedures and complex procedures. Limited use of CT for whole-body scans of asymptomatic patients and as a screening tool for lung cancer and appendicitis is under debate.[5,6] Units with up to 320 detector rows and expanded anatomical coverage and slice width now exist in the United States. The technology exists to make scanners even faster and more portable.[5] Fusion of CT with functional imaging such as that provided by positron emission tomography (PET) and single photon emission computed tomography (SPECT) has emerged as an unparalleled tool in depicting the human body by merging results of two different types of examinations. Fusion of metabolic function information from a nuclear

imaging examination with the anatomic detail of CT exam results provides radiologists and other physicians with better information from which to make a diagnosis.

All of these changes bring improved patient care — enhanced diagnostic information in less time and improved radiation therapy simulation, for instance. To ensure patients' safety and imaging accuracy, those who perform imaging examinations should be ready to meet the demand created by the increased use of CT. The rapid growth and overlap between CT and other imaging specialties has presented many challenges for the education and certification of radiologic technologists.

These challenges are complex and cannot be solved by a single person, organization or regulatory entity. No one can direct or mandate a solution to changing practice and education patterns created by rapid emergence and adoption of technology that has proven its worth in improving patient care. The only way to work toward a solution is to look at the broad picture from as many viewpoints as possible and agree on observations and a future direction. Therefore, this document and the consensus statements were drawn from the combined application of facts, expert opinions and a certain amount of informed speculation.

The organizations and individuals represented do not intend these statements as a "last word," but to serve as the groundwork for discussion, recommendations and future action in addressing the increasing use of CT and its impact on the role radiologic technologists play in ensuring high-quality patient care as medical imaging continues to evolve.

Consensus Panel Meetings

On Aug. 4, 2007, experts in health policy, CT manufacturing, clinical practice and education met in Albuquerque, N.M., for a national, one-day consensus conference sponsored by the American Society of Radiologic Technologists (ASRT) and the American Registry of Radiologic Technologists (ARRT). The 32-member panel represented several other organizations including the Society of Nuclear Medicine (SNM), the American College of Radiology (ACR), the Association of Educators in

Imaging and Radiologic Sciences, the Joint Review Committee on Education in Radiologic Technology, the Nuclear Medicine Technology Certification Board and the U.S. Navy. (See Appendix 1 for a complete list of participants and organizations.)

The purpose of the consensus conference was to examine the dynamic forces influencing the evolution of CT and to achieve consensus on how these forces affect the future of radiologic sciences education and practice. Following a presentation on CT developments, the panel discussed the following questions:

- What are the effects that the increasing emergence and use of CT have on the disciplines of radiography, nuclear medicine and radiation therapy?
- What is the impact those effects have on education and certification?
- What are the CT issues surrounding patient safety and health policy, regulation and reimbursement?

Following a summary of the discussion, panel members participated in a straw poll to determine consensus on CT skills and competencies for entry-level and experienced radiographers, nuclear medicine technologists and radiation therapists. The results of the straw poll appear in Appendix 2.

Panel members received an interim draft consensus document to review and gathered once again on April 5, 2008, in Albuquerque, N.M. The panel reviewed and discussed the straw poll results. In particular, the discussion emphasized the impact of CT on the disciplines of radiography, nuclear medicine and radiation therapy. The discussion also included some specific comments to responses from the poll. The group reviewed and revised the consensus statements.

Consensus Statements

The following statements evolved from the two one-day meetings, examining research and discussing the utilization, role and practice of computed tomography by a panel of experts in health policy, clinical applications and education. (See Appendix 3 for a summary list of consensus statements.)

Consensus Statements on Patient Safety, Regulations and Reimbursement

- Medical imaging and radiation therapy professionals need more education in CT technology, including operation, application and dose optimization, to ensure patient safety.

Discussion

The panel unanimously agreed that physicians and technologists need more education on CT dose. Even with its rapid growth, CT scanning represents a relatively small percentage of the total volume of radiologic procedures, but accounts for a disproportionate amount of total patient radiation exposure. Estimates in recent years placed CT at about 13% of all radiologic procedures, but 70% of patients' radiation exposure.[4,7] The ACR has stated in its white paper on radiation dose that technologists need to be familiar with technical aspects of examinations and associated radiation risk and dose. The ACR also emphasized that to produce high-quality CT images with the lowest possible patient dose, technologists need to understand and use well-established protocols.[2] The increasing number of pediatric and adolescent CT examinations and concerns for safety in CT examinations among this group of patients has resulted in an emphasis on the need to adjust protocols according to body habitus, age and condition.[8,9] Patient safety and radiation dose already are core principles in the educational curriculum for the radiography, nuclear medicine and radiation therapy disciplines, as well as for the CT curriculum.

Discussion from panel members included attention, however, to more than radiation dose. Education in technology application improves examination quality, effectiveness and patient care in general. Ultimately, when medical imaging and radiation therapy professionals thoroughly understand CT operation, techniques and protocols, they can optimize dose and perform safer examinations.

- Health care organizations and government agencies should consider quality assurance (QA) guidelines when developing QA policies and regulations. This is particularly important in instances where regulatory agencies are hard pressed to address emerging technology in a timely fashion.

Discussion

The panel held rigorous discussions on the role of state and federal regulations and practice standards and guidelines on how QA policies and radiologic technology practice develop at the national, regional and facility level. QA and practice guidelines from professional organizations generally keep pace with emerging technologies and trends in the organizations' given specialties. Having these guidelines in place helps provide a framework for regulatory agencies.

CT certification of technologists performing diagnostic CT examinations is increasingly becoming a requirement for reimbursement. Panel members noted that these reimbursement requirements, as well as some facility accreditation recommendations, are encouraging employers to hire CT-certified technologists. The final report of the ACR Blue Ribbon Panel recommends at least one CT-certified technologist per facility.[2] Panel members agreed that employer preference for CT-certified technologists is a national trend.

Consensus Statements on Education and Practice

- Entry-level graduates of radiography, radiation therapy and nuclear medicine programs should have both didactic and clinical education in basic CT procedures.

Discussion

The rapid growth of CT scanning as a diagnostic tool has necessitated a call for all entry-level graduates to obtain at least basic knowledge and skills in CT scanning. The ASRT Computed Tomography Educational Needs Assessment surveyed nearly 2,000 technologists who considered CT their primary or secondary sphere of employment in

2004. Of those surveyed, 68% agreed or strongly agreed that "entry-level programs should increase their emphasis on computed tomography."[10]

Ensuring that entry-level graduates receive didactic and clinical education in basic CT procedures will provide a foundation of understanding of CT operation and application for radiographers, nuclear medicine technologists and radiation therapists, as well as the basis for those technologists who eventually seek CT-specific training and certification. The expectation of CT education will require course additions and curriculum changes and establishment of clinical competency requirements for some educational programs. It also has implications for the ARRT examination. Recognizing the need for basic CT education is a starting point.

It should be noted that radiologic technologists are not alone in struggling with education, practice and competency assessment issues in the evolution of CT technology. In 2005, a report was published by a joint working group to address the qualification of physicians, medical physicists and technologists under the fused specialties of PET-CT. However, the bulk of the report focused on physician training, qualification and coverage issues.[11] A 2005 report from the American College of Cardiology Foundation described a multisociety task force's recommendations concerning clinical competency for physicians who now were involved in cardiac imaging using CT and MR.[12]

- More educational programs in CT are needed to fulfill current and future demand for CT-certified technologists.

Discussion

Panelists agreed that there is a general lack of growth in educational programs targeted at technologists specializing in CT throughout the United States. In particular, having an adequate number of clinical sites to meet current needs — let alone adding to the number of technologists who would require clinical training in CT in the future — is a major challenge. With more than 60 million CT scans being performed each year, the problem does not lie with the number of possible clinical education opportunities, but rather with

securing clinical education sites. Many specific challenges arise concerning scheduling, staffing, certification and other issues. The panel agreed that the need for clinical site affiliations is a problem to address.

The CT Educational Needs Assessment asked respondents the sources for obtaining their CT-specific training. Nearly 95% of those who held CT certificates and 88% of technologists not certified in CT at the time said they received training on the job. Only 23% of technologists certified in CT and 43% of those not certified stated that they received "clinical training as a student in a radiologic technology education program." In addition, 15% of technologists with certification and 23% without certification in CT said they received "formal, didactic coursework within a radiologic technology education program."[10]

In recognition of expanding use of CT in the primary disciplines, the ARRT opened eligibility for CT certification to nuclear medicine technologists and radiation therapists. However, many of those seeking to add CT certification have faced difficulties reaching the clinical experience requirements. Barriers to acquiring clinical competency have been the number and types of exams and availability of equipment and sites for performing required CT exams.

- There is a need for increased education and training for radiographers who operate CT equipment at the entry- and experienced-practitioner levels.

Discussion

The need for increased education and training at the entry level has been discussed. Increased education and training also is needed to prepare experienced radiographers who will perform more complex CT examinations. A census report from IMV Medical Information in Des Plaines, Ill., says that two-thirds of surveyed sites with CT perform CT angiography. More than one half of CT scanners installed in 2007 were multislice units with more than 64-slice capability. Most sites use 3-D software for volumetric

imaging.[1] In March 2008, the American Cancer Society began recommending virtual colonoscopy for colon screening.[13]

In the straw poll of consensus panel members, the panel generally agreed that level of complexity of the CT procedures performed correlated with a radiographer's experience. For example, 74% of panel members disagreed or strongly disagreed that entry-level radiographers will be expected to perform complex CT procedures in the next five years. When asked if only selected radiographers will be expected to perform complex CT procedures, nearly 67% agreed or strongly agreed.

Practice setting largely determines the current and future role of technologists performing CT examinations. A wide disparity can exist between rural and urban settings. Differences also are due to volume, services, staffing and other factors that vary between facilities or employers. Disparities also may exist in clinical site experience. For example, some sites may offer complex examinations and few routine procedures.

Consensus Statement on CT in Diagnostic Radiology

- There are not enough technologists educated in CT to provide adequate staffing for CT coverage around the clock, particularly in smaller and rural facilities. This is further compounded by the increasing number of orders written for CT scans.

Discussion

The previous consensus statement in education and practice addressed the need for education and training of radiographers who perform CT procedures. This statement addresses the consequences of the current lack of education. In fact, it embraces many of the concerns the panel discussed surrounding education, certification and availability of radiographers in the present and future to adequately perform the growing number of CT scans.

The ARRT reports that about 21,000 registered technologists currently hold CT certification. An additional 29,000 registered technologists who are not registered in CT report performing CT procedures. The ASRT CT Needs Assessment asked those respondents who are not certified in CT and who did not plan to become certified in the future the reasons why. The majority of respondents (61%) stated that certification would not lead to higher pay. Slightly more than one-half also cited that their state or employer did not require CT certification to perform CT procedures. In addition, 34% of respondents said that workplace competence assessment validated their ability.[10]

CT is beginning to replace radiography as the initial diagnostic exam. CT scanners now routinely are placed in or near emergency departments and the increasing availability of multidetector-CT units makes possible early emergency evaluation of acute chest pain.[14] This provides one example of change in practice stimulated by the growth of CT in a number of areas. Where radiographers once performed x-ray examinations first in the imaging chain, they may now instead be receiving physician orders for CT examinations. A 2007 survey of emergency department physicians showed that 91% of them significantly underestimated radiation dose from CT scans;[3] this places additional importance on the knowledge and attention of radiologic technologists who perform the exams.

The growth of CT is widespread. The more than 60 million exams performed today can be compared with some 3 million performed in 1980. Advances in technology have permitted new uses, leading to an increase that is particularly notable among pediatric diagnosis and adult screening.[3] Emergency departments have noted increases in pediatric CT emergency imaging of up to 400% for some examinations, most notably chest and cervical spine procedures.[15] A report from the Medicare Payment Advisory Commission stated that the move of many imaging examinations, such as CT, from outpatient departments to physician offices raises concerns about absence of institutional standards governing the performance and interpretation of the studies in physician offices.[16]

Many hospitals and imaging centers have adjusted, but fully staffing small and rural facilities with technologists qualified to perform radiography and the range of CT examinations performed in a given environment can prove challenging. Even in a larger facility, ensuring that enough qualified technologists are available around the clock to perform complex examinations presents a challenge in many markets.

Panel members felt strongly that a proactive approach through these consensus statements and any actions they provoke is preferable to waiting for regulatory or public intervention. By proactively noting the proliferation of CT scanning in health care and reaching consensus on medical imaging and radiation therapy professionals' education and role in practice changes, continued quality and safety in patient care can be ensured.

Consensus Statements on CT in Radiation Therapy

- CT simulation is a core skill in radiation therapy.

Discussion

CT images have been used in radiation therapy treatment planning for more than 20 years. The advent of 3-D CT volumetric imaging and conformal therapies such as intensity-modulated radiation therapy, or IMRT, have together increased the use of CT simulation in radiation therapy. CT simulation now is routinely used for IMRT, stereotactic radiosurgery and other advanced technologies to accurately define the three-dimensional target volume and surrounding sensitive structures.[17,18]

In a straw poll, 77% of panel members agreed or strongly agreed that entry-level radiation therapists will be expected to use CT for simulation in the next five years, and 86% agreed or strongly agreed that experienced radiation therapists will be using CT for simulation within five years.

Although CT simulation differs from diagnostic CT, radiation therapists should have basic education and training in CT skills such as CT simulation, cross-sectional anatomy,

advanced patient care, radiographic contrast and pharmacology as part of their entry-level curriculum. These areas already have been added to the radiation therapy professional curriculum.

- Because of differences between CT simulation and diagnostic CT, radiation therapists should not perform diagnostic CT procedures without additional education in diagnostic CT.

Discussion

In a straw poll of expert panel members, most disagreed with a statement that radiation therapists at any level would have to perform basic or complex diagnostic CT exams in the next five years, although there was some agreement that selected radiation therapists may use CT for diagnostic purposes. (See Appendix B.) Those respondents who currently are practicing radiation therapy thought the possibility of therapists performing diagnostic CT in their radiation oncology roles even less likely.

Traditionally, radiography was the first step in the path to the radiation therapy profession. Today, ARRT statistics show that the percentage of those registered first in radiography who later earn certification in radiation therapy is dropping. This further emphasizes the need for additional education in diagnostic CT for those radiation therapists who will perform diagnostic CT procedures.

Consensus Statement on CT in Nuclear Medicine

- With the advent of fusion imaging, CT has become a core skill for nuclear medicine technologists when using hybrid technology.

Discussion

Nuclear medicine imaging is dynamic, having undergone continuous revision since its 1971 inception. The introduction of fusion imaging has added to changes in nuclear medicine practice and training requirements. Molecular medicine is poised to further

revolutionize the field.[5,19] In 2005, 90% of the PET scanners installed actually were PET-CT scanners. There also has been growth in use of SPECT-CT.[20] The fusion of CT technology with nuclear medicine technology has meant that some practicing nuclear medicine technologists, as well as those entering the field, have needed to learn CT skills. The panel did not, however, reach the degree of consensus on this issue that was reached for radiographers.

The dynamic nature of nuclear medicine is one complicating factor. Nuclear medicine also is highly regulated and varies from one state to another. According to a task force of the SNM, many states with regulatory language concerning licensure prohibit anyone but radiographers from performing CT procedures.[21] In the straw poll of consensus panel members, 23% agreed that entry-level nuclear medicine technologists will be performing routine diagnostic CT exams within five years. A higher percentage (42%) disagreed and 26% were uncertain. The numbers shifted toward performance of CT for more experienced and select radiographers. (See specific results in Appendix 2.)

The scope of practice, as revised by the SNM Technologist Section in 2007, added performance of CT scans and administration of contrast for these exams. The document outlines the scope as "operation of cameras with x-ray tubes for transmission imaging when performed as part of SPECT-CT or PET-CT. Additionally includes diagnostic CT when performed on SPECT-CT or PET-CT cameras, including the administration of oral and intravenous contrast (requires education in CT) and the operation of scanners with x-ray tubes for the measurement of bone density."[22] In July 2007, all U.S. nuclear medicine residency programs began requiring dedicated CT rotations as part of the training program.[19]

Preliminary results of a recent Task Analysis Survey conducted by the Nuclear Medicine Technology Certification Board sheds some light on the current situation. The following question was asked on the survey. "If CT scans are performed in conjunction with SPECT or PET, who operates the CT scanner?" Of the 572 surveys returned, 310 (54.20%) did not answer this question. Of those 262 participants who did respond, 25

(9.55%) answered that an x-ray technologist operates the CT scanner; 52 (19.85%) answered x-ray technologist with CT certification; 122 (46.57%) answered nuclear medicine technologist without x-ray or CT certification; and 61 (23.29%) answered NMT with CT certification.

Nuclear medicine technologists have expressed some practical barriers to obtaining CT certification. In addition to finding sites and types of examinations required to meet clinical experience requirements for CT certification, some state regulations prohibit nuclear medicine technologists from performing CT examinations, even if the technologists holds CT certification.

Conclusion

Evidence from the consensus panel and the literature indicates that the increasing use of CT technology is changing radiological practice faster than many educational institutions, vendors, medical providers and certification and regulatory agencies expected. How these various entities — on organizational and individual levels — can proactively become agents of change to integrate CT technology throughout radiology practice and the radiologic technology professions remains to be seen.

The discussions resulting from these consensus statements will serve as a starting point. The consensus panel identified issues for organizations to address as part of the follow-up process. Work remains, more data need to be gathered and strategies and objectives need to be developed.

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Appendix 2

Straw Poll Survey Results

In a survey of CT consensus task force members conducted in August 2007, several key findings supported subsequent information gathering and ultimately the consensus statements developed by a panel of experts in health policy, CT manufacturing, clinical practice and education. Results of the survey were tabulated and presented to the panel at an April 2008 meeting. Some of the comments that accompanied responses also were included in discussions. Below is a summary of survey findings by discipline/modality.

Radiography

About 55% of consensus task force members agreed that most entry-level radiographers will perform routine CT exams in the next five years (question 3). Nearly 80% agreed or strongly agreed that experienced staff radiographers would perform routine diagnostic CT exams in the next five years (question 4).

Questions about performance of complex procedures, such as CT angiography, brain perfusion studies or CT colonoscopy, produced different results. Nearly 75% of respondents disagreed or strongly disagreed that entry-level staff radiographers would be expected to perform these complex CT procedures in the next five years (question 6). Respondents were more evenly split in opinion on performance of complex CT imaging procedures by more experienced staff radiographers; nearly 28% agreed and the same number disagreed. Another 25% were uncertain. But nearly 14% strongly disagreed (question 7). When it comes to selected radiographers and CT technologists performing these complex exams, the number of respondents who agreed or strongly agreed rose to a combined 67%.

Radiation Therapy

Neither the entire group of respondents, nor those certified in radiation therapy, thought it likely that most entry-level radiation therapists will be expected to perform routine diagnostic CT exams in the next five years (question 18). More respondents thought that experienced radiation therapists may perform CT, but nearly 46% still disagreed that therapists will perform routine diagnostic CT exams within the next five years and 31% agreed (question 19). When asked about selected radiation therapists performing routine CT imaging procedures, those who agreed rose to 38% (question 20). For the most part, respondents agreed that most radiation therapists of all experience levels will not be expected to perform complex CT diagnostic procedures within the next five years (questions 21 – 23).

CT scanning is used in radiation therapy for simulation. More than 77% of respondents agreed that most entry-level staff radiation therapists would be expected to use CT scanning for simulation in the next five years and the percentage is higher for experienced radiation therapists (questions 24 and 25).

Nuclear Medicine

When asked about the prospect of entry-level staff nuclear medicine technologists performing routine diagnostic CT procedures within the next five years, only 23% of panel members agreed that they would be expected to do so and nearly 42% disagreed. An additional 29% were uncertain. As for experienced nuclear medicine technologists, 40% of those polled agreed or strongly agreed that they would perform diagnostic CT and 29% disagreed, while nearly 26% were uncertain. Agreement concerning selected technologists in nuclear medicine performing routine CT procedures rose slightly — to 50%.

No one believed that entry-level nuclear medicine technologists would be asked to perform complex CT procedures, although about 22% were uncertain. A relatively high number — 25% strongly disagreed with the statement. Even selected nuclear medicine technologists were not expected to perform complex diagnostic CT procedures; only 28%

agreed that they will, which was a smaller percentage than the uncertain or disagree totals. When asked specifically about fusion imaging, respondents agreed that even entry-level nuclear medicine technologists will use CT for fusion imaging (73.5% agree or strongly agree) and more than 88% agreed that most experienced nuclear medicine technologists would as well.

QUESTIONS

1. Please indicate if you are (mark all that apply):

	Response Percent	Response Count
Staff member of a Professional Society, Certification Agency, or Accreditation Organization	34.3%	12
Board member of Professional Society, Certification Agency, or Accreditation Organization	**37.1%**	13
Staff member of Federal or State Governmental or Regulatory Agency	2.9%	1
Commercial Applications Specialist	5.7%	2
Educator or Clinical Instructor	22.9%	8
Administrator	11.4%	4
Other	11.4%	4
view Other (please describe)		5
answered question		**35**
skipped question		**2**

2. Please indicate your certification areas (Mark all that apply):

	Response Percent	Response Count
Radiography	79.4%	27
Nuclear Medicine Technology	20.6%	7
Radiation Therapy	11.8%	4
CT	26.5%	9
Other	41.2%	14
view Other (please list)		17
answered question		34
skipped question		3

3. Within the next five years most entry level staff radiographers will be expected to perform routine diagnostic CT imaging procedures (for example, head, chest, abdomen).

	Response Percent	Response Count
Strongly Agree	25.0%	9
Agree	**30.6%**	11
Uncertain	19.4%	7
Disagree	25.0%	9
Strongly Disagree	0.0%	0
view Comments:		6
answered question		**36**
skipped question		**1**

4. Within the next five years most experienced staff radiographers will be expected to perform routine diagnostic CT imaging procedures (for example, head, chest, abdomen).

	Response Percent	Response Count
Strongly Agree	36.1%	13
Agree	**41.7%**	15
Uncertain	11.1%	4
Disagree	11.1%	4
Strongly Disagree	0.0%	0
view Comments:		4
answered question		**36**
skipped question		**1**

5. Within the next five years only selected staff radiographers and CT Techs will be expected to perform routine diagnostic CT imaging procedures (for example, head, chest, abdomen).

	Response Percent	Response Count
Strongly Agree	20.0%	7
Agree	14.3%	5
Uncertain	11.4%	4
Disagree	**45.7%**	16
Strongly Disagree	8.6%	3
view Comments:		4
answered question		**35**
skipped question		**2**

6. Within the next five years most entry level staff radiographers will be expected to perform complex diagnostic CT imaging procedures (for example, CTA, CT Brain Perfusion Studies, CT Colonoscopy).

	Response Percent	Response Count
Strongly Agree	2.9%	1
Agree	8.6%	3
Uncertain	14.3%	5
Disagree	**57.1%**	20
Strongly Disagree	17.1%	6
view Comments:		3
answered question		**35**
skipped question		**2**

7. Within the next five years most experienced staff radiographers will be expected to perform complex diagnostic CT imaging procedures (for example, CTA, CT Brain Perfusion Studies, CT Colonoscopy).

	Response Percent	Response Count
Strongly Agree	5.6%	2
Agree	**27.8%**	10
Uncertain	25.0%	9
Disagree	**27.8%**	10
Strongly Disagree	13.9%	5
view Comments:		3
answered question		**36**
skipped question		**1**

8. Within the next five years only selected staff radiographers and CT Techs will be expected to perform complex diagnostic CT imaging procedures (for example, CTA, CT Brain Perfusion Studies, CT Colonoscopy).

	Response Percent	Response Count
Strongly Agree	25.0%	9
Agree	**41.7%**	15
Uncertain	19.4%	7
Disagree	11.1%	4
Strongly Disagree	2.8%	1
view Comments:		2
answered question		**36**
skipped question		**1**

9. Within the next five years most entry level staff nuclear medicine technologists will be expected to perform routine diagnostic CT imaging procedures (for example, head, chest, abdomen).

	Response Percent	Response Count
Strongly Agree	2.9%	1
Agree	20.0%	7
Uncertain	28.6%	10
Disagree	**42.9%**	15
Strongly Disagree	5.7%	2
view Comments:		5
answered question		**35**
skipped question		**2**

10. Within the next five years most experienced staff nuclear medicine technologists will be expected to perform routine diagnostic CT imaging procedures (for example, head, chest, abdomen).

	Response Percent	Response Count
Strongly Agree	8.6%	3
Agree	**31.4%**	11
Uncertain	25.7%	9
Disagree	28.6%	10
Strongly Disagree	5.7%	2
view Comments:		4
answered question		**35**
skipped question		**2**

11. Within the next five years only selected staff nuclear medicine technologists will be expected to perform routine diagnostic CT imaging procedures (for example, head, chest, abdomen).

	Response Percent	Response Count
Strongly Agree	8.3%	3
Agree	**41.7%**	15
Uncertain	36.1%	13
Disagree	8.3%	3
Strongly Disagree	5.6%	2
view Comments:		3
answered question		**36**
skipped question		**1**

12. Within the next five years most entry level staff nuclear medicine technologists will be expected to perform complex diagnostic CT imaging procedures (for example, CTA, CT Brain Perfusion Studies, CT Colonoscopy).

	Response Percent	Response Count
Strongly Agree	0.0%	0
Agree	0.0%	0
Uncertain	22.2%	8
Disagree	**52.8%**	19
Strongly Disagree	25.0%	9
view Comments:		4
answered question		**36**
skipped question		**1**

13. Within the next five years most experienced staff nuclear medicine technologists will be expected to perform complex diagnostic CT imaging procedures (for example, CTA, CT Brain Perfusion Studies, CT Colonoscopy).

	Response Percent	Response Count
Strongly Agree	2.8%	1
Agree	13.9%	5
Uncertain	19.4%	7
Disagree	**38.9%**	14
Strongly Disagree	25.0%	9
view Comments:		3
answered question		**36**
skipped question		**1**

14. Within the next five years only selected staff nuclear medicine technologists will be expected to perform complex diagnostic CT imaging procedures (for example, CTA, CT Brain Perfusion Studies, CT Colonoscopy).

	Response Percent	Response Count
Strongly Agree	5.6%	2
Agree	22.2%	8
Uncertain	**30.6%**	11
Disagree	22.2%	8
Strongly Disagree	19.4%	7
view Comments:		3
answered question		**36**
skipped question		**1**

15. Within the next five years most entry level staff nuclear medicine technologists will be expected to use CT for fusion imaging.

	Response Percent	Response Count
Strongly Agree	23.5%	8
Agree	**50.0%**	17
Uncertain	17.6%	6
Disagree	8.8%	3
Strongly Disagree	0.0%	0
view Comments:		4
answered question		**34**
skipped question		**3**

16. Within the next five years most experienced staff nuclear medicine technologists will be expected to use CT for fusion imaging.

	Response Percent	Response Count
Strongly Agree	27.8%	10
Agree	**61.1%**	22
Uncertain	11.1%	4
Disagree	0.0%	0
Strongly Disagree	0.0%	0
view Comments:		3
answered question		**36**
skipped question		**1**

17. Within the next five years only selected staff nuclear medicine technologists will be expected to use CT for fusion imaging.

	Response Percent	Response Count
Strong Agree	17.1%	6
Agree	**37.1%**	13
Uncertain	25.7%	9
Disagree	17.1%	6
Strongly Disagree	2.9%	1
view Comments:		2
answered question		**35**
skipped question		**2**

18. Within the next five years most entry level staff radiation therapists will be expected to perform routine diagnostic CT imaging procedures (for example, head, chest, abdomen).

	Response Percent	Response Count
Strongly Agree	2.9%	1
Agree	11.4%	4
Uncertain	25.7%	9
Disagree	**48.6%**	17
Strongly Disagree	11.4%	4
view Comments:		5
	answered question	**35**
	skipped question	**2**

19. Within the next five years most experienced staff radiation therapists will be expected to perform routine diagnostic CT imaging procedures (for example, head, chest, abdomen).

	Response Percent	Response Count
Strongly Agree	0.0%	0
Agree	31.4%	11
Uncertain	14.3%	5
Disagree	**45.7%**	16
Strongly Disagree	8.6%	3
view Comments:		4
	answered question	**35**
	skipped question	**2**

20. Within the next five years only selected staff radiation therapists will be expected to perform routine diagnostic CT imaging procedures (for example, head, chest, abdomen).

	Response Percent	Response Count
Strongly Agree	0.0%	0
Agree	**38.2%**	13
Uncertain	23.5%	8
Disagree	32.4%	11
Strongly Disagree	5.9%	2
view Comments:		3
answered question		**34**
skipped question		**3**

21. Within the next five years most entry level staff radiation therapists will be expected to perform complex diagnostic CT imaging procedures (for example CTA, CT Brain Perfusion Studies, CT Colonoscopy).

	Response Percent	Response Count
Strongly Agree	0.0%	0
Agree	2.8%	1
Uncertain	8.3%	3
Disagree	**63.9%**	23
Strongly Disagree	25.0%	9
view Comments:		5
answered question		**36**
skipped question		**1**

22. Within the next five years most experienced staff radiation therapists will be expected to perform complex diagnostic CT imaging procedures (for example CTA, CT Brain Perfusion Studies, CT Colonoscopy).

	Response Percent	Response Count
Strongly Agree	0.0%	0
Agree	2.9%	1
Uncertain	28.6%	10
Disagree	**45.7%**	16
Strongly Disagree	22.9%	8
view Comments:		4
answered question		**35**
skipped question		**2**

23. Within the next five years only selected staff radiation therapists will be expected to perform complex diagnostic CT imaging procedures (for example CTA, CT Brain Perfusion Studies, CT Colonoscopy).

	Response Percent	Response Count
Strongly Agree	0.0%	0
Agree	14.3%	5
Uncertain	28.6%	10
Disagree	**40.0%**	14
Strongly Disagree	17.1%	6
view Comments:		3
answered question		**35**
skipped question		**2**

24. Within the next five years most entry level staff radiation therapists will be expected to use CT for simulation.

	Response Percent	Response Count
Strongly Agree	**41.7%**	15
Agree	36.1%	13
Uncertain	19.4%	7
Disagree	2.8%	1
Strongly Disagree	0.0%	0
view Comments:		2
answered question		**36**
skipped question		**1**

25. Within the next five years most experienced staff radiation therapists will be expected to use CT for simulation.

	Response Percent	Response Count
Strongly Agree	**50.0%**	18
Agree	36.1%	13
Uncertain	8.3%	3
Disagree	5.6%	2
Strongly Disagree	0.0%	0
view Comments:		3
answered question		**36**
skipped question		**1**

26. Within the next five years only selected staff radiation therapists will be expected to use CT for simulation.

	Response Percent	Response Count
Strongly Agree	17.1%	6
Agree	20.0%	7
Uncertain	11.4%	4
Disagree	**42.9%**	15
Strongly Disagree	8.6%	3
	view Comments:	2
	answered question	**35**
	skipped question	**2**

Appendix 3

Summary of Consensus Statements

The following statements evolved from two days of meeting, examining research and discussing the utilization, role and practice of computed tomography by a panel of experts in health policy, clinical applications and education.

Consensus Statements on Patient Safety, Regulations and Reimbursement

- Medical imaging and radiation therapy professionals need more education in CT technology, including operation, application and dose optimization to ensure patient safety.

- Health care organizations and government agencies should consider quality assurance guidelines when developing QA policies and regulations. This is particularly important in instances where regulatory agencies are hard pressed to address emerging technology in a timely fashion.

Consensus Statements on Education and Practice

- Entry-level graduates of radiography, radiation therapy and nuclear medicine programs should have both didactic and clinical education in basic CT procedures.

- More educational programs in CT are needed to fulfill current and future demand for CT-certified technologists.

- There is a need for increased education and training for radiographers who operate CT equipment at the entry- and experienced-practitioner levels.

Consensus Statement on CT in Radiography

- There are not enough technologists educated in CT to provide adequate staffing for CT coverage around the clock, particularly in smaller and rural facilities. This is further compounded by the increasing number of orders written for CT scans.

Consensus Statements on CT in Radiation Therapy

- CT simulation is a core skill in radiation therapy.

- Because of differences between CT simulation and diagnostic CT, radiation therapists should not perform diagnostic CT procedures without additional education in diagnostic CT.

Consensus Statement on CT in Nuclear Medicine

- With the advent of fusion imaging, CT has become a core skill for nuclear medicine technologists when using hybrid technology.

Appendix 4

The following issues were identified by the CT Consensus Panel for various organizations to consider when defining and facilitating changing practice for medical imaging and radiation therapy professionals regarding computed tomography.

1. Explore curriculum specific to cardiology. Some technologists are working for cardiologists instead of radiologists. This is particularly important in CT, but there also is cardiac imaging in ultrasound, nuclear medicine and MR.
2. Increase the focus on continuing education (CE) opportunities in CT. Organizations and educational institutions need to develop CE programs. Develop a comprehensive program, e.g., online coursework. Also, make it as easy as possible for schools to sponsor CE courses in CT. Provide funding to get programs started. Look for grant money, such as by tying the program to geriatric imaging.
3. Create a basic certification exam in CT, with only 10 or 15 comps. It is difficult for people to do 125 comps to get their CT certification; this would provide a fundamental level of certification in CT.
4. Create an advanced certification exam in CT, e.g., advanced cardiac, advanced postprocessing.
5. Explore the possibility of creating a CT exam solely for technologists who perform fusion imaging.
6. It is time to review the CT certification exam. CT has evolved into something very different. Do we put didactic knowledge into each of the three primary exams? That would allow individuals who take those exams to do basic CT. Then have the CT certification as an advanced registry for those who work in the CT department and do complex exams.
7. Define "basic" or "routine" CT procedures vs. "complex" CT procedures.
8. Encourage flexibility within state regulations.
9. ASRT and SNMTS should work with the American Healthcare Radiology Administrators to determine what managers expect when they purchase hybrid

technology. How is the equipment going to be used? We need to identify practice patterns and expectations.

10. Facilitate clinical experiences. Make it easier for people to complete their clinical education if they aren't in a formal education program. Provide a list of facilities where people can get their clinical experience. Look at the preceptor model for additional clinical experience, similar to the radiologist assistant.