Summary of Workshop on CT in Emergency Medicine: Ensuring Appropriate Use

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This paper addresses the increasing use of CT in medical radiologic imaging, with a focus on applications in emergency medicine. The rapidly increasing use of CT in medical imaging over the past 3 decades has been a major subject in many recent publications, including a discussion of concerns about patient radiation doses, unnecessary CT examinations, and the costs of CT examinations. One area of these concerns has been the use of CT examinations for triage, selection of treatment options, and release of patients from emergency medical settings. On September 23 and 24, 2009, the National Council on Radiation Protection and Measurements held a workshop on appropriate uses of CT imaging with emergency patients. The workshop was cosponsored by 8 private and government organizations: the American Association of Physicists in Medicine, the American College of Emergency Physicians, the ACR, the American Society of Emergency Radiology, the Centers for Disease Control and Prevention, Landauer, Inc, the Society for Academic Emergency Medicine, and the US Environmental Protection Agency. This paper presents a summary of discussions at the workshop and recommendations for important areas of consideration in a subsequent consensus paper to be prepared on clinical guidance for applications of CT in emergency medicine procedures.

Key Words: CT, imaging, emergency medicine, patient CT radiation doses, appropriate applications of CT

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INTRODUCTION

The establishment of emergency departments (EDs) and the specialty of emergency medicine is one of the most significant advances in the American health care system in the past half century. The presence of residency-trained and board-certified emergency physicians committed to accurate triage, diagnosis, and treatment of a broad range of traumatic injuries or acute health problems has significantly reduced both patient morbidity and mortality. In addition to traditional evaluation techniques, including patient history and physical examination, radiologic imaging is a major element in the diagnosis of patients presenting with complaints ranging from trauma to chronic health effects. These medical problems, which occur 24 hours a day, 365 days a year, have appropriately resulted in EDs serving as the "safety net" of modern health care.

The advent of CT in the 1970s was a major advance in the value of radiographic imaging for detecting and identifying adverse medical conditions. CT imaging is a significant asset for emergency medicine.

During the past 3 decades, widespread acceptance of CT imaging, increased demands for services, and medical liability issues have led to the proliferation of CT scanners in most hospitals, clinics, and imaging centers in the United States.

The medical application of CT averaged about 3 million procedures annually in the early 1980s. In 2006, patients in the United States received 67 million CT scans, with the number increasing annually [1]. Several factors have contributed to this increase, the most significant being that in the ED, CT imaging provides a rapid, highly sensitive and specific diagnostic modality with consistent predictive value for emergency patients.

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Despite the value of CT imaging, its expanding use has led to two issues that represent challenges for physicians who request CT imaging for their patients. One is the relatively higher costs of CT scans compared with other forms of imaging, such as standard radiography or ultrasound. The other is the extent of ionizing radiation exposure to patients receiving consecutive or multiple CT scans within a short period of time.

In many instances, the opportunity in EDs to obtain a contributory patient history is limited and, as the result of an inadequate information infrastructure, the review of previous medical records often is not possible. An emergency physician's decision as to what diagnostic procedure to use must be prompt and lead to either immediate treatment or a decision on which consultant the patient should be referred to by the ED. In those circumstances, the responsible radiologist performs and interprets the CT examination or other imaging procedure as soon as possible. The information obtained from a CT scan is comprehensive. Thus, the CT scan is often the prevailing and recommended choice over traditional radiography, ultrasound, or MRI. These are the benefits of CT in emergency medicine, but a recognition of the potential risks is also necessary.

Factors, such as costs and the benefit and risk of imaging with the resultant radiation exposure, merit the attention of emergency physicians and radiologists alike. The American College of Emergency Physicians (ACEP) and the ACR have expressed concerns and given consideration to ways of improving ED use of CT scanning and potential solutions for safely modulating its use. This shared concern prompted their agreement to sponsor a workshop, Computed Tomography in Emergency Medicine: Ensuring Appropriate Use, which was organized and conducted in Bethesda, Maryland, by the National Council on Radiation Protection and Measurements (NCRP), on September 23 and 24, 2009, and the preparation of a summary report on the information shared and the conclusions reached. In addition to ACEP and the ACR, the workshop was cosponsored by the American Association of Physicists in Medicine, the American Society of Emergency Radiology, the Centers for Disease Control and Prevention, Landauer, Inc, the Society for Academic Emergency Medicine, and the US Environmental Protection Agency.

This summary report describes many of the highlights of the workshop organized by NCRP. The workshop agenda and PowerPoint presentations of all speakers are available on the NCRP's Web site at http://www.ncrponline.org. The workshop presentations and this summary form a basis for the preparation of a report that will provide recommendations on a potential path forward to modulate CT use in emergency medicine, trauma, and acute health care.

THE GROWTH AND VALUE OF CT SCANNING IN EMERGENCY MEDICINE

The first CT head scanners were introduced in 1972 and body scanners a few years later. Their capacity for cross-sectional imaging was heralded as the most significant advance in diagnostic radiology since the discovery of x-rays, and their use grew during the same decade that emergency medicine training was established. The historic dilemma of perceiving 3-D anatomy in a 2-D image was resolved. Bones and overlapping tissues were not impediments to cross-sectional images, allowing critical imaging of traumatized patients. The use of contrast media with CT scans permitted functional imaging of specific organ systems.

In the first decade of CT applications, hospital planning authorities challenged the need for CT scanners in many communities. The medical acceptance and promotion of CT scanners by radiologists and clinicians in most disciplines convinced hospital executives that CT scanning was essential as a primary imaging technique, rather than as a tertiary method for which some critics asserted the modality was best suited. Most health care insurance organizations, including Medicare, agreed to pay for CT scans of any anatomic site. By the early 1980s, an estimated 3 million CT scans per year reflected the growing acceptance of the technique. The sophistication of CT scanners increased steadily over the next 2 decades. The production of multiple images and spiral body imaging enhanced the information in CT scans, reduced the time required for performance of examinations, and helped reduce the extent of radiation exposure. As the imaging efficiency increased, the ability to obtain sequential imaging of body sections increased and panoramic CT imaging, referred to as "pan-scanning," has become commonplace.

CT has proven its critical value in the detection and diagnosis of trauma patients and those with chest pain. Diagnosis and management of fatal diseases such as aortic dissection, pulmonary emboli, and others have been revolutionized with CT imaging. The mystery of the "black box" of the abdomen has been revealed, improving the diagnosis of conditions such as bowel obstruction, bowel necrosis, ureteral stones, appendicitis, pancreatitis, diverticulitis, pyelonephritis, and so on. CT scans also became the principal modality for evaluating intracranial problems and, to an ever increasing extent, the diagnosis of cancers.

The NCRP's [1] report number 160, *Ionizing Radiation Exposure of the Population of the United States*, documented a 7-fold increase in total medical radiation exposures to members of the US population from the early 1980s to 2006. CT scans in the United States accounted for 17% of all radiologic and nuclear imaging procedures

in 2006 [1]. The general availability of CT scanners in hospitals has made possible the routine use of CT studies for patients. It was estimated in the NCRP report that the annual number of CT scans in the United States had risen to 60 million in 2006 and to 72 million by 2008. That increase in CT procedures reflected an increase in the American population but, to a greater extent, the selection of CT imaging instead of other imaging modalities.

INCREASES IN MEDICAL RADIATION DOSES FROM CT SCANS

Given the increasing number of patients seen in EDs, a significant proportion of CT scans, estimated as a third or more of the total CT scans in the United States, currently are performed for patients in EDs. Because of the common lack of medical data for emergency patients, physicians must request prompt imaging. Often, a patient's medical condition reflects trauma that occurred subsequent to any previous images. Even if the tentative diagnosis is disease rather than trauma, an emergency physician is tasked to identify, treat, or exclude life-threatening and limb-threatening conditions. This is more than the focus of emergency medicine, it is also a federal mandate as a result of the Emergency Medical Treatment and Active Labor Act. For trauma patients, or those who cannot provide medical histories or be subjected to accurate physical examination (eg, those who are intoxicated or unconscious), CT is often the most appropriate and efficacious means to evaluate the patients' conditions.

However, a key reality in modern medicine is that many advances in diagnosis and treatment bear some element of risk. Benefits and risks vary with the conditions of individual patients and the advanced technology and treatments used. As previously described, there are several factors to be considered in emergency and acute medical care.

In the first weeks after the discovery of x-rays, physicians using them noted that chronic or excessive exposure to x-rays had adverse biologic effects, including skin lesions and malignant changes. Because early x-ray exposures were less intense than current ones, most of the ill effects were seen in physicians who experienced chronic exposures, not in patients who had single examinations. The same physicians noted that calculated exposures of cancerous tissues and a variety of other health problems were corrective. Radiation therapy for cancer grew in use, and the technology became more sophisticated in parallel with advances in x-ray diagnosis. However, for all that is known about contemporary radiation effects, physicians seeking diagnostic imaging information using CT or other x-ray imaging procedures must make a benefit-risk decision appropriate for each patient.

Another factor that has an effect on decisions about CT benefits and risks is the development of CT scanners that produce multiple images, some numbering more than 100, and other CT machines that rotate around a patient's body to produce multiple images that include the whole body. These machines have controls that can be used to limit the sites and extent of images. However, the use of such controls is not automatic or obligatory. The implementation of restraints on exposure doses is the obligation of radiologists and technologists, and not of physicians who refer patients for CT or other imaging procedures.

As discussed above, in 2006, about 17% of x-ray imaging procedures were CT scans, with traditional x-ray films and fluoroscopic examinations amounting to 74% and nuclear cardiac scans approximately 5% of the total number of procedures [1]. However, CT scans contributed 49% of the total estimated dose, with radiographic studies contributing 11% and nuclear medicine studies 26%.

IMAGE OPTIMIZATION AND DOSE REDUCTION

The phrase "as low as reasonably achievable" (ALARA) for radiation doses is emphasized in the training of radiologists and other members of the radiology team as the basis for attaining needed imaging results with a minimum of exposure to individual patients. This is a concept, rather than specific requirements on radiation dose, that applies to the performance of an imaging examination requested by a referring physician.

In the decades since the beginning of CT scans, their value has been appreciated by most physicians, including those in emergency medicine. In addition, their value also has been endorsed by most patients and their families. Therefore, if a CT scan is regarded as the most effective form of diagnostic imaging, patients (and in some cases their lawyers) sometimes ask why an attending emergency physician does not select an immediate CT scan rather than another type of imaging procedure or none at all.

Only in recent years have most informed patients become aware that there is an element of risk that accompanies the benefit of CT scans. If the benefit clearly outweighs the risk, then the ALARA approach in minimizing dose to the patient becomes the applicable principle. Radiologists have developed appropriateness criteria that relate the range of imaging procedures to initial clinical assessments of patient complaints. Those criteria are developed by expert committees of the ACR with the participation of experts from other disciplines [2]. If an

appropriateness criterion relates to kidney or urologic symptoms, the participating clinicians are urologists. If the criterion relates to bone and joint problems, orthopedists are working members of the ACR committee. In recent years, health care insurance companies, reviewing requests for imaging compensation, have come to rely on appropriateness criteria. The harmonization of the ACR Appropriateness Criteria® with clinical decision rules could further aid in the appropriate use of CT imaging and decrease the variability in CT applications and patient doses.

Because emergency physicians manage a broad range of patient complaints, taking into account patient ages and overall health conditions, it is less than ideal to concentrate on limited body systems or a single choice of appropriate diagnostic techniques, including imaging procedures. However, CT has become the diagnostic imaging procedure of choice in many EDs.

REGULATORY AND LEGAL ASPECTS

Most American health care professionals, including emergency physicians and radiologists, consider their medical legal risk exposure when evaluating patients. The same concern affects hospital management and medical group practices.

For patients who do not respond favorably to treatment or who have any negative outcome, the possibility of litigation has grown to a level that affects physicians, other health care providers and institutions. The American public expects a health care system with zero defects or errors. Therefore, in addition to determining the most efficacious procedures, responsible doctors are forced to practice defensive medicine. With CT scans often regarded as the optimal imaging procedure, a decision to exclude imaging, based on the clinical assessment, raises the possible accusation that a failure to get the information revealed by a properly interpreted CT scan (an act of omission) is a worse violation of good practice than the decision to undertake a procedure that may have limited value or a greater risk than benefit. Essentially, the cost and radiation exposure from a CT scan pose less of a malpractice risk to a physician and the health care system than not ordering the study. This defensive practice occurs with emergency physicians, radiologists, and other medical consultants, whether they work in primary care or specialties.

In addition to the potential for litigation, the medical use of ionizing radiation procedures is subject to state licensure for medical practice and other public regulations. All states require the registration of medical radiation facilities, the registration of responsible physicians, and, in a majority of states, the licensure of radiologic technologists. In 2008, federal laws imposed specific qualifications for any physicians who purport to perform medical imaging procedures, specifically including CT scans. The FDA's Center for Devices and Radiological Health continues to impose specific requirements for CT scanners and other medical radiation-emitting devices. State radiation control programs have responsibility for regular inspections of all licensed radiography facilities to determine the compliance of equipment with federal and state requirements. Meeting these legal requirements and regulations is the responsibility of all physicians who choose to perform and interpret medical imaging procedures that involve ionizing radiation.

GENERAL CONCLUSIONS AND RECOMMENDATIONS

The effectiveness of CT scanning has been demonstrated by more than 30 years of experience in trauma care and the treatment of life-threatening conditions. This experience has clearly demonstrated the value of 3-D anatomic information in the treatment of adverse conditions in most parts of the human body and has contributed substantially to the clinical judgment of physicians and their choice of treatment for diagnosed problems.

As a generalization, the benefit-risk estimates for CT scanning favor its use over most other imaging procedures and many other types of diagnostic technology. However, concerns have arisen regarding the increase in clinical use of CT scans, which results in greater ionizing radiation exposures than most other imaging techniques and can also amount to greater costs to patients than many other imaging techniques. These concerns have attracted the attention of the ACEP and ACR, leading organizations in their disciplines of emergency medicine and radiology. Such concerns prompted the workshop convened by the NCRP to define the circumstances and programs for assessing the value of CT scanning while addressing the issues of utilization patterns, radiation exposures, and overutilization. It is clear that multiple factors contribute to the use of CT imaging in the ED, including its diagnostic accuracy, patient expectations, ease of access to CT scanners, and legal protection against malpractice suits, just to name a few. The following initial recommendations are presented on the basis of discussions at the NCRP workshop:

1. Educate health care providers and others of the status and appropriate applications of CT scanning in emergency medicine and acute care.
   a. Review ACR Appropriateness Criteria® for CT scan applications in evaluating emergency patient complaints.
   b. The ACR and ACEP should collaborate in the development of clinical decision recommenda-

tions for the utilization of CT imaging in emergency care where applicable.

2. Educational efforts for emergency physicians and radiologists should be organized and promoted by ACEP, the ACR, and other societies representing their disciplines. These efforts should include
   a. presentations at scientific meetings,
   b. joint articles in scientific journals that address balancing between the benefit and risk of CT imaging and radiation exposure,
   c. instruction of technologists and other support personnel, and
   d. specific training for medical students and residents.
3. Emphasize ALARA principles and describe the clinical mandate established by the Emergency Medical Treatment and Active Labor Act in presentations.
4. Promote processes and skills to reduce the need for CT imaging when possible, such as the use of traditional radiography, ultrasound, and emergency point-of-care ultrasound.
5. Communicate concerns on the overutilization of CT to hospitals, together with recommended collaborative protocols to reduce variability in CT scanning utilization in emergency medicine.
6. Communicate with federal and state regulatory agencies regarding the importance of clinician-developed decision rules in the applications of CT in emergency medicine and the significance of relative indemnification when following these rules.
7. Develop mechanisms for reliable recording for emergency medicine patients of the number and doses received in CT scans and other imaging procedures.
8. Develop and adopt protocols for modulating the risks of CT medical imaging of children in emergency medicine settings, such as those advocated in the Image Gently^{SM} campaign.
9. Develop evidence-based guidelines that address the benefits of CT imaging in emergency medicine, including improvements in patient treatments and outcomes.

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