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CT UPDATE

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Radiation Safety in CT

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Computerized tomography (CT) scanning is a life saving technology which has contributed immeasurably to patient care and to physicians' ability to accurately and authoritatively diagnose their patients. There have been significant advances in CT imaging in recent years, driven by the advent of multidetector scanners, improved image quality, and a rapid expansion in the indications for CT imaging. Some examples include CT pulmonary arteriography which has largely replaced V/Q scanning and catheter pulmonary arteriography and CT urography and stone protocol exams that have largely replaced the venerable intravenous pyelogram (IVP). In 1993, 18 million CT exams were performed in the United States. In 2006, approximately 63 million CT studies were performed. This is an annual growth rate of over 10%[i].

Concurrent with the increase in utilization has been an increase in the radiation dose administered with each study performed. The risks of CT scanning and radiation exposure are poorly understood by patients and physicians alike. Early studies were performed with slice intervals up to 10mm. Current exams now frequently utilize scan increments of .5 or 1mm. The improvement in image quality and diagnostic accuracy has been dramatic, but so has the increased dose of radiation with each exam.

RADIATION RISKS

CT utilizes ionizing radiation (X-rays) for image production. X-rays produce free electrons when they pass through tissue. These free electrons may directly interact with cellular DNA producing breaks in the double helix or combine with other molecules to produce free radicals which damage DNA. Repair mechanisms exist in the body but may fail resulting in cell death or loss of function. Some mutated cells may survive to cause cancers in somatic cells or inheritable genetic mutations in germ cells. Cell death examples include skin burns or cataracts and occur only when a dose threshold has been passed. Genetic mutations lead to "stochastic effects" such as cancers. These effects do not have a dose threshold. Instead, the probability increases directly with increasing dose. Cancer induction is the primary risk associated with X-ray exposure.

Calculating absorbed radiation dose is very complicated and imprecise for the individual patient. Effective dose estimates averaged whole body dose and is expressed in *Sieverts* (Sv). CT dosing generally is expressed as a dose-length product or CT dose index which take into account the anatomic territory included in each scan. It is estimated that abdominal and pelvic CT scanning imparts approximately 8-15 mSv of radiation exposure to the average patient. More complex scanning can result in up to 35 mSv of exposure. The actual dose for an individual patient depends on many factors including patient size (larger patients require more dose), anatomic range imaged, and multiple technical factors. Average background radiation dose, by contrast, is around 2mSv/year. A single view chest X-ray exposes a patient to approximately 0.02mSv[ii].

Calculating the cancer risk associated with radiation exposure from medical imaging is also complicated and imprecise. Risk models are based on data gleaned from 100,000 survivors of the 1945 nuclear blasts over Hiroshima and Nagasaki. The probability of developing cancer from all causes is 420 out of 1,000[iii]. Because of this high, natural background risk, there is great difficulty in determining those cancers caused by radiation exposure. Additionally, the types of cancers caused by radiation and the age range in which they occur mirror those which occur "naturally". The risk of radiation induced malignancy is increased in the young and in radiation sensitive tissue such as thyroid and breast tissue. Nonetheless, it is clear that radiation exposure increases cancer risk, that there is no "safe" lower threshold, and that the risk increases with increased exposure. The actual risks of medical radiation are poorly understood, but real[iv].

A recent New England Journal of Medicine article suggests that CT radiation may be responsible for 1.5-2.0% of all cancers in the near future[v]. A review article in Archives of Internal Medicine from 2009 estimates 29,000 cancers will be caused by radiation exposure from CT performed in 2007 alone[vi]. In the same issue, Smith-Bindman et al estimate that one in every 270 women who undergo CT coronary arteriography at age 40 will develop cancer from that exam[vii]. These estimates are imprecise and based on large, unproven assumptions but highlight the increasing awareness of the risks which accompany the benefits of increased utilization of CT imaging.

SAFETY MEASURES

Despite the complexity and challenges in precisely quantifying the risks of CT imaging, safety measures have been developed and will continue to be refined for such imaging studies. There has been a significant increase in knowledge and awareness of the risks of radiation exposure from medical imaging, both in the medical literature and in the lay press. Examples include improperly calibrated machines on the west coast that resulted in widely publicized cases of radiation burns from repeated CT perfusion studies in stroke patients at several hospitals.

The American College of Radiology (ACR) has been in the forefront of the radiation safety campaign. Several national programs have been initiated including the "Image Gently" campaign for pediatric imaging and the newer "Image Wisely" campaign for adult imaging. The ACR has developed widely available appropriateness criteria for imaging exams which rates the relative value of imaging studies for specific disease entities and patient complaints. The ACR endorses the ALARA principle for radiation exposure; as low as reasonably achievable. Our radiologists refer to these resources on a routine basis.

CT manufacturers are actively incorporating dose reduction technology into their machines and large strides are being made in reducing dose through a variety of technical innovations. These include on the fly tube modulation which varies the strength of the X-ray beam depending on the body part being imaged, coning devices, and a variety of software developments and reconstruction algorithms which significantly reduce dose while maintaining high image quality.

The CT scanners in our facilities are carefully monitored on a regular basis with a physicist in charge of proper calibration and machine function. The dosing parameters for each study are monitored and audited. Current software upgrades allowing dose reduction are in place. Individual dose from every exam is recorded and included in the formal dictation of the study.

The physicians of Grand Traverse Radiologists, P.C. are committed to high quality imaging but also to the safety of the patients who pass through our department. All outpatient CT requests are individually reviewed and CT exams tailored to the clinical question, when these questions are made available to the radiologist. Alternative imaging modalities are suggested to ordering physicians when appropriate. By providing detailed information to the radiologist, the optimal test can be completed for the patient. The most effective technique for reducing radiation exposure, however, is to decrease the number of unnecessary and inappropriate CT exams performed. It has been estimated that up to 30% of CT examinations performed in the United States are unnecessary. In a recent review of primary care referrals at the University of Washington, the researchers found orders for

head CT and spine CT to be inappropriate 62% and 52% of the time respectively[viii]. A review of ER utilization of CT scanning at Duke University from 2006 studied increased scanning in specific anatomic regions over a five year period. Cervical spine CT increased 463%, chest CT increased 226%, abdominal CT increased 72%, and head CT increased 51%. This accompanied an increase in total ER patient volume of 13%. The researchers also noted that it was entirely unclear if this increase in utilization resulted in any improvement in patient outcomes[ix]. It is extremely important that physicians be aware of the risk/benefit ratio for their patients when requesting CT examinations.

NEXT STEPS

The public, medical professionals, insurance providers, and government agencies are all becoming aware of the explosive increase in utilization of CT scanning and its risks. The American College of Radiology has issued a white paper on radiation dose in medicine[x] that outlines an aggressive agenda for radiologists, referring clinicians, technologists, patients, medical physicists, and manufacturers. The FDA has published its Initiative to Reduce Unnecessary Radiation Exposure from Medical Imaging in 2010[xi] outlining concrete steps to be taken in this regard. The National Institutes of Health have endorsed a nationwide national radiation exposure registry.

At Munson Medical Center, the Radiation Safety Committee has strongly endorsed an expanded role for diagnostic medical physicists to provide expertise in all areas of radiation safety including quality assurance, image protocol development and management. A "flag" has been inserted into the POE process which alerts an ordering clinician when a patient has already had 5 or more CT scans in the Munson system. The alert requires an acknowledgement from the physician before proceeding to order additional CT studies. Software exists which would automatically link CT requests in POE to the ACR's Appropriateness Criteria to help clinicians in the decision making process in regards to CT imaging. In some centers, use of this software has allowed discontinuation of precertification requirements by insurers. Grand Traverse Radiologists, P.C. is working with facilities to investigate the possibility of pursuing this option in the future.

CONCLUSION

CT is a powerful diagnostic tool that has immensely improved medical care. It has revolutionized the practice of medicine and when used appropriately the benefits far outweigh the risks. It is incumbent upon physicians and health care systems to ensure that this life saving technology is used safely and appropriately. The technical factors relating to decreasing exposure are being actively addressed by radiologists, technologists, medical physicists, and manufacturers. Appropriate utilization of this technology is crucial and the risks and benefits of medical imaging should be carefully considered in every patient before a CT scan is ordered.

The radiologists of Grand Traverse Radiologists, P.C. are actively involved in dose reduction and finding and implementing solutions to the problems of overutilization at the facilities we serve. Please feel free to utilize our expertise in medical imaging when deciding the best approach to imaging decision making for your patients.

The ACR Appropriateness Criteria are available online at:

http://www.acr.org/SecondaryMainMenuCategories/qualitysafety/appcriteria.aspx

WHO TO CALL FOR MORE INFORMATION

If you have any questions regarding any of the information provided in this newsletter, please contact C. Paul Williams, MD, CT/CTA Modality Chief or James P. Picotte, MD, CT/CTA Assistant Modality Chief or the CT radiologist on duty at 231-935-6428.

REFERENCE

i Mettler FA Jr., Thomadsen BR, Bhargavan M, et al: Medical radiation exposure in the U.S. in 2006: Preliminary results. Health Phys 95: 502-507, 2008

ii Mettler FA Jr, Huda W, Yoshizumi TT, et al: Effective Doses in Radiology and Diagnostic Nuclear Medicine: A Catalog. Radiology 248: 254-263, 2008

iii ACR Appropriateness Criteria, Radiation Dose Assessment Introduction. Available at: http://www.acr.org/SecondaryMainMenuCategories/qualitysafety/appcriteria/RLLInformation.aspx

iv Thrall, James: Radiation Exposure: Politics and Opinion vs Science and Pragmatism. JACR, Vol. 6 issue 3: 133-134, 2009

v Brenner DJ, Hall EJ: Computed tomography-an increasing source of radiation exposure. N Engl J Med 357: 2277-2284, 2007

vi Berrington de Gonzalez, A, Mahadevappa M, et al: Projected Cancer Risks From Computed Tomographic Scan Performed in the United States in 2007. Archives of Internal Medicine 169 No.22: 2071-2077, 2009

vii Smith-Bindman et al: Radiation Dose Associated With Common Computed Tomography Examinations and The Associated Lifetime Attributable Risk of Cancer. Archives of Internal Medicine, 169 No 22: 2078-2086, 2009

viii Lehnert BE, Bree RL: Analysis of Appropriateness of Outpatient CT and MRI Referred From Primary Care Clinics at an Academic Medical Center: How Critical is the Need for Improved Decision Support? JACR, Vol 7 Issue 3, 192-197, 2010

ix Broder J, Warshauer DM: Increasing utilization of computed tomography in the adult emergency department, 2000-2005: Emergency Radiology 13: 25-30, 2006

x Amis ES Jr, Butler PF, Applegate KE, et al: American College of Radiology White Paper on Radiation Dose in Medicine: JACR 2007; 4: 272-284

xi Initiative to Reduce Unnecessary Radiation Exposure from Medical Imaging: Center for Devices and Radiological Health, U.S. F.D.A., February, 2010

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