SQU Med J, February 2011, Vol. 11, Iss. 1, pp. 1-4, Epub. 12th Feb 11
Submitted 11th Jan 11
Accepted 12th Jan 10

EDITORIAL

Radiation Exposure from Medical Imaging
A Wake-up Call for Oman!

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التعرض للإشعاع من التصوير الطبي
جرس إنذار لعُمان !

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Medical imaging using X-rays is like a double-edged sword. On the one side, we cannot do without it because of its enormous benefit in medical diagnosis, but on the other side, we risk exposing ourselves to potentially harmful low-dose radiation. Typically, two-thirds of all medical imaging procedures involve the use of ionising radiation, either X-rays in diagnostic radiology or gamma rays in nuclear medicine. Thus there is an urgent need to educate medical staff on the appropriate utility of this diagnostic tool, and for the creation of a regulatory body controlling and monitoring its use. This is of particular urgency in Oman.

Since the introduction of computed tomography (CT) scanning, diagnostic accuracy has significantly improved in clinical medicine, but concomitantly radiation exposure to human subjects has also significantly increased. By far, the CT scan results in much higher radiation exposure to the patients than does plain radiography, typically 40 to 50 times more.[1] A vivid example is the CT of the abdomen versus plain film. A plain X-ray of the abdomen results in about a 0.25 milligray (mGy) dose to the stomach which is about 40 times lower than the 10 mGy dose from an adult abdominal CT and the much higher 20 mGy dose in the case of the neonatal abdominal CT.[1]

Fazel *et al.* reviewed almost a million non-elderly adults between 2005 and 2007, and discovered that CT scanning and nuclear imaging accounted for over 75% of the cumulative effective dose to the population; however, CT scans and nuclear medicine together accounted for only 21% of total procedures in that study.[2] Other studies have also shown that CT scans of paediatric patients result in alarming radiation doses.[3,4,5] This is a source of concern given that such a population is still at a tender age.

Such studies show that physicians need to restrategise significantly how they request medical imaging studies, and especially CT scans, in the paediatric population. The increase in the numbers of medical imaging scans involving ionising radiation is alarming. In the United States, the number of CT scans in 2006 was 62 million, and since then it has been increasing at an unprecedented rate, both in United States and elsewhere.[6] In 2010, of the 5 billion medical imaging procedures worldwide, two-thirds utilised ionising radiation,[7] thus the need of discernment on our part in requesting diagnostic imaging. We need to look into the clinical indications for CT more critically and adhere more closely to the guidelines and "Appropriateness Criteria" set by the American College of Radiology (ACR) and other national radiological institutions.[8] Radiation is much more damaging to the growing child who has a longer life expectancy than to an adult. We, as physicians, therefore need to consider alternative imaging methods as much as possible and increase our use of ultrasound and magnetic resonance imaging (MRI) in place of CT scans and other radiation-dependant

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modalities whenever possible. Perhaps, more significant in increasing the unnecessary radiation exposure of the public is the repetition of medical imaging studies. It is not uncommon for patients to resort to 'doctor shopping' which often entails the repetition of imaging procedures. This may be triggered by a lack of faith in the initial images or by the financial interests of the clinics involved. Unnecessary repetition of imaging studies is today a major source of unnecessary radiation exposure for patients.

Physicians need to be educated about the dangers of radiation and the benefits of its wise use. They also need to take the initiative to learn more about the risks of their orders. For example, every CT scanner clearly shows the dose from a particular scan to a patient, but unfortunately, very few radiologists ever bother to review the dose they have given to their patients. Modern CT scanners will give the CT dose index (CTDIvol) per slice, expressed in mGy per volume, and also the dose length product (DLP) which represents the total exposure dose to the length of the area imaged (slice dose x length). DLP is expressed as mGy–cm.[9] In the case of mammography, the mean glandular dose (MGD) is also available. We need to make greater use of these exposure figures in appreciating how much radiation dose our patients receive at each imaging session.

Physicians should consider joining the "Image Wisely" organisation and take the pledge to be acutely aware of the radiation dose to the patients. There they will get educated about the necessary precautions. "Image Wisely" is an organisation sponsored by the ACR, the Radiological Society of North America (RSNA), The American Association of Physicists and other reputable organisations to promote judicial use of radiological science for diagnoses.[10]

There is also a growing momentum to get patients involved in radiation awareness and protection. One way would be to inform the patient each time they have an imaging study about the radiation dose to which they have been exposed. Unfortunately, the difficulty will be for the physicians to explain to the patients what that dose or their cumulative dose means as we have limited knowledge about the biological effects of various doses of low-dose radiation exposure. Perhaps we should also consider giving patients electronic "Radiation Registry Cards" to carry around so that each radiation exposure dose is added and an ongoing record kept since radiation is cumulative throughout one's life. The X-ray machines and CT scanners of the future will have to be modified so that with each exposure the scanner can register the dose on the patients' "Radiation Registry Card". If this were to be implemented, it would be one of the steps to come to grips with the emerging problem of rising radiation exposure.

What then is known about the tissue damage caused by low-dose radiation exposure? There is a significant amount of data known about high-dose radiation exposure and this is mainly from the survivors of the two atomic bombings of Japan in 1945 and the Chernobyl Nuclear Plant accident in Ukraine in 1986. Unfortunately, while the effects of high-dose radiation exposure have a linear relationship with the dose this cannot be extrapolated down to the lower dose or to zero. At higher doses, the biological effects are generally "deterministic" whereby the severity of the effect is dose-dependent and there exists a threshold dose above which the effects occur.[11] At lower doses, the effects are "stochastic", whereby the probability of an effect occurring is dose-dependent, but there is no threshold dose below which we could be relatively certain that no adverse effect will occur.[11] The best known stochastic effect is cancer production from radiation exposure. There is a significant amount of epidemiological data which indicates that exposure to low-dose radiation may result in cancer including cases of leukaemia, as well as thyroid nodules and other cancers.[12]

At the 2010 UN General Assembly, The United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR) presented the *radiation risks estimate for cancer* and for hereditary effects. They defined a low-dose to be 200 mGy (or milliSivert) or below or 0.1 mGy (or 0.1 mSv) per minute for exposure from external sources such as X-rays.[12] They pointed out with respect to radiation-induced cancer, that the long delay (often years or decades) between exposure and disease presented a major difficulty in attributing specific diseases to low-dose radiation exposure. This is compounded by the anyway high spontaneous incidence of disease associated with ageing. Besides epidemiological data, there are experimental studies that show the dose response relationship with cellular and sub-cellular elements exposed to radiation. The target appears to be the chromosomal DNA molecule. If the radiation damage to a group of genes is not repaired, the cell will die, but even if repaired the surviving cells may show DNA mutations that may affect cell behaviour in the exposed individual. Even a minor degree of mutation can result in development of cancer.[12]

There are also several *radiation-associated non-cancer diseases*, which are a result of radiation exposure. The best example is congenital disorders from exposure to a developing foetus, the neurological system being the most susceptible.[12] The risk will depend on the dose and the timing of exposure during pregnancy. UNSCEAR also pointed out that recently there is increased evidence of cataract development after low-dose radiation exposure.[12] Until recently, cataracts have been related only to high-dose exposure.

The third group of disorders related to radiation exposure is the *heritable effects of radiation*. UNSCEAR presented evidence that damage to DNA of germ cells resulted in heritable diseases. Unfortunately, these may be passed on to offspring and to several future generations. The evidence is clearer with higher than lower doses, but there is experimental evidence in animals that mutations induced by radiation can indeed appear in several generations.[12]

For the optimists in the medical profession, there is a group who believe in radiation hormesis.[13] This is the hypothesis that a small dose of radiation may actually be beneficial to living tissues. Mice exposed to low dose of radiation became resistant to the effects of future exposure to radiation and also resistant to certain diseases.[13] It is my wishful thinking that this be true, but unfortunately the evidence is not yet strong enough.

Perhaps in Oman at this stage, we more importantly need good regulations to control the handling and uses of ionising radiation. Unfortunately, there are currently no regulations in Oman that control X-ray machines, and only lax regulations for handling radioactive substances. Thus the use of low-dose radiation in Omani medicine is potentially dangerous to our community. We need tougher regulations on the purchase of X-ray machines and on the running these machines. In some private clinics in Oman, unqualified technologists run X-ray machines as there are no specific licensing regulations. The training requirements for radiological technologists are also limited. In addition, there are no training requirements for physicians who use X-ray machines. Unfortunately, there are physicians who actually run fluoroscopic machines without adequate licensing procedures. Not all radiological procedures and cardiac catheterisation procedures are adequately monitored from the equipment point of view, or by the physicians or technologists involved. The good news is that there is a move in the government towards setting up such a regulatory authority.

It should be mandatory for any physician handling radioactive material or using X-ray machines to attend a course on radiation safety and the use of these materials and machines to be certified prior to any use. Likewise, the technologists or nurses involved must have a similar course and certification. In addition, Oman needs to recognise medical physics as a specialised profession. Medical physicists are needed in all radiology and nuclear medicine departments to be in charge of quality control and assurance and as radiation safety officers.

What we need in Oman now is education of medical doctors on the dangers of medical imaging that utilises ionising radiation, in particular CT scanning and cardiac catheterisation studies. We also need continuing medical education on the appropriate criteria and clinical indications for the uses of these diagnostic tools.[14] Most importantly, and perhaps of great urgency, is the creation of an independent regulatory body to regulate the safe use of ionising regulation in medicine and otherwise. This governmental body needs to be free of the control of any ministry, and has to have authority to license the use of radioactive materials and of X-ray-producing equipment, as well as regulatory control over the education of staff handling both low and higher dose radiation sources in medicine and elsewhere. We need to respect and control low-dose radiation to safeguard ourselves and our future generations.

References

1. Brenner DJ, Hall EJ. Computed Tomography – An increasing source of radiation exposure. N Engl J Med 2007; 357:2277–84.
2. Fazel R, Krumholz HM, Wang Y, Ross JS, Chen J, Ting HH, et al. Exposure to lowdose ionizing radiation from medical imaging procedures. N Engl J Med 2009; 361:849–57.
3. Radiation Exposure from Medical Imaging Procedures. From: http://www.emoryhealthcare.org/radiology/pdf/nejm-letter.pdf Accessed January 2011.
4. Brenner D, Hricak H, Radiation exposure from medical imaging: Time to regulate? JAMA 2010; 304:208–9. Commentary: From: http://jama.ama-assn.org/content/304/2/208.extract Accessed: January 2011.
5. Dorfman AL, Fazel R, Einstein AJ, Applegate KE, Krumholz HM, Wang Y, et al. Use of medical imaging procedures with ionizing radiation in children: a population-based study. Arch Pediatr Adolesc Med 2011; Jan 3. [Epub ahead of print]. From: http://archpedi.ama-assn.org/cgi/content/short/archpediatrics.2010.270. Accessed: January 2011.
6. Coursey CA, Frush DP. CT and Radiation: What radiologists should know. From: http://www.medscape.com/viewarticle/572551 Accessed: January 2011.
7. Roobottom CA, Mitchell G, Morgan-Hughes G. Radiation-reduction strategies in cardiac computed tomographic angiography. Clin Radiol 2010;65:859–67.doi:10.1016/j.crad.2010.04.021. PMID 20933639.
8. ACR Appropriateness Criteria. From: http://www.acr.org/secondarymainmenucategories/quality_safety/app_criteria.aspx. Accessed:January 2011.
9. Sources and effects of ionising radiation From: http://www.unscear.org/docs/reports/2008/09-86753_Report_2008_GA_Report.pdf.Accessed:January 2011.
10. Radiation exposure from medical diagnostic imaging procedures. From: https://www.hps.org/documents/meddiagimaging.pdf. Accessed:January 2011.
11. Holmes EB, White GL, Gaffney DK. Ionizing Radiation Exposure, Medical Imaging. From: http://emedicine.medscape.com/article/1464228-overview Accessed:January 2011.
12. Report of the United Nations Scientific Committee on the Effects of Atomic Radiation (to General Assembly August 2010): From: http://daccess-dds-ny.un.org/doc/UNDOC/GEN/V10/563/16/PDF/ V1056316.pdf?OpenElement Accessed: January 2011.
13. Radiation hormesis. From: http://en.wikipedia.org/wiki/Radiation_hormesis. Accessed: January 2011.
14. Larson DB, Johnson LW, Schnell BM, Salisbury SR, Forman HP. National Trends in CT Use in the Emergency Department: 1995–2007. Radiology 2011; 258:164–73. From: http://radiology.rsna.org/content/258/1/164.full.pdf+html Accessed: January 2011.