A Literature Review about Radiation Safety Management in Computed Tomography CT

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WHICH SAFETY MANAGEMENT TECHNIQUES CAN BE USED TO PROTECT PATIENTS DURING CT SCANS?

The Lead Shielding

Lead shielding is primarily made to reduce the impact of scatter radiation in lead-sensitive or radiation-sensitive patient organs. A typical lead shield has a thickness ranging from 0.25mm to 1.0mm and comes in a variety of shapes and sizes. The most common types of lead shields include thyroid collars, wrap-around aprons, protective gears, eye shields, and male gonadal capsules (Demaio et al., 2014, 567). Regardless of the shape, size, or even the design of the lead shield, the primary goal is to reduce the amount of radiation dose to the parts of the patients that are positioned beneath the shield. For example, during the CT scan of the head, the lead shielding is utilized to reduce excessive radiations from accessing the breasts, thyroid, and even the eyes. The shielding restricts the radiation waves and scatters radiations within the targeted organ to prevent unnecessary harms that may be caused by scattering radiation waves. For instance, it is estimated that a 0.35mm lead-equivalent apron can reduce radiation scatter to up to 57%. In a head CT scan, there was an average dose reduction of 45% in the thyroid region and a 76% in breast tissues using a head or a collar lead-equivalent shield. In the collar-style shield, there was a further dose reduction of 46-54%, and there was a further 51% reduction in the entrance skin dosage for a lead-equivalent hen the thyroid shield was used (Demaio et al., 2014, 565).

It is important to note that in investigating the significance of lead shielding, scholars establish that lead shield may be of particular importance when scanning pregnant women. For example, there was a 35% reduction in fetal dosage when a lead protection apron was placed on the anterior parts of the patient. A maximum fetal dose reduction was further observed when a

0.25mm and 1.0mm of the lead protective cover was placed to shield pregnant patients. The results indicated a 55% fetal dose reduction. Sources further revealed that a 0.35mm shield [in thickness] double-layered cover similar to 0.70mm offered the best protective layer and achieved the maximum patient safety and comfort (Demaio et al., 2014, 566). More clearly, of all the lead shield thickness tested, a double layered 0.70mm shield offered a stable balance between patient comfort and fetal dose reduction.

Bismuth Shielding

The bismuth shielding is a new type of protection. This shielding is composed of latex rubber and the bismuth material and is designed to significantly reduce the surface radiation dosages to specific radioactive or radiosensitive organs. The bismuth is placed within an acquired radiation range and acts as a selective filter to scatter radiations. During a CT examination, sources identify that a bismuth shield will only allow a sufficient amount of photons to pass from the tube to the detectors (Demaio et al., 2014, 568). During a CT examination, it is noted that the bismuth shielding of a padded form is placed directly above the radio-sensitive organs. However, the bismuth shield is re-usable particularly when the padded forms are sanitized properly before a scan. It is important to note that during a CT scan the bismuth shields are 1mm thick and are used in conjunction with a foam pad to provide comfort between radio-sensitive organs and the imaging material. For instance, during a chest scan of a female patient, the bismuth shields can be placed directly over the chest organs of a supine female body to selectively filter out any radiation that exposes any sensitive areas like the breast and the stomach.

In researches involving the eyes, the thyroid, and the breasts, the bismuth has been known to reduce radiation dose by close to 74% - and during cardiac CT scans, the shields can reduce dosage to the breast by close to 57%. Perhaps a major advantage of the bismuth over the lead shielding is that the bismuth is recyclable and re-usable when used in combination with a padded form. Also, the bismuth is more effective in trapping scattered radiations as they combine both the latex rubber and the bismuth materials. The only advantage with the lead shielding is that it is particularly beneficial during the scanning of pregnant women. Also, the lead shielding is relatively inexpensive and can be equally as effective as the bismuth particularly when there is a double-layered 0.35 mm thick protector.

THE AMOUNT OF RADIATION WAVES THAT IS SAFE DURING CT SCANS

Another publication examines the knowledge gaps and monitoring approaches from CT scans. The publication summarizes the proceedings from a Radiation Dose Summit and brings to insight means and ways to achieve monitor radiations exposures from CT scans. The publication contends that in cases of stark uncertainties regarding the biologic effects of radiation exposure, the most fulfilling course of action is to keep the radiation dosages to as a low as possible. Also, information should be sufficient to guide intervention approaches and to enhance the prescription of accurate dosages (Boone, Hendee, McNitt-Gray, and Seltzer, 2012, 557). The paper further contends that reasonably accurate radiation doses should be administered during scans that are dangerous to radio-sensitive patient's organs. It is important, however, to note that reasonable estimates should take into account the scanner factors, patient sizes, and the use of correct estimates in the identification of methods that allow practitioners and physicians to identify where further reduction efforts should be applied (Boone et al., 2012, 558). It is important to note that in enhancing radiation safety management in CT patients, there is need to integrate reasonable dosage estimate into the patient’s medical records. Such an integration should be done in a scalable fashion so as to permit for the tracking of the patient’s periodic dosages.

Ann Bell seeks to examine a range of safety protocols that should be considered as part of CT examinations. First and foremost, the author identifies varied types of risks that are synonymous with CT scans (Bell, 2016, 14). The ionizing radiations, for example, are revealed to cause damages to the body's cellular organs. The ionizing radiations necessitate the passing of photons through the body's tissues and in the process leading to the formation of ion pairs. These ion pairs affect the DNA formation leading to irreversible body effects. A 2009 study from the Cancer National Institute estimates that approximately 14,500 untimely deaths and 29,000 new cancerous infections were as a result of exposure to excessive radiations that led to the formation of ion pairs which in turn affected the DNA and led to the growth of cancerous cells (Albert, 2013, 80). As part of examining the safety protocols, this publication reveals that practitioners and clinicians should implement desirable dosage estimates (Bell, 2016, 63).

THE EFFECTIVENESS OF RADIATION AND THE RISK IT EXPOSES TO PATIENTS

This literature by Chintapalli, Montgomery, Hatab, and Katabathina, seeks to examine procedures in dose management as part of radiation safety management. The publication covers scanner-indices in radiation exposure in increasing awareness about CT scan examinations – and discusses how radiologists can alter technical factors during scanning so as to reduce radiation doses. It is important to note that a major conclusion derived is that CT-guided procedures are both safe and effective – but due consideration is required as part of increasing the safety of medical examination (Chintapalli, Montgomery, Hatab, Katabathina, and Guy, 2012, 5). Scanner parameters are critical additions in any CT-guided interventions and they should be readily displayed as part of enhancing radiation safety management. The role of the scan parameters is to adjust the longitudinal scan length, to monitor radiation transmissions, and to contain the scanner transmissions within pre-defined scopes (Chintapalli et al., 2012, 7). A suitable equipment is the use of the exposure time product, which measures in the milliampere seconds mAs – is a team approach to dose reduction that is quite appropriate in various types of scans and computed tomography examinations.

A special report was generated from a Summit on the Management of Radiation Dose in computed tomography. The summit engaged stakeholders from academic, industry, clinical practice, and regulatory agencies. The most promising technologies discussed in the special reports pertained the use of x-ray including; detectors, sensors, noise reduction, image reconstruction, and algorithms for post-processing (McCullough, Chen, Kalender, Leng, Samei, Taguchi, Wang, and Pettigrew, 2012, 570). Access to standard data sets for raw processing was also identified as a critical requirement as part of radiation safety management. The publication revealed that current commercially present techniques such as beam-shaping filters, the optimization of tube potential, and automatic exposure control are critically underpinning in achieving an enhanced safety in CT scanning. Similar methods and techniques that are increasingly becoming widespread acceptance, including noise reduction, iterative reconstruction, and post-processing algorithms were seen as fundamental as part of achieving safety in routine CT scanning.

This publication supports that the above-mentioned techniques and technologies can possibly reduce radiation doses by a factor of 2-4 (McCullough et al., 2012, 574). There are additional tools and methods that show potential for dosage reduction, but which are several years to commercial acceptance, include; photo-counting detectors, interior tomography tools, and compressed sensing. This analysis reveals that the above special reports remain fundamental in showing how key developments in computing and scanning can help alleviate technical issues that affect scanning processes. More clearly, the publications offered an insight on new developments in terms of machinery and innovation that will assist CT technologists to avoid fundamental errors – and in the process enhance radiation safety management in computed tomography.

SAFETY PROCEDURES ON THE AMOUNT OF RADIATION DOSE AND EXPOSURE FROM CT SCANS

Safety Considerations on the Amount of Radiation Dosage

The ever-increasing concerns of the developments in safe and effective radiation control devices have led manufacturers to focus on radiation dose reduction tools. Three major radiation dose reduction techniques and devices are identified, and they include; iterative reconstruction, automated tube selection, and the automated tube modulation (Ramah et al., 2013, 40). The central principle of the automated tube moderation is to allow for a constant image quality of CT scans regardless of the patient's varied characteristics – by maintain such constant image qualities, it is possible to reduce the amount of dosage (Trattner, 2014, 276). The three fundamental operational principles for the automated tube modulation is to adapt the tube to the current stage of the body, to increase the automated tube for more attenuating areas, and to decrease the automated tube for less attenuated areas. The modulation tube has four areas of modulation the first being the angular modulation, followed by the longitudinal modulation, then the temporal, and finally the combination modulation (Ramah et al., 2013, 39). All these attenuations are done to allow the moderated tube to maintain the quality of CT scan images while at the same time reducing the radiation dosage.

The automated tube selection uses a software program to reduce dosage usages in CT scans. The results show that the ATPS system or device achieves a statistically significant reduction of radiation dosages when compared to the standard protocols that use a 120kwk setting (Ramah et al., 2013, 38). This software-based technique uses a programmed setting that alters the radiation dosages depending on the set parameters and key changes in the patient's sensory organs. For instance, when the ATP system is used, the automated tube selection makes it possible to alter the levels of radiation dosages depending on changing characteristics including changes in the body's functioning (Ramah et al., 2013, 41). This analysis hence supports that both software and hardware-controlled techniques are critical additions in the CT scanning innovations. Other than reducing the tube current, the ATP leads to a sharp decline in photons in both abdominal and chest imaging practices. The iterative reconstruction provides an alteration of algorithms to improve the image quality and to lower the radiation dosage. Key improvements in IR and its consequent implementation makes it possible to enhance image quality and to reduce exposure to dangerous, excessive radiations (Trattner, 2014, 275).

The Conclusion of the Literature Review

Multiple studies and scientific research have been conducted on the radiation safety management. Most of this literature focus on two fundamental areas of patient safety. The first area is the safety management strategies that are utilized to protect patients during CT scans. The literature identifies that the bismuth and the lead shielding are classic incentives when conducting periodic CT examinations. The lead shields use lead metals to provide an easy and a flexible protection of radiation-sensitive organs from scattered radiations. Protective aprons, thyroid collar, and eye shields are examples of lead shields. The bismuth protectors combine both latex rubber and the bismuth materials – and they can be re-used particularly when a padded form is used. The second area examines safety procedures on the amount of CT scan radiation exposure with a focus on three major radiation reduction techniques. The first are iterative reconstructions, followed by the automatic tube modulation, and finally the automatic tube potential selection. The above tools and techniques contain various operational principles that make it possible and easy to schedule dosage reductions during scanning.

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