Evolution of direct digital radiography (ddr)

Introduction:

The evolution of radiographic technology has advantageously developed in some cases with the hopeful intentions of benefitting patients and members of staff. Advancement from conventional radiography to computed radiography (CR) to direct digital radiography (DDR) but despite the intentions unforeseen shortcomings have arisen.

This report will consist of the implications of evolution of DDR for both patients and members of staff; existing literature will review the progression – following onto the recent developments within the technology. The recent developments enable current literature to hypothesise the progression of medical imaging. It allows professionals to feedback to manufacturers of how successful the advanced technology is within a clinical environment.

Digital imaging is the predominate image modality used in UK hospitals and was first introduced within a clinical setting in 1980 (Lança & Silva, 2013). CR and DDR are sub-sections within digital imaging. Direct DDR converts x-ray photons directly into an electrical signal using an Amorphous-selenium (a-Se) imaging plate which forms an image (Körner, 2007). Indirect DDR converts x-ray photons into light then an electrical signal to form an image using amorphous silicon (a-Si) – thus needing a further step before an image is produced (Carver & Carver, 2012). However, CR uses digital radiography system that uses a cassette with a photo-stimuable phosphors (PSPs) along with an image reader to form an image (Carver & Carver, 2012). To compare both CR and DDR the main difference is the efficiency of DDR compared to CR. The imaging process of DDR is achieved within the rooms console; an image should appear within 3-5 seconds after an exposure. This allows for the image to be appraised almost immediately and if any repeats or additional views are required (Vealé & Carter, 2014). CR is significantly slower than that of DDR, the CR reader needs to read and digitise the cassette to create an image. Also, PSPs are always switched on which increases the likelihood of background and scatter radiation; thus, a cassette should always be erased after a period of non-use to ensure background radiation does not hinder image quality (Seibert, 2009). Implications of staff and patients such as efficiency of work flow and how much time an examination takes will be discussed further within this report.

Implications for Patients

The use of DDR within diagnostic imaging departments has allowed for an efficient workflow, improved patient care and vigilant professional operators. Patient care and safety during an examination is of high importance when patients are critically ill are attending the department. Severely ill patients' conditions are time variable and the condition can deteriorate rapidly with no known reason. DDR offers radiographer attendance as image capture and processing is completed within the console room – the patient is never left unattended. Carter and Vealé (2014) stated within three to five seconds after exposure an image should be displayed on the monitor. On occasions the radiographer could be working on their own and the patient may be unattended by a member of staff from the department; since the radiographer has no need to leave the room to capture or process it is vital to be alert to any adverse changes in the patient's condition which could potentially avoid any life-threatening emergencies (Ehrlich & Coakes, 2017).

This advantageous implementation allows for the safety of patients and ensures the examination is as efficient, safe and easy for the patient's requirements.

Dose reduction is also a key advantage of the use of DDR within an imaging department. It is the radiographer's responsibility to ensure images are at optimum quality; modification of exposure factors may be required to create consistent and optimal images (The Royal College of Radiologists, 2015). However, it is also the radiographer's responsibility to ensure radiation dose is kept as low as reasonably achievable (ALARA) (The Department of Health and Social Care, 2017). Ensuring the ALARA principle is implemented it will help reduce the risk of patients from suffering from side effects of low levels of radiation over the years (Ching, et al., 2014). Modern DDR equipment is designed to reduce dose but having no compromise on image quality or patient care and aids within productivity and throughput of patients (Samsung, 2016). Manufacturers have implemented a feature known as ' exposure index' (EI) that provide information to the radiographer of the quantity of exposure reaching the detector (Mothiram, et al., 2014). An international standardised EI was introduced by International Electrotechnical Commission (IEC) and American Association of Physicists in Medicine (AAPM) and manufacturers to offset the existing wide range EI (Carestream, 2016). The EIs are proportional to the ratio signal to noise squared – this is related to the image quality. Carestream (2016) stated that exposure index is used to ensure the exam performed is unique and specific to the anatomical part requiring exposure. There are three default ' Target Exposure Index' (TEI) that are preloaded within a system for; the bucky, paediatric examinations and non-bucky work. The preloaded TEI is specific to the exam selected and works alongside factors such as the IEC exposure index and the deviation index (DI) to ensure exposure factors are kept as low as possible but still achieving an optimal image. Thus, in turn reducing patient dose as pe-set exposures reduces the risks of underexposure or overexposure of images that would require a repeat radiograph.

Conversely DDR has led to a trend known as the “ dose creep”. Dose creep is the steady increase of x-ray exposure over a period which subsequently increases patient radiation dose. Contrariwise literature would argue DDR does not reduce dose but instead increases the dose due to pre-set exposures (Hayre, 2016). The wide-exposure latitude of DDR is thought to be the reason for the dose creep (Gibson & Davidson, 2012). It could be stated that the correct exposure factors must be selected on an individual basis to ensure ALARA is implemented (Seeram, et al., 2012). Hayre (2016) stated that the pre-set exposures within DDR lack individuality which subsequently results in radiographers unintentionally either under or over exposing patients. A factor which reduces dose and improves image quality is the use of collimation. The correct collimation decreases the amount of tissue irradiated as the field size is reduced to only the region of interest this in turn increases the image quality due to reduction of scatter radiation (Karami & Zabihzadeh, 2017).

Implications for Staff

The use of DDR equipment within an imaging department is also to benefit the wellbeing of radiographers. Radiographers provide an imaging department twenty-four hours a day, seven days a week; this then confirms the equipment within the department to benefit the wellbeing and health of the professionals. Manufacturers have designed the modern DDR equipment with the aim of ‘ ease of use for the operator’. Samsung (2016) stated the integration of ‘ soft handling’ within the equipment had allowed radiographers to benefit from less strenuous physical pressure from hauling the unit.

As back injury is a result of poor manual handling of transferring patients or not using the equipment to the best of their abilities; it was reported within a study of 219, 000 radiographic technologists between 67% and 83% were suffering from pain due to work-related musculoskeletal disorders (WRMSD) (Fisher, Thomas F.;, 2015). Manufacturers have become conscientious of WRMSD so have created aims to not only improve DDR equipment for the benefit of patients but also the wellbeing of the operators using their equipment.

Future Developments

Samsung (2016) have developed DDR image receptors which has a high detective quantum efficiency (DQE). DQE is a parameter that indicates the detector performance. Thus, manufacturers have designed detectors with a high DQE to reduce patient exposures with the use of flat panel DR systems. Flat-panel detectors are used in DDR for the x-rays to be directly converted to charge. This uses thin film transistors (TFT array) to read the pixels to produce and process an image immediately. This development coincides with ensuring image quality is at its optimum but reducing radiation dose

(Escartin , 2017). Also, the flat panel detectors allow for an efficient processing time of image – Escartin (2017) stated due to TFT converting the charge into an image directly discards the processing of phosphor plate intermediate step to produce an image. Manufacturers are constantly working with clinicians to improve upon detector efficiency and reducing patient dose.

Samsung (2016) have created a software called “ SimGrid” for their DDR equipment that reduces the high frequency and scatter radiation without the need for a physical grid. Images from the SimGrid software were noticed to be a higher quality because of the reduction in noise and the improvements to contrast. The software allows for an efficient post-processing of an image and efficient workflow. It removes the physical preparation of the exam of installing the grid and aligning to the completion of the exam with removal of the grid and replacing it to the inside of the bucky. The statistics show an average of 15. 2 seconds reduction in exam time from preparation to completion (Samsung, 2016). Thus, improving workflow and efficient patient care but not hindering the quality of image.

DDR detectors have progressed to wireless, but the detectors if damaged are extremely expensive to repair or replace and can reduce the throughput of patients as a detector and possibly room could be out of use. Carestream have designed detectors to overcome the drawbacks the innovated detectors were experiencing. The DRX plus detector has been designed to be more cost-effective by ensuring durability; improvements such as withstanding higher weights, toleration of being dropped and resistance to fluid – some detectors can withstand submersion in a meter of water for approximately thirty minutes and still function properly (Töpfer & Wojcik, 2015). Canon have constructed their wireless detectors with carbon fibre – this allows the detector to be extremely light. The reduction in weight of the detector has benefitted clinicians by reducing the physical strain which thus reduces work-related injuries (Canon, 2017).

Conclusion

The evolution of DDR technology has had advantageous implements that literature has illustrated; improvement of efficient workflow and patient care. The DDR technology has improved efficiency of image processing which allows for patient care and safety, patients are never left unattended during an examination which ensures the patient is monitored and observed continuously.

Radiation dose has been reduced due to introduction of exposure index alongside pe-set exposures and post-processing features which reduces the risk of underexposure or overexposure of images that would require a repeat radiograph. But still achieving an optimal image.

Conversely literature would argue DDR has led to the trend of ‘ dose creep’. DDR has lost individuality of exposure factors and instead relies heavily upon pre-set exposures. Radiographers should always implement the ALARA principle and more care should be taken to reduce dose; such as correct use of collimation.

Literature evaluated DDR technology benefited the wellbeing of radiographers; the modern ‘ ease of use for the operator’ implication has resulted in clinicians benefitting from less physical pressure of strenuous hauling of a unit. Thus, reducing staff absences from work-related injuries.

Manufacturers are working with clinicians for future developments; improvements like creating detectors that reduce dose, ease of use to improve workflow and detector efficiency but no compromise on image quality. Also, DDR detectors are being designed to be more durable and withstand a higher volume of patient throughput; and reducing the physical strain on clinicians.

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