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Full Length Research Paper

An investigation of the effect of ionising radiation on nurses and their patients during dialysis

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Humans are all exposed to many different forms of radiation - radio waves, microwaves, ultraviolet, X-rays, etc. The form of radiation involved in Nuclear Medicine is called ionising radiation. This poster will provide advice to haemodialysis staff that may have to carry out dialysis on patients who have received ionising radiation as part of a medical investigation. All patients who are referred to the Nuclear Medicine Department for imaging procedures are given an injection of a pharmaceutical preparation with a radioactive compound attached to it. The vast majority of the patients are studied using Technetium -99m as a radioactive tag but on occasions, compounds like Iodine -123 and Gallium- 67 are also used. The different radioactive materials have different physical decay rates. Following administration of the pharmaceutical agent, the patient is deemed "radioactive". For this reason, unless it is clinically justified, haemodialysis should not be performed on patients in the 24 h period after a nuclear medicine injection. However, if haemodialysis is required, certain protocols must be carried out, because some risks are associated with the procedure. The main risks associated with these patients are external irradiation, internal contamination and fluid over load. Due to the short half-life of the radioactivity, these risks, in general, only warrant control in the 24 h period following the radioactive injection.

Key words: Haemodialysis patients, radioactivity.

INTRODUCTION

Nuclear medicine imaging involves the administration of a radioactive substance to patients. Environmental exposure to radiation includes radio waves, microwaves, ultraviolet and X-rays. There are many natural sources of ionising radiation, for example, the sun, elements in the earth and in the air, and even the components in human bodies.(1)

In Ireland, approximately 3,000 units (microsieverts) of naturally occurring background ionising radiation are obtained each year. Radiation workers, such as those who work in X-ray or Nuclear Medicine, are permitted to receive up to 6,000 microsieverts per year and non-radiation workers, such as general nursing staff are permitted to receive up to 1,000 microsieverts per year from sources of ionising radiation other than natural background. In addition to external sources of radiation, humans have naturally occurring radioactive substances (for example, Potassium ^{40}) in their bodies. Background radiation levels vary depending on location. The average background radiation levels in Ireland are approximately 10 microsieverts per day, although airline flight adds to the background radiation dose. For instance, a flight from Dublin to Paris gives a dose of 5 microsieverts.

Patients undergoing Nuclear Medicine imaging procedures receive an injection of a pharmaceutical preparation labelled with a radioactive compound. Over a period of time, the radiopharmaceutical accumulates in the organ of interest. Some of the product stays in the vascular system and some in the extracellular fluid. As a consequence, radioactive materials decay rapidly with time. In addition to physical decay, there is also a reduction in activity by biological clearance. The most common pathway for biological clearance is urinary excretion (Figure 1).

Dialysis patients have impaired or absent renal

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*Corresponding author. E-mail: niamhmoore@hotmail.com function, so they cannot eliminate these substances. They rely on dialysis and physical decay to clear these radioactive substances from the body.

OBJECTIVES

The need for guidelines was identified when a patient required dialysis after a nuclear imaging scan. The nursing staffs were concerned about the danger of exposure to levels of radiation. The Department of Medical Physics and Clinical Engineering with the renal nursing staff formulated a policy, after which several meetings were held with key stakeholders.

A literature review was undertaken to look at the following:

(a) The identification of the compounds involved in scans.
(b) The analysis of the procedures involved with a patient having a nuclear scan.
(c) Identifying potenional risks, hazards or dangers.
(d) The listing of safety considerations.
(e) Defining standard precautions.

OUTCOMES 1: IDENTIFICATION OF THE COMPOUNDS

Technetium^{99m}

This is the radionuclide that is most commonly used in dialysis. Once a sample of technetium has been injected into the body, it can be collected in certain areas of the body, depending on its exact make-up. If Technetium-labelled Methylene Diphosphonate (MDP) is used, the substance collected from the skeleton is used for bone imaging. The most widely used type of technetium based diagnostic imaging is bone imaging. Technetium is preferred because of its short half-life of 6.04 h. TC^{99m} emits gamma rays only, and the patient having Tc^{99m} radiopharmaceuticals can pose a risk of external exposure. Nevertheless, blood and, to a lesser extent, perspiration can pose a risk of internal contamination (Figure 2).

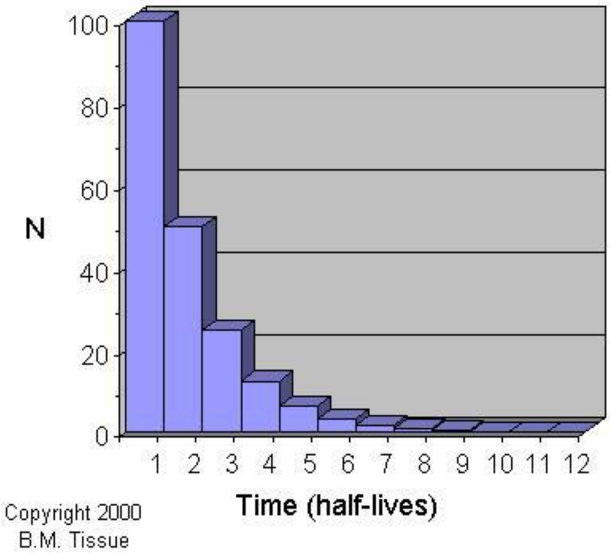

Figure 1. Tc-99m MDP

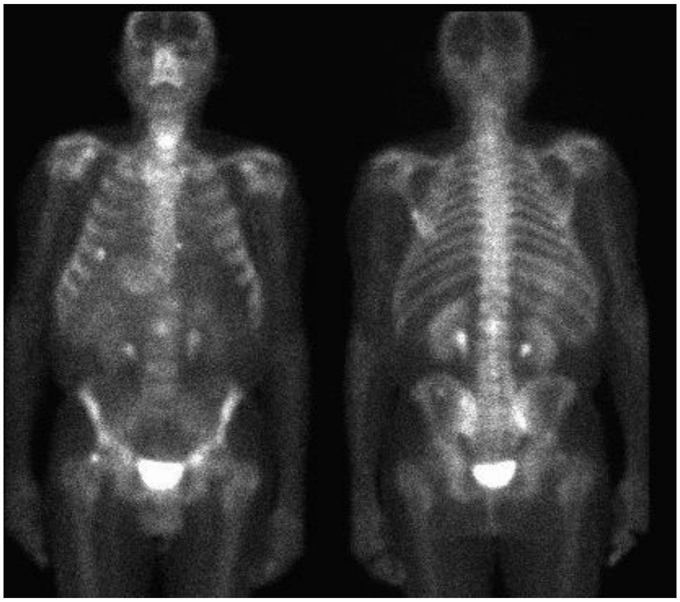

Figure 2. Tc-99m MDP.

Iodine^{123}

This is a radioisotope of iodine used in nuclear medicine imaging, including single photon emission computed tomography (SPECT) with a pure gamma emission. It is used for studies of thyroid metabolism and for imaging some neuroendocrine tumours. Its rate of decay is a physical half-life of 13.22 h. Iodine^{131} is a radioisotope of iodine used in nuclear medicine imaging, both diagnostically and therapeutically. Diagnostic tests exploit the mechanism of absorption of iodine by the normal cells of the thyroid gland. As an example, iodine^{131} is one of the radioactive isotopes of iodine that can be used to test how well the thyroid gland is functioning. The primary risk from exposure to high levels of iodine^{131} is the chance occurrence of radiogenic thyroid cancer in later life. Other risks include the possibility of non-cancerous growths.

Iodine^{131} is used for studies of thyroid metabolism and for imaging some neuroendocrine tumours, including single photon emission computed tomography (SPECT) with a beta and gamma emission. However, the rate of decay is a physical half-life of 8 days.

Gallium^{67}

A gamma-ray emitting nuclide is used in its citrate form as a tumour- and inflammation-localizing radiotracer. It has a high affinity for certain tumours, and also for non-neoplastic lesions, such as abscesses, useful in staging of lymphomas and in localizing occult abscesses. Its half life is 78.1 h.

Fluorine^{18}

It emits a positron (positive electron), which in turn rapidly emits two high-energy gamma rays. It is the main radionuclide used in Positron Emission Tomography (PET) imaging (Figure 3). When combined with a glucose analogue (FDG), it is used in the detection and staging of a wide range of tumours. It has a half life of 110 min. For the fact that glucose is taken up in the muscle, patients for PET imaging are kept in a resting position for approximately one hour after their FDG injection.

The material is excreted by the kidneys, and the gamma rays resulting from F^{18} are relatively penetrating the kidneys, which require thicker shields.

OUTCOMES 2: STANDARD PRECAUTIONS

Thestandard precautions against external exposure are: (a) time, (b) distance and (c) shielding, while the standard precautions against biological hazards are effective in preventing internal contamination.

Time

Exposure is related to the duration of time spent in contact with the patient. The more the exposure is greater, the closer it occurs to the time of the injection.

Distance

Very small increases in distance from a source dramatically reduce the external exposure (Inverse-Square law).

Shielding

For longer times in close contact with the patient, it is prudent to wear a lead rubber apron (X-ray apron), which can reduce exposure from Technetium Tc^{99m} by about 70%, or utilize a mobile shield (Figure 4).

The radiation from PET products is more penetrating and a lead rubber apron would only reduce the exposure by ~6%. When observing a patient, one should try to keep >1 m from the radioactive patient. The dose rate from patients immediately after a bone scan is carried out on a patient is 10 microsieverts per hour at one metre.

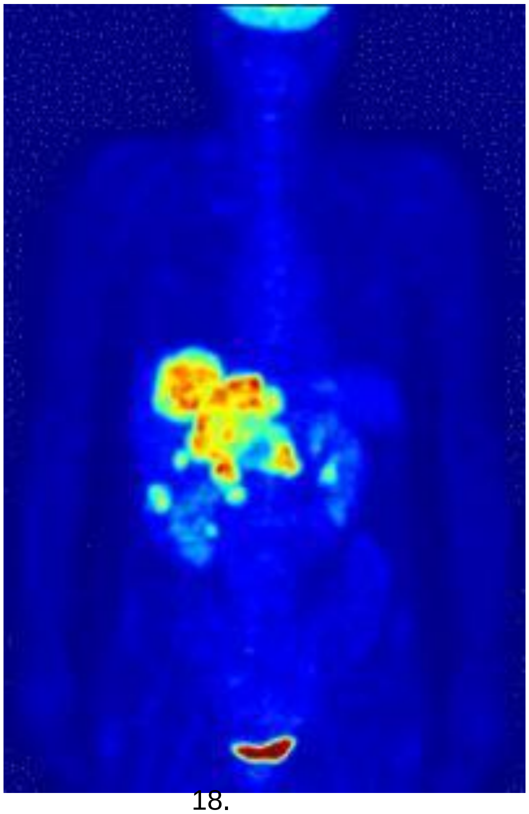

Figure 3. Fluorine^{18}.

Fundamentally, immediately after a PET scan with F^{18} FDG, the dose rate is 30 microsieverts per hour at one metre. Ten microsieverts is about the same dose, as a member of the public receives, on average, same amount each day from background radiation.

OUTCOMES 3: THE GUIDELINES

The development of guidelines for haemodialysis staff was the important focus of this exercise. Three areas that the guidelines cover are the patient, staff and environment.

The patient

Patients must wear a yellow or red wristband (Figure 5) stating that they are radioactive. Where possible, dialyse the patient before the bone scan, or try to delay dialysis for as long as possible to facilitate radioactive decay. Children and pregnant women should be prohibited to come in contact with the patient; and when dealing with patient eliminations, that is, bed pan / urinals, quick disposal of waste is essential.

Figure 4. Mobile lead screen.

Figure 5. Yellow or red wristband.

Figure 6. Lead apron worn by staff with small electronic dosimeters attached to it.

Figure 7. Disposal of consumables in labelled hazard bags.

The staff

Real-time measurements of radiation exposure can be made with small electronic dosimeters (Figure 6). Electronic dosimeters alert the wearer when radiation levels are increasing. When X-ray portering staff are moving the patient from nuclear medicine to dialysis, they must wear a lead apron (Figure 6).

Figure 8. Medical physics and clinical engineering staff monitoring the dialysis station.

The environment

If using an elevator, only the patient and staff are allowed to travel together. Used consumables, bloodlines, dialysers and disposable sheets should be kept from the treatment area or areas where personnel could come in contact with them. They should be placed in biohazard bin or bag (Figure 7) away from contact until medical physics staff can dispose them.

Waste from the patient may lie in the drains down stream from the treatment area. This may be a risk to other staff away from the dialysis unit (Plumbers). As such the Technical Service Department should be contacted.

OUTCOMES 4: ENVIRONMENTAL MONITORING

Environmental monitoring equipment may be used to detect contamination. Hand held Geiger Counters (Figure 8) and large area Proportional Counters can be used in the dialysis room. Swabs are sometimes also taken and counted with very sensitive equipment to detect residual contamination. All areas should be monitored by the medical physics staff after the patient has left the room.

Conclusions

Dialysis may be performed safely on nuclear medicine patients . A multidisciplinary approach is critical in all stages of formulating the treatment plan. Clear protocols should be prepared. These need to be reviewed regularly by the multidisciplinary team. Staff briefings before and after the procedures are very helpful; and in addition, liaison with other hospital departments allows access to a range of expertise and equipment.

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