Radiation Hazards to Personnel from the Veterinary Scintigraphy Service of the Autonomous University of Barcelona (UAB)

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Abstract. This paper quantifies the extent of the radiation hazards to personnel from the Scintigraphy Service of the Veterinary Clinic Hospital of the Universitat Autonoma of Barcelona (UAB). This Service uses Technetium-99m for nuclear medicine imaging diagnostic procedures in horses, mainly bone scans for the lameness diagnostic examination. The radioactive installation consists of an imaging room and a set of 3 boxes, each designed for isolating a given horse. In addition, an underground tank has been built to collect, if it is necessary, the liquid that the horse may urinate while being scanned. The possible radiological risk has been estimated in the most unfavourable situation, i.e., when a unit dosage is administered to the horse, usually intravenously, using a shielded syringe. Typical activities supplied to the horse vary between 1 and 5 GBq of $^{99m}$Tc. The dose rate has been measured at different points on the horse surface and in the radioactive installation environment. We have found that during the dosage administration the dose rate at 10 cm from the horse surface is 1.5 mSv/h, for 4.5 GBq of $^{99m}$Tc. However, since the injection procedure has a short duration, normally less than 2 minutes, the associated risk is low. Additionally, we describe the radioactive waste management of the whole process, from the $^{99m}$Tc injection to the animal until the declassification of contaminated material. We implant this management according to the Spanish Regulation and adapting it to the installation that we described below.

1. Introduction.

Nuclear medicine bone imaging or scintigraphy is a useful mode of diagnosis for horses’ lameness. This procedure is based on the intravenous administration of a radiopharmaceutical, normally technetium-99m, gamma low energy emission (140 keV) with a short half-life period (6 h) and activity that depends on the animal weight, 8 MBq/kg usually [1,2]. The given activity could be higher than the one administered in human medicine.

The Hospital Clinic Veterinary (HCV) Scintigraphy Service of the Universitat Autonoma de Barcelona (UAB) is together with two more the only Scintigraphy Services in Spain. Since it opened, in August 2000, 40 horses bone scans were made in this Service.

In Veterinary Medicine is important to decrease the personnel radiation hazard from horses undergoing scintigraphy keeping the animals’ confined in a controlled area until the dose rate would be below 0.5 µSv/h. The main radiation hazards points related with this procedure are the moment of radiopharmaceutical injection, holding the horse while the exploration and the contamination with the horse urine. In order to reduce the radiation exposition during the $^{99m}$Tc injection of the horse, the syringe has a lead shielding.

Another thing that we want to point out is that the amount of excreted activity by the horse is much higher than the human’s one, for this reason is necessary to establish a specific veterinary radioactive waste management. A diuretic is given to the horses to avoid contamination of the exploration room while the bone scan is done. Moreover there is a wheeled bucket just in case the horse urinates during the procedure. The most radiation hazard from the horse is the contaminated bedding, where the horse eliminates nearly all the $^{99m}$Tc by the urine.

The aim of this study is to report the results of the radiation dose rates during all the horse bone scintigraphy procedure using technetium 99m. We also report the Scintigraphy Service personnel dose rate while doing the exploration and also the description of the radiation waste management.
2. Experimental method

Bone scintigraphy is one of the diagnostic procedures that uses benign radioactive molecules, called radiopharmaceutical, in the Veterinary Medicine, as the Human Medicine does. This procedure is regulated by the normatives set out in the Spanish ionising radiations regulations registered in the BOE.

The radioisotope administration is normally carried out by vein in the animals. Typical activities administered to animals vary between 1-7 GBq, depending on the animal age and weight. Some of the most used radioisotopes are: \( ^{99m} \text{Tc} \), \( ^{67} \text{Ga} \), \( ^{113m} \text{In} \), \( ^{201} \text{Tl} \) and \( ^{123} \text{I} \).

The Veterinary Clinic Hospital (HCV) Scintigraphy Service (SG) is only allowed to use \( ^{99m} \text{Tc} \), as a monodosis, and we made our experimental study based on this radioisotope conditions.

2.1. HCV Scintigraphy Service

The HCV Scintigraphy Service of the UAB is composed by one exploration room and three isolating boxes. The exploration room together with one of the isolating room are in the same building and the other two isolating boxes are in another building closed to the first.

2.1.1. Scintigraphy Exploration room

This room is 42 m\(^2\) and the walls and the floor are made of a waterproof material that is easily decontaminated if needed. The wall has a 3 mm lead covered sheet for shielding the people outside the room.

The floor is covered by a nonporous, nonslippery material, in order to avoid that the horses, once sedated, could fall down. Connected to this room, there is a 750 litres capacity underground metallic box in order to facilitate the liquid waste material removal and deposition (figure 1). And there is also an electric pump connected to this box to empty it to the general drains.

FIG.1. The Scintigraphy Exploration Room and the radioactive waste disposal transverse section.
2.1.2. Isolation boxes

The HCV Scintigraphy Service has three isolation boxes. The main box will be used for the confinement of the horse after the radioisotope injection and after the examination during the radionuclide decay period. This box is very closed to the exploration room, it is used the day of the exploration because it is under the radiation regulations requirements in Spain [3]. The other two are in a different building near this mean one and are used just in the case more than three animals must be explored a week, they are only for 24 hours radiopharmaceutical injected horses.

The main box is 9 m$^2$ and the walls are covered by a 3 mm lead sheet with a nonslipping and non porous floor as the one in the exploration room. Moreover before the horse gets into the box, it is covered with absorbent bedding material, in order to absorb contaminated urine and faeces.

During the animal confinement period, the box is signalised as a control area with a label where it is written the name and phone number of the installation supervisor and some instructions related with the horse:

- do not feed this horse.
- do not enter in this box.
- in case the horse needs veterinary attention please phone the supervisor.
- the dosage injected, the time of injection and the radiopharmaceutical.

2.2. Description of the study

In this work the public and Scintigraphy Service personnel radiation hazards from a horse undergoing bone scintigraphy has been studied.

This study was made while a bone scintigraphy exploration was done for a horse lameness diagnosis in a horse injected with 5.2 GBq of $^{99m}$Tc.

The control test was divided into three parts:

A. To know the radiation dose received by the personnel who works during the scintigraphy: i.e. the injecting person and the horse holding person while the exploration. Both of them had an electronic dosimeter for a direct lecture of the radiation (SIEMENS EPD2).

![FIG. 2. The horse holding person and the horse with there are marked the measurement points.](image)
B. To know the environmental dose at surface, 0.5, 1 and 2 m from the horse, perpendicular to points of the horse with a RAMGENE1 monitor. In figure 2, the bone scanned horse and the different surfaces points where the different measurements were made are showed. Point 1) the region of the parotid salivary gland, 2) lateral aspect of the thorax at the level of the caudal scapula, 3) lateral aspect of the thorax at the level of the mid-body of the last rib, 4) caudal ventral abdomen in the region of the bladder and 5) gluteal region, lateral to the sacrum.

C. To know the environmental dose rates far from horse in the exploration room and in the main isolation box with contaminated bedding. These measurements were made in different points and distances.

In figure 3 the places where environmental radiation measurements were taken are showed, these measurement where made inside and outside of the Scantigraphy Service.

2.2.1. Equipment

The HCV Scintigraphy Service of UAB has a Human Medicine Gamma camera, Elscint Apex 609, guided by a hydraulic mechanic arm that allows getting the right position for every different anatomy region exploration of the animal, see figure 4.

As we already mentioned, we assess the personnel radiation dose rates using a hand held electronic monitor (SIEMENS EPD2). Those dosimeter are able to register gamma and X-rays in the range 20 keV to 6 MeV and beta radiation in the range 250 keV to 1.5 MeV. The radiation is detected by three silicone diode detectors which are sensitive to the different types and energies of radiation. The dosimeter calculates the total dose accumulated and the dose rate for the both penetrating and superficial dose. These are displayable on the LCD dosimeter.
FIG. 4. Picture while a bone scintigraphy exploration in a horse.

The ROTEM RAM GENE 1 monitor was used to assess the environmental contamination. These monitors are equipped with a recessed internal GM pancake detector of 4.45 cm effective diameter, with a thin mica window covered by a protective stainless steel wire mesh screen. The sensitivity ($^{137}$Cs) is approx. 5.8 cps/µSv/h.

2.3. Radioactive waste management

The residual waste generated from the examination are liquid and solid, nevertheless they have a short half-life period so they will be evacuated following the conventional way after they decay to background level. It is necessary to follow the ALARA criteria to make it.

What is done in the HCV Scintigraphy Service is to keep closed and isolated the box, where the injected horse was placed, during the period of time necessary for the injected radioisotope to decay from the contaminated bedding to background level. Making this we avoid hospital personnel exposition to the injected horse and the contaminated box. The bedding contaminated material is removed from the box 72 hours after the exploration starts. Before to disposal as normal trash, the radioactive status of the waste must be determined to ascertain that it is below 0.5 µSv/h. Once this happens all the bedding material is evacuated as a normal solid residue [3, 4].

In the case of the liquid residues, we can have a urine contamination of the exploration room from the horse miction while doing the exploration or a contamination by pouring a radioisotope monodose. Both of them are very unlikely to happen. In the case that we have a contamination from the urine or the radiopharmaceutical it will be necessary to diluted the product with water and collect it in the metal box collector placed underground. The liquid waste will remain there until the authorized decay period is completed and then it will be poured to the main drains.

It is important to point that from the time that the HCV Scintigraphy Service started to work to now, the metal box collector was never used because there was never a contamination of the exploration room.

3. Results

Immediately after injecting a 5.2 GBq of $^{99m}$Tc dose to the horse, the dose rate at a perpendicular distance of 0.01 m from the injection point was 1.5 mSv/h. Keeping in mind that the injection procedure does not take longer than 2 minutes the dose rate estimated for the injecting person is below 1 µSv/h. This means a very low hazard.
The bone scintigraphy exploration of the horse started 3 hours after the radiopharmaceutical injection and it took 1.5 hours. The accumulated dose of the radiopharmaceutical injecting person, who was near the gamma camera monitor during the scintigraphy, was 3 µSv and the one of the horse holding person was 8 µSv. The dosimeter in both cases was placed under the lead pinafore.

As we said before the radiation dose rates perpendicular from the horse surface were taken in 5 different points of the horse. At a distance of 0.05 m from the horse, the point where the higher dose rate measured was the head and the lesser dose rate was measured in the gluteal region.

In figure 5, the values of dose rates measured in point 1 of the horse are showed. From a distance of 0.5 m or further, there are no differences between point 1 to 4 related with the dose rates measurements, because we measure the whole body radiation from this distance. The medial dose rate at 0.5 m from the horse, during the exploration, was 44 µSv/h and from 2 m was 10 µSv/h.

The radiation environmental levels, as we see in figure 3, were measured in different points, even outside the building (points 4, 5, and 7). The dose rate on these places was always inferior to the official limit for the public. This means that HCV Scintigraphy Service observes the official radiation regulations requirements. In point 3, behind the lead shielded wall of the box, the higher value was of 1.5 µSv/h and behind the box door, 52 µSv/h.

4. Conclusions

The dose rates values measured outside from the HCV Scintigraphy Service building where like the normal background level, which means that the environment radiological protection is assessed in an optimal way.

The chance of urine contamination of the floor of the exploration room during the horse bone scan is very unlikely because the personnel inject a diuretic 1.5 hours before the exploration is carried out.

The personnel radiation hazard of a veterinarian, who makes a horse bone scintigraphy once a week, is very low, because the accumulated dose rate would be below 1 mSv/year.

5. References

