HERCA
HEADS OF THE EUROPEAN RADIOLOGICAL PROTECTION COMPETENT AUTHORITIES

Guidelines on radiation protection education and training of veterinary professionals

11 May 2017

This document was approved by the Board of HERCA on 11 May 2017 in Warsaw (Poland)

Index

Guidelines on radiation protection education and training of veterinary professionals

1. Introduction

This document deals with the education and training requirements of all veterinary professionals such as the veterinarians, the veterinary radiographers and veterinary assistants.

The education and training requirements in this document have been formulated as learning outcomes in terms of knowledge, skills and competences for the professionals concerned. This model has been proposed by the European Commission and has also been used by the "MEDRAPET"-project, which dealt with education and training requirements for the different professionals involved in human medicine applications of ionising radiation.

The "MEDRAPET"-project results have meanwhile been published as number 175 of the EC's Radiation Protection Series (RP): Guidelines on Radiation Protection Education and Training of Medical Professionals in the European Union, on which current document is largely based and inspired.

The learning outcomes are divided into two separate levels of education and training. The core learning outcomes should be attained by all veterinary professionals performing or assisting in procedures using ionising radiation. Certain practices, such as when performing nuclear medicine, radiotherapy or interventional radiology procedures, imply specific or greater risks and therefore call for additional education and training, which are dealt with in the additional learning outcomes.

The education and training requirements included in the tables that follow were developed in accordance with the graded approach principle. They therefore take into account the radiation risks associated with the different types of procedures they concern. These requirements have to be met before the veterinary professionals start to work with ionising radiation for diagnostic or therapeutic purposes. Once they have achieved the suggested level of knowledge, skills and competences (KSC), they should refresh and update their radiation protection KSC at regular time intervals in order to keep abreast of the continuous changes resulting from advances in science and technology and the related evolution of practice.

This document does not specify any education and training requirements for owners or handlers of the animal, who could be present during -or even actively take part in- a procedure. These people are not considered as professionally exposed personnel, but as members of the public, taking into account all related radiation protection requirements that apply where the procedures are performed. If the veterinary radiological practitioner judges that the presence of such persons is justifiable, then prior to the exposure taking place they should be informed on the possible radiological risks they would expose themselves to, and should be offered the free choice to accept these risks or not. If they chose to stay present or to actively assist, then they need to be instructed on how to behave in order to keep exposures ALARA.

Particular attention should be paid to the fulfilment of all radiation protection requirements mentioned above if children are concerned or women of childbearing age whose pregnancy cannot be excluded, or breastfeeding women in the case of nuclear medicine procedures.

Local rules and regulations may prohibit the presence of these vulnerable population subgroups.

It is possible to further formalise this, by having the owner/handler sign an informed consent form which states that they have, prior to the onset of the procedure, been informed about the risks of exposure and on how to behave as to reduce these risks to the extent practicable.

The physical environment in which veterinary procedures involving ionizing radiation are performed may vary and this may have an impact on the related risks. For that reason in the tables hereafter a distinction has sometimes been made between procedures performed in the well-controlled environment of the veterinary clinic or practice, referred to as “on site” and procedures done elsewhere, for instance in a stable or outside in the field, referred to as “off-site”.

Chapter 1: Radiation protection education and training requirements for veterinary doctors

This chapter deals with the education and training requirements of the veterinarians, working with ionising radiation.

The core learning outcomes that are dealt with in the first table underneath should be attained by all veterinarians. Most and for all, they must be able to deal with possible radiation exposure risks implied by the use of ionising radiation in procedures they perform themselves, which a large majority do.

But all, even those who don't perform such procedures themselves, should have some awareness of the risks, their magnitude and their possible specific characteristics (such as in nuclear medicine) for procedures they refer their animal patients to.

They should also know the basics of how to protect against these risks, understand the principles of justification, optimisation and dose limitation and be able to apply these principles in veterinary practice.

The veterinarians also play a key role in informing their staff and the owners/handlers of the animals on the risks related to the use of ionising radiation.

Table 1. Core learning outcomes in radiation protection for veterinary doctors

Core radiation protection for all veterinary doctors		
Knowledge **on the physical interaction principles of radiation with matter** (leading to imaging, shielding and biological effects) (facts, principles, theories, practices)	Skills (cognitive and practical)	Competence (responsibility and autonomy)
K1. The different natural and artificial radiation sources and their relative contribution to exposure of the population K2. The fundamental characteristics of radioactivity and the different radiation types emitted K3. The physical characteristics of X-rays and their use in imaging systems K4. The fundamentals of radiation detection K5. The fundamental radiological quantities and units K6. The basics of the biological effects of radiation K7. The basic principles of veterinary applications of nuclear medicine -both diagnostic and therapeutic- and the associated risks to staff and public K8. The differences between deterministic and stochastic effects and their respective dose ranges for doses received by the personnel and owners K9. The relation between effective dose and the risk of cancer and hereditary effects K10. The 'linear no-threshold' (LNT) hypothesis K11. The general principles of radiation protection and the concepts of justification, optimisation and dose limits K12. The general regulations relevant to radiation protection in the veterinary sector K13. The regulatory requirements that apply for a practice with regard to the site, the equipment and its Quality Control, the Quality Assurance	S1. Identify the legal radiation protection obligations in daily practice S2. Apply state of the art practical radiation protection measures with emphasis on minimising exposures to staff and owners/handlers (sedation, cassette holders, …), taking safety issues into account S3. Communicate the most important factors that influence staff doses, in particular understand the impact of stray radiation correct positioning and limiting the number of persons involved S4. Compare reported staff doses to background doses and communicate about possible associated risks in comparison to other risks in daily life, in particular to (possibly) pregnant staff members S5. Estimate the dose received by non-professionals assisting in procedures and communicate about possible associated risks in particular to (possibly) pregnant women S6. Communicate about specific risks of nuclear medicine procedures and the protection principles that apply S7. Perform required quality assurance S8. Apply the protection principles of time, distance, shielding correctly	C1. Implement the national radiation protection regulatory requirements in daily practice: identify flaws in implementation and correct where needed C2. Take full responsibility for the justification and optimisation of procedures that require the use of ionising radiation performed by oneself or under ones' authority, both on site within the practice and in particular when ionising radiations are used off-site C3. Take responsibility for the justification of procedures referred for more advanced imaging of therapy procedures implying the application of ionising radiation based on contemporary scientific information and indications for their use C4. Provide information to personnel and owners regarding risks and benefits of the radiographic procedures

Core radiation protection for all veterinary doctors		
Knowledge **on the physical interaction principles of radiation with matter** (leading to imaging, shielding and biological effects) (facts, principles, theories, practices)	Skills (cognitive and practical)	Competence (responsibility and autonomy)
K14. The fundamentals of protection by limiting exposure time, taking distance and shielding K15. The radiation protection aspects with respect to owners or other laypersons taking part in the radiological procedures K16. The radiation protection aspects with respect to staff and their unborn K17. The principles of quality control and quality assurance with respect to radiation protection K18. The specific radiation protection issues of working off-site K19. The risks associated with transportation and handling of the X-ray device and required quality assurance **K20.** The phenomenon of accidental/unintended exposures and how to manage these	S9. Optimise the choice of the site and set-up when working off-site, delineate controlled/supervised area S10. Correctly inquire about possible pregnancy	

Table 2. Additional learning outcomes for veterinary doctors working in the field of nuclear medicine

Additional radiation protection requirements for veterinary doctors working in the field of nuclear medicine		
Knowledge (facts, principles, theories, practices)	Skills (cognitive and practical)	Competence (responsibility and autonomy)
K1. The regulatory framework governing the practice of nuclear medicine in your country K2. The requirements for regulatory compliance with respect to the management and use of sealed and unsealed sources; including requirements for storage, shielding, record-keeping, waste management, transport and audit K3. The relevant regulations concerning treatment of animals on an in-patient/out-patient basis, as well as their t release criteria, where applicable K4. The justification aspects, in particular when considering off-site procedures K5. The basics of working with radiopharmaceuticals (e.g. preparation, quality control, quality assurance) K6. The concepts and tools for scaling administered activity depending on animal size/weight K7. The principles and process steps involved in the administration of the different forms of radiopharmaceuticals applied K8. The actions that should be taken after misadministration and accidental/unintended contamination K9. The influence of physiological and pathophysiological processes in the metabolism of radiopharmaceuticals as sources of internal and external radiation exposure for staff and for members of the public K10. The quantitative dose assessment and estimation of risk for staff and for members of the public, where applicable	S1. For each diagnostic or therapeutic procedure, apply European and national regulations, recommendations and standards related to staff safety, owner/handler and environmental safety S2. Develop an organisational policy for the safe handling of unsealed radionuclides (e.g. storage, shielding, record keeping, transportation, and waste) S3. Develop an organisational policy to keep doses to personnel from external and internal (inhalation, ingestion) exposure ALARA S4. Apply the principles of justification (risk / benefit assessment), optimisation (ALARA) and dose limitation S5. Decide on radiopharmaceuticals and procedures to be used S6. Apply the basics of working with radiopharmaceuticals (e.g. preparation, quality control, quality assurance) S7. Develop organisational policies for the optimisation of staff exposures in all specialised procedures S8. Design appropriate safety measures for management of animals that are submitted to therapeutic nuclear medicine procedures including release criteria when working on-site and specific safety requirements when working off-site	C1. Take responsibility for the justification of every nuclear medicine procedure C2. Take responsibility for compliance with regulatory requirements and ALARA principles concerning occupational and public radiation exposures, including the risk to pregnant and/or breastfeeding owners/handlers C3. Take responsibility for optimising the administration of the radiopharmaceutical and the activity used for a given diagnostic or therapeutic procedure based on case-specific information C4. Develop and implement SOPs for all specialised procedures performed regularly C5. Take responsibility for dealing with incidents/accidents/events C6. Advise owners on the risks and benefits of a planned nuclear medicine procedure by using oral and written information and instructions C7. Provide oral and/or written instructions to owners/handlers of animals that have been submitted to therapeutic nuclear medicine procedures C8. As legal person responsible for the undertaking, assume responsibility for implementing an organisational policy for protecting pregnant and breastfeeding workers from exposure risks in controlled areas

Additional radiation protection requirements for veterinary doctors working in the field of nuclear medicine		
Knowledge (facts, principles, theories, practices)	Skills (cognitive and practical)	Competence (responsibility and autonomy)
K11. The dose limits for professionally exposed workers (including organ doses), for pregnant workers and for members of the general public, such as for owners/handlers K12. The procedures with potentially high doses for extremities and eye lenses, such as the use of high-energy beta emitters. K13. The relevant occupational radiation protection issues associated with all specialised procedures performed, e.g. radio-synovectomy, targeted therapies with alpha or beta emitters	S9. Explain, where applicable, the estimated dose and the corresponding risk for members of the public, exposed/potentially exposed as a result of nuclear medicine procedures S10. Estimate the total dose to the owner and/or handler S11. Identify the required instructions for owners and handlers for minimising exposure (external and internal) S12. Deal with and/or solve incidents, accidents, events, contaminations S13. Identify procedures that require special operational protection, e.g. extra shielding, remote handling or specific dose monitoring, e.g. finger dosimeters or incorporation monitoring S14. Apply for ethical and legal approval of exposure in medical research, where applicable S15. Apply the transport regulation (ADR) with respect to radioactive substances	C9. As legal person responsible for the undertaking, assume responsibility for communicating on worker radiation protection / the organisation policy for staff protection C10. As legal person responsible for the undertaking, assume responsibility for implementing a monitoring programme for external and internal exposures of workers commensurate with the procedures performed and the corresponding risks

Table 3. Additional learning outcomes for veterinary doctors working in the field of radiotherapy

Additional radiation protection requirements for veterinary doctors working in the field of radiotherapy		
Knowledge (facts, principles, theories, practices)	Skills (cognitive and practical)	Competence (responsibility and autonomy)
K1. The interaction of radiation at the molecular level and the effects of oxygen, sensitizers and protectors K2. The cellular effects, mechanisms of cell death and cell survival curves K3. DNA damage and the repair of radiation damage K4. The radiosensitivity of normal tissue systems and organs K5. Tumorigenesis and leukaemogenisis K6. The effect of time-dose fractionation, Linear Energy Transfer (LET), different radiation modalities and the interaction between cytotoxic therapy and radiation K7. The atomic and nuclear structure K8. Radioactive decay K9. Radioisotopes K10. Radiation transport in tissues K11. The mechanisms of operation of the used equipment (X-ray tube, …) K12. Absorbed dose K13. Target absorbed dose specification in external radiotherapy K14. Target absorbed dose specification in brachytherapy K15. Algorithms for 3D dose calculations K16. Applications of conformal radiotherapy, intensity modulated radiation therapy (IMRT), image guided radiotherapy (IGRT), stereotactic radiotherapy and particle therapy K17. The risk of possible side-effects (deterministic effects and secondary tumors…) K18. Radiation weighting factor	S1. Apply your knowledge of clinical and radiological anatomy, physics and biology to diagnosis and therapy decision making S2. Apply treatment planning including 3D planning and virtual and CT simulation. Apply these procedures to plan animal treatments S3. Evaluate the benefits of conformal and special radiotherapy techniques if available (IORT, stereotactic radiotherapy) S4. Apply algorithms for dose calculations S5. Examine treatment options in the light of the prognosis S6. Develop an evidence-based treatment strategy and assess patients for curative and palliative external beam radiotherapy and brachytherapy S7. Analyse and synthesise research evidence to change practice S8. Develop a radiotherapy treatment strategy and technique S9. Adapt treatment plans according to the animal‘s individual needs, pre-morbid conditions, toxicity of radiotherapy and systemic treatments S10. Assess and manage animals undergoing external beam radiotherapy and brachytherapy S11. Adapt course of radiotherapy treatment for individual animals according to severity of reactions, including adjustment for gaps in treatment	C1. Consult owners/handlers on radiotherapy and ensure follow up of treatment response C2. Recommend appropriate dose and fractionation schedule for curative and palliative external beam radiotherapy and brachytherapy C3. Audit an external beam radiotherapy/brachytherapy treatment plan in collaboration with physicists, radiographers and other veterinary professional and be aware of the consequences of one’s actions and those of others C4. Assess the risk of an external beam radiation therapy and brachytherapy treatment plan C5. Engage in planning using IMRT and other techniques such as stereotactic, particle and IGRT, if available C6. Authorise a radiotherapy treatment C7. Assess animals for combined modality therapy C8. Take clinical responsibility for the delivery of radiation therapy together with systemic agents (and where necessary to work in collaboration with other specialists involved in systemic therapies) on an in-patient or out-patient basis C9. Take responsibility for the clinical implications and procedures of brachytherapy using sealed and unsealed sources C10. Engage in QA and follow safety policies C11. Manage accidental/unintended exposures including notifying to the competent authority

Additional radiation protection requirements for veterinary doctors working in the field of radiotherapy		
Knowledge (facts, principles, theories, practices)	Skills (cognitive and practical)	Competence (responsibility and autonomy)
K19. Equivalent dose – tissue weighting factor K20. Occupational/public health consequences of radiation exposure, radiation protection and dose limits for occupational and public exposure K21. The management of accidental/unintended exposures K22. The European and national legislation Evidence based radiotherapy	S12. Analyse tissue reaction S13. Investigate accidental/unintended exposures	

Table 4. Additional learning outcomes for veterinary doctors working in the field of interventional radiology

Additional radiation protection requirements for veterinary doctors working in the field of interventional radiology		
Knowledge **(facts, principles, theories, practices)**	**Skills** **(cognitive and practical)**	**Competence** **(responsibility and autonomy)**
K1. The specific requirements of image acquisition and image quality aspects with respect to fluoroscopy	S1. Application of radiation physics to optimise interventional protocols, obtaining desired procedure outcome(s) while minimising exposure	C1. Choice of the best interventional equipment for your animal patient range, taking into account the resources available
K2. The detailed understanding of the following features of fluoroscopes: flat-panel/image-intensifier detectors (including problems with image intensifiers such as geometric distortion, environmental magnetic field effects), continuous and pulsed acquisition (including frame rate), automatic brightness control, high-dose rate fluoroscopy, cine runs, last image hold, road mapping	S2. Application, on a daily basis, of all technical features and capabilities of the available equipment that allow quality-improvement and dose-reduction	C2. Provision of advice to owners/handlers on the radiation-related risks and on the expected benefits of a planned interventional procedure
K3. The radiobiological dose-effect relationships relevant to interventional radiology with respect to staff, public and animal safety, including discussion of the physical and biological background; response of tissues to radiation on molecular, cellular and macroscopic level; deterministic effects in particular on skin and lens of the eye, models of radiation-induced cancer risk, hereditary risks; and radiation effects on adults, children and unborn.	S3. Ability to recognise acute radiation skin effects and, where needed, adequately treat them	C3. Assumption of responsibility for justification of radiation exposure in every individual interventional radiology procedure
K4. The principle of ALARA and its applicability to interventional radiology settings	S4. Application of optimised procedure protocols by using SOPs for interventional radiology and by adapting these to the specific characteristics of the animal	C4. Assumption of responsibility for optimising the technique/protocol used for a given interventional procedure based on animal-specific characteristics and needs
K5. The meaning of justification and optimisation as applied to interventional radiology practices	S5. Choice of the best compromise between risk-benefit ratio (image quality and procedure outcome vs radiation exposure) on a case-by-case basis	C5. Assumption of responsibility for avoiding, where feasible, very high doses to the skin, which could cause deterministic effects
K6. The concepts and tools for dose management in interventional radiology with respect to staff, members of the public and animals	S6. Supervision of the use of personal protective equipment by interventional staff, support in the monitoring of the workplace and individual exposure assessment, investigation and follow up, health surveillance and related recording	C6. Follow-up of animals to check for the appearance of deterministic effects
K7. The factors influencing image quality and dose in interventional radiology	S7. Application of and advise on the use of radiation protection measures in interventional radiology, particularly for the hands and the eyes	C7. Assumption of responsibility for and establishment of procedures to ensure limitation of dose to staff and, where applicable, to members of the public
K8. The methods and tools for dose management in interventional radiology	S8. Recognition of cases of high skin doses which may require specific follow-up	C8. Assumption of responsibility for procurement of images of sufficient quality for the clinical purpose, while minimising staff exposure
	S9. Computational estimation of risk to staff and, where applicable, to members of the public, starting from measurement data	C9. Assumption of responsibility for conforming with radiation protection regulations

Additional radiation protection requirements for veterinary doctors working in the field of interventional radiology		
Knowledge **(facts, principles, theories, practices)**	**Skills** **(cognitive and practical)**	**Competence** **(responsibility and autonomy)**
K9. The basic concepts exposure measurement and computational dose estimation in interventional radiology K10. The key considerations relevant to radiation protection when designing an interventional radiology unit K11. The expected doses (to staff and, where applicable, to members of the public, to reference animal for the main interventional radiology procedures K12. The quantitative risk and dose assessment for workers (and public, where applicable) in interventional radiology K13. The ability to define quality assurance in interventional radiology, to explain its management and to assign responsibilities. K14. The ability to list the key components of image quality and their relation to procedural staff and animal patient exposure K15. The regulatory framework relevant to the practice of veterinary interventional radiology in the country of practice	S10. Avoidance of unnecessary radiation exposure during interventional radiology procedures by optimising techniques (x-ray field size and positioning, tube-to-skin distance, beam filtration, minimisation and record-keeping of fluoroscopy time, avoidance of non-essential projections) S11. Development of an organisational policy to keep doses to interventional radiology staff ALARA S12. Able to find and apply the relevant regulations for any clinical situation in interventional radiology	

Chapter 2: Radiation protection education and training requirements for veterinary assistants and veterinary radiographers

This chapter deals with the education and training requirements of the veterinary radiographers and veterinary assistants, working with ionising radiation.

Veterinary radiographers or assistants are veterinary professionals that actively partake in the care of animals, but do not qualify as veterinarians. Depending on the specific country and the education system, these professionals go by different names. They work under the supervision and responsibility of a veterinarian and can be involved in procedures using ionising radiation. In this latter case, they need to have an appropriate level of education and training in order to perform their job in a safe manner.

Most and for all, they must be able to deal with possible radiation exposure risks implied by the use of ionising radiation in procedures they perform themselves.

But all, even those who don't perform such procedures themselves, should have some awareness of the risks, their magnitude and of their possible specific characteristics (such as in nuclear medicine) for procedures they assist in doing. They should also know the basic rules of how to protect against these risks.

Attention should be paid as to keep the education and training packages for these persons very practice-oriented and adequately limited in volume to be practicable, in particular for those who don't perform procedures themselves.

In contrast to the education and training requirements for veterinarians, not all requirements in this document necessarily need to be attained by all veterinary radiographers or assistants. Depending on their scope of practice and the degree of autonomy they have in the different countries, the level of education and training may differ. Therefore, countries may choose to omit some of the requirements.

Although certain countries give their veterinary assistants/radiographers a high level of autonomy and responsibility, it is preferable that higher risk diagnostic or treatment procedures should be performed by the veterinarians themselves. This does not imply that a veterinary assistant or radiographer can't take an active part in these procedures. Examples of such higher risk diagnostic procedures or treatments are interventional radiology and radiotherapy including nuclear medicine treatment procedures.

Table 5. Core learning outcomes in radiation protection for veterinary radiographers and veterinary assistants

Core radiation protection for all veterinary radiographers and veterinary assistants		
Knowledge on the physical interaction principles of radiation with matter (leading to imaging, shielding and biological effects) (facts, principles, theories, practices)	**Skills (cognitive and practical)**	**Competence (responsibility and autonomy)**
K1. The different natural and artificial radiation sources and their relative contribution to exposure of the population K2. The fundamental characteristics of radioactivity and the different radiation types emitted K3. The physical characteristics of X-rays and their use in imaging systems K4. The fundamentals of radiation detection K5. The fundamental radiological quantities and units K6. The basics of the biological effects of radiation K7. The relation between effective dose and the risk of cancer and hereditary effects K8. The 'linear no-threshold' (LNT) hypothesis K9. The general principles of radiation protection and the understanding of the principles of justification, optimisation and dose limits K10. The general regulation relevant to radiation protection in the veterinary sector K11. The regulatory requirements that apply for a practice with regard to the site, the equipment and its quality control, the quality assurance K12. The fundamentals of protection by limiting exposure time, taking distance and shielding	S1. Use the appropriate medical devices in an effective, safe and efficient manner S2. Identify the legal radiation protection obligations in daily practice S3. Apply radiation protection measures in daily practice, including when accidental/unintended exposures occur S4. Communicate the most important factors that influence colleagues, owners and handlers doses, in particular understand the impact of stray radiation and positioning of persons involved S5. Perform required quality assurance S6. Apply the protection principles of time, distance, shielding correctly S7. Optimise the choice of the temporary sites and set-up when working off-site, delineate controlled/supervised area, if applicable S8. Use effective, safe and efficient radiation protection methods in relation to staff, the general public and the environment applying current safety standards, legislation, guidelines and regulations S9. Critically reflect on and evaluate one's own experience and practice S10. Recognise the complicated situation pertaining to radiation protection regarding scientific knowledge	C1. Practice effectively, accurately and safely, while taking into account guidance of legal, ethical and professional frameworks. C2. Take responsibility for the optimisation of procedures implying the application of ionising radiation performed by oneself autonomously or under ones' authority, in particular when off-site, if applicable (for the tasks you are entrusted to perform by the veterinarian) C3. Avoid unnecessary exposure and minimise necessary exposure as part of optimisation C4. Carry out work in a safe manner when using ionising radiation, taking into account current safety standards, guidelines and regulations C5. Participate in the process of creating and guaranteeing maximum safety for oneself, others and the animal involved, during examinations/treatments involving ionising radiation and apply the ALARA principle C6. Notify the responsible practitioner, if a request or referral in one's professional opinion, is dangerous or inappropriate C7. Recognise the limitations of one's own scope of competence and seek advice and guidance accordingly C8. Recognise the radiation hazards associated with one's work and take measures to minimise them C9. Monitor radiation exposure with the use of a personal dosimeter

Core radiation protection for all veterinary radiographers and veterinary assistants		
Knowledge **on the physical interaction principles of radiation with matter (leading to imaging, shielding and biological effects)** **(facts, principles, theories, practices)**	**Skills** **(cognitive and practical)**	**Competence** **(responsibility and autonomy)**
K13. The occupational risks to health and safety that may be encountered such as safe moving and handling of animals and equipment K14. The radiation protection aspects with respect to owners or other laypersons and their unborn children when taking part in the radiological procedures K15. The principles of quality control and quality assurance with respect to radiation protection K16. The specific radiation protection issues of working off-site K17. The risks associated with transportation and handling of the mobile X-ray device and the commensurate quality assurance requirements K18. The phenomenon of accidental/unintended exposures	on the one side and societal concern and personal emotions on the other side S11. Identify different image quality standards for different techniques S12. Apply the concepts and tools for radiation protection optimisation	C10. Establish safe working conditions according to the recommendations and the statutory requirements of European, national, regional legislation, where applicable C11. Inform and instruct other personnel, handlers, owners and persons of the public present or participating in matters relating to appropriate radiation protection practices C12. Place radiation risks in relation to other risks within a societal context C13. Reflect on one's own radiation risk perception C14. Evaluate the results of routine quality assurance tests

Table 6. Additional learning outcomes for veterinary radiographers and veterinary assistants working in the field of nuclear medicine

Additional radiation protection requirements for veterinary doctors working in the field of nuclear medicine		
Knowledge **(facts, principles, theories, practices)**	**Skills** **(cognitive and practical)**	**Competence** **(responsibility and autonomy)**
K1. The physical principles of how radionuclides can be generated K2. The possibilities to physically shield radionuclides K3. The relevant occupational radiation protection issues associated with all specialised procedures performed K4. The regulatory framework governing the practice of nuclear medicine in your country K5. The requirements for regulatory compliance with respect to the management and use of sealed and unsealed sources; including requirements for storage, shielding, record-keeping, waste management, transport, quality assurance and audit. K6. The relevant regulations concerning treating an animal on an in-patient/out-patient basis, as well as their release criteria, where applicable K7. The basics of working with radiopharmaceuticals (e.g. preparation, quality control, quality assurance) K8. The way to administer a radionuclide dose in a way that no, or very little, residue is left within the dispensing device (e.g. syringe) K9. The radiation protection principles, legal requirements and practical solutions which can be used to enhance safe storage, handling and disposal of radioactive materials	S1. For each diagnostic or therapeutic procedure, apply European and national regulations, recommendations and standards related to staff, owner/handler and environmental safety S2. Apply the principles of justification (risk / benefit assessment), optimisation (ALARA) and dose limitation S3. Translate guidance and local rules into practical working routines so as to minimise dose to colleagues S4. Perform and interpret quality control tests to determine whether nuclear medicine equipment is within manufacturer specification S5. Use devices which can be used to monitor and also minimise radiation dose S6. Use all relevant laboratory equipment S7. Be able to work fast and clean when handling radionuclides but not at the expense of incurring an adverse event S8. Apply the basics of working with radiopharmaceuticals (e.g. preparation, quality control, quality assurance) S9. Be able to prepare, manipulate and administer radioisotopes to animals, assuring prior and post-administration radioprotection measures S10. Draw up the correct quantity of radiopharmaceutical for administration	C1. Take responsibility for conforming to national regulations for all handling of unsealed radioactive substances. C2. Take responsibility for conforming to local standards and standard SOPs while handling unsealed radioactive substances C3. Take responsibility for the optimisation of every nuclear medicine procedure C4. Take responsibility for interpreting QC tests to determine whether nuclear medicine equipment is within manufacturer specification C5. Comply with good manufacturing practice when working in the radiopharmacy C6. Take responsibility for handling unsealed radioactive substances in a manner that accidental / unintended exposure of oneself as well as of co-workers is avoided C7. Take responsibility for compliance with regulatory requirements and ALARA principles concerning occupational and public radiation exposures, including the risk to pregnant and/or breastfeeding owners/handlers and colleagues C8. Take responsibility for drawing up the correct quantity of radiopharmaceutical for administration, taking into account DRLs where applicable

Additional radiation protection requirements for veterinary doctors working in the field of nuclear medicine

Knowledge (facts, principles, theories, practices)	Skills (cognitive and practical)	Competence (responsibility and autonomy)
K10. State how time, distance, shielding, monitoring and audit can be used to minimise doses received by staff and public	S11. Administer radiopharmaceuticals that are used for diagnostic procedures	C9. Take responsibility for the administration of radiopharmaceuticals which are used for diagnostic procedures
K11. The biological and physical half-lives of the radiopharmaceuticals used for diagnostic and therapeutic procedures	S12. Assist the veterinary doctor with the administration of radiopharmaceuticals used for therapeutic procedures	C10. Take responsibility for appropriate radiation protection advice to owners/handlers of animals undergoing diagnostic nuclear medicine procedures
K12. The concepts and tools for scaling administered activity depending on animal size/weight	S13. Inform and instruct the owner on the procedures and respond appropriately to questions	C11. Assume responsibility for dealing with incidents/accidents/events in a safe and efficient manner
K13. The principles and process steps involved in the administration of the different forms of radiopharmaceuticals applied	S14. Offer appropriate radiation protection advice to owners/handlers of animals undergoing diagnostic nuclear medicine procedures	C12. Contribute to advising owners on the risks and benefits of a planned nuclear medicine procedure
K14. What action should be taken after misadministration and accidental/unintended contamination	S15. Explain, where applicable, quantitative dose and risk assessment for members of the public, owners handlers / exposed/potentially exposed as a result of nuclear medicine procedures	C13. Give instructions to owners/handlers of animals that have been submitted to nuclear medicine therapy procedures
K15. With good practice in mind, explain how a radioactive spill should be dealt with	S16. Be aware of the fact that after an administration of radioactive substances an animal should be separated from others	C14. Assist in explaining procedures to the owner and responding appropriately to their questions
K16. The influence of physiological and pathophysiological processes in the metabolism of radiopharmaceuticals from uptake to elimination	S17. Care for animals that require a high level of care whilst at the same time minimising personal radiation dose	C15. Execute the clinical workflow so that the risk of exposure to individuals (e.g. pregnant females) is minimised
K17. The nature and sources of internal and external radiation exposure for workers in nuclear medicine and for members of the public	S18. Organise clinical workflow so that radioactive animals have minimal contact with at risk individuals (e.g. pregnant females)	C16. Take responsibility for providing appropriate care for animals whilst at the same time minimising personal radiation dose
K18. Quantitatively assess dose and estimate risk for workers in nuclear medicine and for members of the public, where applicable	S19. Assess total dose to the owner and/or handler	C17. Take responsibility for performing the diagnostic procedure to a suitable standard, ensuring that no repeat examination is required because of technical deficiency.
K19. The relevant dose limits for workers (including organ doses), for pregnant workers and for members of the general public, such as owners/handlers	S20. Identify the required instructions for owners and handlers for minimising exposure (external and internal)	
K20. The procedures with potentially high doses for extremities and eye lenses, such as when using high-energy beta emitters.	S21. Deal with and/or solve incidents, accidents,/events, contamination and notify the person legally responsible for the procedure	
	S22. Identify procedures that require special operational protection, e.g. extra/appropriate shielding, remote	

Additional radiation protection requirements for veterinary doctors working in the field of nuclear medicine		
Knowledge **(facts, principles, theories, practices)**	**Skills** **(cognitive and practical)**	**Competence** **(responsibility and autonomy)**
K21. The practical measures that should be carried out to minimise dose to staff, members of the public for hybrid procedures involving X-ray CT	handling or specific dose monitoring, e.g. finger dosimeters or incorporation monitoring S23. Apply for ethical and legal approval of exposure in medical research, where applicable S24. Acquire and process images and data that have clinical relevance, observing the principles of exposure optimisation and dose management (e.g. PET/CT)	

Table 7. Additional learning outcomes for veterinary radiographers and veterinary assistants working in the field of radiotherapy

Additional radiation protection requirements for veterinary doctors working in the field of radiotherapy		
Knowledge **(facts, principles, theories, practices)**	**Skills** **(cognitive and practical)**	**Competence** **(responsibility and autonomy)**
K1. The basic principles underpinning the scientific, effective, safe and efficient use of medical devices used in radiation therapy, including medical imaging devices used for tumour localisation and treatment planning and the treatment itself	S1. Use radiation protection methods relating to staff and the general public, taking into account current safety standards, guidelines and regulations	C1. Work under supervision of the responsible veterinarian in a safe manner when carrying out treatments with ionising radiation, taking into account current safety standards, guidelines and regulations
K2. The principles of radiation protection underpinning radiation therapy treatments and medical imaging examinations for tumour localisation and treatment planning to include: radiation hazards, radiation shielding, detection methods, current national and international radiation protection legislation and regulations relating to staff and the general public	S2. Recognise the signs and symptoms associated with treatment in different sites	C2. Assess the daily physical and behavioral status of the animal prior, during and after the treatment
K3. The principles of radiobiology underpinning radiation and cytotoxic therapy treatments, and medical imaging examinations for tumour localisation and treatment planning to include: cell biology, effects of ionising and non-ionising radiation, radiation risks, radio sensitivity, side effects of radiation therapy treatments	S3. Identify the side effects associated with the individual treatment	C3. Record all side effects and report to the responsible veterinarian in accordance with department protocol
K4. The effect of time-dose fractionation, and interaction between cytotoxic therapy and radiation	S4. Define the effects of concomitant treatment	C4. Apply safety procedures when using brachytherapy sources, if applicable
K5. The principle of Gross Target Volume (GTV), Clinical Target Volume (CTV) and Planning Target Volume (PTV)	S5. Be familiar with reporting systems and reporting protocols	C5. Engage in quality assurance and follow safety policies
K6. The principle of Organs at Risk (OAR)	S6. Describe the radiation hazards and how they are managed	C6. Check if all parameters, devices and settings are correct
K7. The different brachytherapy systems, if applicable	S7. Effective, safe and efficient use of positioning, immobilisation and beam shielding devices used in radiation therapy	C7. Report incidents and near incidents to the multidisciplinary team
K8. The principles of positioning, immobilisation and beam shielding devices used in radiation therapy	S8. Approach occupational risks to health and safety such as safe moving and handling of the animal and equipment in a safe and effective manner	C8. Examine any incident or near incident and how they can be prevented in the future
K9. The different radiation therapy verification systems		C9. Routinely inspect the area to ensure that radiation protection measures are in place and functional

Table 8. Additional learning outcomes for veterinary radiographers and veterinary assistants working in the field of interventional radiology

Additional radiation protection requirements for veterinary doctors working in the field of interventional radiology		
Knowledge **(facts, principles, theories, practices)**	**Skills** **(cognitive and practical)**	**Competence** **(responsibility and autonomy)**
K1. The specific requirements of image acquisition and image quality aspects with respect to fluoroscopy K2. The understanding of the following features of fluoroscopes: flat-panel/image-intensifier detectors (including problems with image intensifiers such as geometric distortion, environmental magnetic field effects), continuous and pulsed acquisition (including frame rate), automatic brightness control, high-dose rate fluoroscopy, cine runs, last image hold, road mapping K3. The radiobiological dose-effect relationships relevant to interventional radiology with respect to staff, public and animal patient safety (such as deterministic effects particularly on the skin and the lens of the eye) K4. The principle of ALARA and its applicability to interventional radiology settings K5. The meaning of justification and optimisation as applied to interventional radiology practices K6. The key considerations relevant to radiation protection for an interventional radiology unit K7. The expected dose-ranges to staff for the main interventional radiology procedures they are assisting in K8. Their role within the local quality management system. K9. The basic regulatory framework relevant to the practice of veterinary interventional radiology in the country of practice	S1. Application of radiation physics to optimise interventional protocols in collaboration with the responsible veterinarian S2. Application, on a daily basis, of all technical features and capabilities of the available equipment that allow quality-improvement and dose-reduction S3. Ability to recognise acute radiation skin effects S4. Application of optimised procedure protocols by using SOPs for interventional radiology and by adapting these to the specific characteristics of the animal S5. The use of personal protective equipment by interventional staff, assist in the monitoring of the workplace and individual exposure assessment, investigation S6. Application of radiation protection measures in interventional radiology, particularly for the hands and the eyes S7. Recognition of cases of high skin doses which may require specific follow-up S8. Avoidance of unnecessary radiation exposure during interventional radiology procedures by optimising techniques (x-ray field size and positioning, tube-to-skin distance, beam filtration, minimisation and record-keeping of fluoroscopy time, avoidance of non-essential projections) S9. Able to apply the relevant regulations for any clinical situation in IR interventional radiology	C1. Assist in the provision of advice to owners/handlers on the radiation-related risks and on the expected benefits of a planned interventional procedure C2. Participate in optimising the technique/protocol used for a given interventional procedure based on animal -specific characteristics and needs C3. Assist in avoiding, where feasible, very high doses to the skin of the animal, which could cause deterministic effects C4. Taking responsibility in avoiding high doses to their skin and eyes C5. Assist in the procurement of images of sufficient quality for the clinical purpose, while minimising staff exposure C6. Work under supervision of the responsible veterinarian in a safe manner when carrying out procedures with ionising radiation, taking into account current safety standards, guidelines and regulations