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The Clinical Application of Electron Radiotherapy in the Management of Cancer in Companion Animals

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Introduction

Over the past 6,000 years, domestic dogs and cats have developed a profound dependency on humans, not only for sustenance but also for companionship. Selective breeding, influenced by human preference, has produced the diversity of companion animal breeds we see today. This co-evolution has led to what is commonly referred to as the *Human–Animal Bond*, a mutually beneficial relationship that enhances the quality of life for both species.

However, as with humans, animals age and become susceptible to chronic diseases, notably cancer, which is a leading cause of death in geriatric companion animals. With advances in veterinary medicine, including improved nutrition, infectious disease control, and access to specialist care such as oncology and advanced surgery, companion animals are living longer than previously. This longevity is accompanied by an increased incidence of cancer, with approximately 50% of geriatric dogs and 33% of geriatric cats being expected to develop neoplasia.

This article provides an overview of cancer pathogenesis, the principles of radiotherapy, and the clinical application of electron beam therapy in the treatment of neoplastic disease in dogs and cats.

Cancer Pathogenesis

Cancer is fundamentally a disease of uncontrolled cellular proliferation. This transformation typically begins with genetic mutations—often affecting tumour suppressor genes and regulatory DNA sequences, which allow a cell to evade normal growth controls and apoptosis.

Contributing factors include chronic inflammation, environmental mutagens, and the cumulative effects of ageing.

Malignant cells may spread locally or metastasise via lymphatic or hematogenous routes to distant sites. Locally, tumour growth can result in tissue disruption, inflammation, and pain through the compression of adjacent structures. The biological behaviour of a tumour, including its growth rate and metastatic potential, varies widely depending on histological type and location.

Therapeutic Modalities

The primary treatment options for cancer in veterinary patients include surgical excision, chemotherapy, and radiation therapy, often used in combination. Treatment decisions are guided by tumour type, stage, grade, and anatomical considerations.

Chemotherapy and radiotherapy primarily target cells during mitosis, rendering rapidly dividing tumour cells more susceptible than most normal tissues. However, dormant cancer cells may evade treatment, necessitating long-term follow-up. Remission refers to periods during which no clinical or diagnostic evidence of disease is present. Although immunotherapy is now well established in human oncology, its application in veterinary oncology remains under active investigation.

Electron Beam Radiotherapy

Linear accelerators (LINACs) used in veterinary radiotherapy can generate both photon and electron beams. Electron beams are particularly well-suited for treating superficial neoplasms due to their limited tissue penetration (typically 4–5 cm). This makes them ideal for addressing cutaneous and subcutaneous tumours, as well as lesions on the limbs and torso.

In South Africa, photon therapy is seldom employed in veterinary practice due to the significant infrastructure and imaging costs involved.

Key considerations when evaluating suitability for electron beam therapy include:

- Tumour histology and radiosensitivity
- Anatomical location and staging
- Adjacent tissue tolerance
- Cost and logistical feasibility for the owner

Tumour Radiosensitivity

Radiosensitivity varies by tumour type, largely based on mitotic index and cell origin:

- **High Sensitivity**: Haematopoietic and lymphoid tumours (e.g., mast cell tumours)
- **Moderate Sensitivity**: Epithelial tumours (e.g., squamous cell carcinoma)
- **Low Sensitivity**: Mesenchymal tumours (e.g., soft tissue sarcomas)

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Fractionated radiation protocols, delivering smaller doses across multiple sessions, enable tumour control while preserving adjacent normal tissue function.

This approach is particularly important given the asynchronous cell division within most tumours.

Clinical Case Review: 20-Year Experience

Over a two-decade period, more than 1,500 companion animals (approximately equal numbers of dogs and cats) were referred for radiotherapy. Treatment protocols included pre-operative, post-operative, and combination therapies.

Canine Cases:

- 50% Squamous Cell Carcinoma (SCC)
- 26% Soft Tissue Sarcomas
- 24% Mast Cell Tumours (MCT)

Feline Cases:

- 95% SCC
- 5% Other tumour types

This data offers valuable insight into tumour prevalence and treatment response, informing future case management strategies.

Common Tumour Types Treated

Squamous Cell Carcinoma (SCC)

SCC is frequently associated with UVB exposure, particularly in non-pigmented or lightly pigmented skin. South Africa's high UV index is a significant risk factor.

UV-induced DNA damage in basal epidermal cells drives dysregulated squamous proliferation.

SCCs typically respond well to electron beam therapy, especially when detected early.

Prevention:

- *Dogs*: UV-protective Lycra bodysuits and topical sunscreens that penetrate the epidermis
- *Cats*: Indoor confinement during peak UV hours and installation of UV-filtering window films

Mast Cell Tumours (MCT)

MCTs demonstrate variable biological behaviour. Diagnostic workup includes cytological or histological grading, with mitotic index and cellular morphology informing prognosis.

Electron beam therapy is effective in treating localised disease, particularly in high-grade or surgically inaccessible lesions. For disseminated disease, combined modalities are indicated.

Soft Tissue Sarcomas

These mesenchymal tumours include fibrosarcomas, liposarcomas, chondrosarcomas, and peripheral nerve sheath tumours. They are often slow-growing with low metastatic potential but are locally invasive and prone to recurrence. Pre-operative radiation can reduce tumour volume and improve surgical margins; post-operative radiation aids in local control when excision is incomplete.

Clinical Recommendations

Optimal outcomes depend on:

- **Early Detection**: Prompt identification of non-healing lesions, especially on non-pigmented skin, or unusual subcutaneous masses.
- **Client Education**: Pet owners should be encouraged to seek veterinary evaluation for persistent skin changes or lumps.
- **Palliative Benefits**: Even when a cure is not achievable, radiotherapy often improves quality of life—enhancing appetite, grooming behaviour, and activity levels within days of treatment.



QUESTION 1

Which factor is most strongly associated with the development of squamous cell carcinoma (SCC) in companion animals in South Africa?

a. High-fat diet
b. Environmental pollution
c. Ultraviolet B (UVB) exposure
d. Vaccination status
e. Lack of Vitamin D

Explanation: *SCC is strongly linked to UVB-induced DNA damage in non-pigmented skin. South Africa's high UV index increases the risk, especially in animals with light or no pigmentation. This exposure disrupts cellular DNA in the basal epidermis, triggering carcinogenesis.*

QUESTION 2

What is the primary benefit of electron beam radiotherapy in veterinary oncology?

a. Ability to treat systemic disease
b. Deep tissue penetration
c. Limited penetration depth suitable for superficial tumours
d. No requirement for sedation or anaesthesia
e. Machines easy to maintain

Explanation: *Electron beams from linear accelerators penetrate tissues only to a depth of about 4–5 cm, making them ideal for treating superficial lesions such as skin, subcutaneous tissues, on the limbs, and trunk masses, which are common tumour sites in small animals*

QUESTION 3

Which of the following tumour types is generally classified as highly radiosensitive?

a. Squamous cell carcinoma
b. Mast cell tumours
c. Soft tissue sarcomas
d. Fibrosarcomas
e. Lipoma

Explanation: *Tumours of haematopoietic and lymphoid origin, including mast cell tumours, have high mitotic activity and are therefore more sensitive to radiation therapy, which targets dividing cells.*

QUESTION 4

What percentage of geriatric dogs is estimated to develop cancer?

a. 25%
b. 50%
c. 60%
d. 80%
e. 10%

Explanation: *Cancer prevalence increases with age. Approximately 50% of geriatric dogs develop some form of neoplasia, making cancer one of the leading causes of death in older dogs.*

QUESTION 5

Which of the following is NOT a typical characteristic of soft tissue sarcomas?

a. Low metastatic potential
b. High local recurrence rate
c. Rapid systemic spread
d. Mesenchymal origin
e. High apoptosis response

Explanation: *Soft tissue sarcomas are typically slow-growing with low metastatic potential. However, they have a high local recurrence rate due to infiltrative growth and difficulty in achieving clean surgical margins.*

QUESTION 6

What is the main rationale behind using fractionated radiotherapy in animals?

a. To reduce anaesthesia time
b. To allow normal tissue recovery while targeting tumour cells
c. To avoid using CT scans
d. To reduce the cost of each treatment
e. To improve the rate of angiogenesis

Explanation: *Fractionated doses spread over several sessions maximise tumour cell kill while minimising damage to normal tissue. It also accounts for tumour heterogeneity, as not all malignant cells divide synchronously*

QUESTION 7

What is one of the most commonly reported positive outcomes of palliative radiotherapy in animals?

a. Tumour eradication after two treatments
b. Improved appetite and activity levels
c. Regression of all metastases
d. Complete hair regrowth
e. Pets show good muscle and glowing coats

Explanation: *Palliative radiotherapy often relieves pain and reduces tumour burden, leading to noticeable improvements in appetite, grooming, and general behaviour even when curative intent is not possible.*

QUESTION 8

What makes electron beam therapy preferable over photon therapy in South Africa?

a. Photon therapy is not effective in animals
b. Photon equipment and imaging costs are prohibitive
c. Electron beams are better for deep-seated tumours
d. Photon therapy has more side effects
e. No sedation for electron therapy

Explanation: *Photon therapy requires advanced imaging (e.g., CT) and high-cost infrastructure. Due to financial and logistical constraints, many South African veterinary centres use electron therapy as a more practical solution.*

QUESTION 9

In the reviewed 20-year clinical case series, what percentage of feline tumours treated were SCC?

a. 80%
b. 85%
c. 95%
d. 100%
e. 5%

Explanation: *An overwhelming majority of feline tumours referred for radiation therapy in the case series were SCC, likely due to UV exposure and the high prevalence of non-pigmented skin in cats' nasal planum and pinnae*

QUESTION 10

Which of the following tumour characteristics is LEAST likely to influence suitability for radiotherapy?

a. Tumour location
b. Histologic type
c. Radiation sensitivity
d. Coat colour of the animal
e. The size of the tumour

Explanation: *While coat or skin pigmentation can influence UV exposure and cancer risk, once a tumour has developed, factors like location, histological type, radiosensitivity, and adjacent tissue tolerance are critical in determining radiotherapy suitability. Coat colour is not a treatment planning parameter.*

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