VETERINARY RADIATION ONCOLOGY GROUP

(VRTOG)

GUIDELINES AND QUALITY ASSURANCE

PROGRAM RECOMMENDATIONS

1.0 Introduction

The primary goal of veterinary oncologists and their supporting organizations is to provide the best possible care to every animal with cancer. There are many different approaches to providing optimal care. Each is tailored to local needs and resources. However, in every circumstance, the integration of highly trained personnel and expensive facilities is required. Although good radiation therapy programs always have included procedures specifically designed to minimize error and risk and to promote consistent high quality patient care, these activities should become formalized Quality Assurance Programs available to all in order to assure veterinary patients and their owners of their level of care and to allow for standardization of care enabling cooperative studies. Each patient, whether part of an organized study or not, must become a source of information available for continual improvement of therapeutic performance. These recommendations are largely taken from *"Radiation Oncology in Integrated Cancer Management: Report of the Intersociety Council for Radiation Oncology"* which establishes direction for the care of human cancer patients who receive radiation therapy.

2.0 Objectives

2.1 Establish reasonable standards for radiation therapy, inclusive of those for personnel, equipment, facilities and operations, to assure quality patient management.

2.2 Establish reasonable standards that allow for comparable management of patients in complying facilities participating in cooperative studies.

3.0 The Process of Radiation Therapy

A critical step is the initial evaluation of the patient and assessment of the tumor. This requires a pertinent history, complete physical examination, and review of all diagnostic studies. The radiation oncologist must be aware of the biologic characteristics of the patient's cancer as a basis for estimating its clinical behavior and planning treatment as well as the presence of intercurrrent disease that could complicate administration of therapy or alter normal tissue tolerance. The documented extent of each cancer must be recorded as a basis for staging. This will support an estimate of the prognosis for each patient and will enable comparison of treatment performances between different veterinary centers.

Initial decisions can then be made as to the risk:benefit ratio associated with therapy, selection of cure or palliation as the objective, and the identification of adjuvant therapies that may be of benefit. The choice of teletherapy vs. brachytherapy, method and pattern of delivery, dose and sequencing with other treatments are subsequently established.

Treatment planning requires determination of the tumor site and extent in relation to normal tissues. This assessment is based on physical examination, endoscopy, diagnostic imaging and findings at surgery. The radiation oncologist specifies the doses desired

throughout the tumor and sets limits of doses to critical structures. The calculation of doses at multiple sites and the mapping of isodose patterns require precise knowledge of anatomic information in multiple planes and the use of computerized planning programs. One can then define the treatment which satisfies these requirements.

After the therapeutic approach is selected, the target volume is confirmed and recorded radiographically whether at simulation, with a portal imaging system, or via port films. Devices to aid in positioning and immobilizing the patient, normal tissue shields, compensating filters and other aids will need to be available and on occasion designed and fabricated.

Treatments are carried out under the supervision of the radiation oncologist. It is essential that all treatment applications be described in detail and signed. Likewise, any changes in the planned treatment that may require adjustment in immobilization, new calculations and even a new treatment plan should be carefully documented.

Although the radiation oncologist may not set up each treatment, they should be available for confirmation of treatment. A variety of specific checks to insure conformity to the planned treatment should be in place. Portal verification films are periodically ordered and reviewed. The specific intervals may vary according to the requirements of the individual patient or be outlined in specific study protocols. A daily treatment record that indicates the ports treated, the dose administered and the person administering the dose is required.

Periodic post-treatment assessment of normal tissue and tumor response is essential. All findings should be recorded in detail and kept in the patient's file.

4.0 Quality Assurance of Radiation Therapy

The purpose of a Quality Assurance Program is the objective, systematic monitoring of the quality and appropriateness of patient care. Such a program is essential for all activities in radiation oncology.

Equipment: Minimal requirements for equipment include: 1) a teletherapy unit; 2) access to equipment to accurately calibrate and measure dosimetric characteristics of all treatment units in the department; 3) capability to provide appropriate dose distribution information for external beam treatment; 4) field-shaping capability and 5) access to CT and/or MR imaging capability. Other equipment available may include access to an electron beam source or a low energy x-ray unit, 3-dimensional planning systems, brachytherapy equipment and sources for intracavitary and interstitial treatment, and equipment for accurate simulation of the treatment units.

Minimal programs include: 1) calibration of equipment and measurement of radiation beam characteristics to assure accurate and reliable delivery of the radiation dose; 2) charting systems for recording treatment dose; 3) accurate calculation of dose and dose distributions, checks of dose calculation and ongoing reviews of accumulating doses and

4) appropriate safety programs for protection of personnel. The last item is carefully regulated by the national and state radiation regulatory agencies and will not be addressed further.

The success of radiation therapy is dependent on the accuracy of delivery of specified doses to selected targets, both in tumors and normal tissues. The margin for prevention of serious error may be small. Therefore quality assurance (QA) of external beam radiation therapy equipment is a continual evaluation of the machine's functional performance. This performance affects the geometric and dosimetric accuracy of the applied dose to the patient. Functional performance of radiotherapy equipment can change due to electronic malfunction, component failure, mechanical breakdown, deterioration and general aging of equipment. QA measurements should be performed periodically on all therapy equipment. A list of tests for a typical QA program is summarized in the attached Table 1 and Table 2. This information was derived from the *Comprehensive QA for radiation oncology: Report of AAPM Radiation Therapy Committee Task Group 40*, a subcommittee of the American Association of Physicists in Medicine. The tolerances reported in the tables are values intended to make it possible to achieve an overall dosimetric uncertainty of +/- 5% and an overall spatial uncertainty of +/- 5 mm.

4.2 Treatment planning

The treatment planning computer system should be tested over a range of parameters typical of those used in the clinic. Treatment planning may refer to any of three distinct processes.

1. Nongraphical planning is often used for single or parallel-opposed fields. In this approach, the daily treatment time for the prescribed dose to a point on the central axis is calculated using central axis depth dose, tissue-air ratios (TARs), tissue-phantom ratios (TPRs) or tissue maximum ratios (TMRs) and beam output calibration tables.
2. Traditional graphical planning is used for many patients. In this method, a target volume is defined from CT or MR images, or orthogonal simulation radiographs, and the patients contour is obtained from CT or mechanical surface contouring techniques. The field arrangements are designed and dose distributions calculated on one or a limited number of axial images using a computerized treatment planning system. The radiation oncologist prescribes the dose to a point or an isodose line.
3. Three-dimensional planning differs from the above in that target volumes, normal tissue volumes, and surface contours are defined directly on a series of contiguous CT or MR images. Field apertures are defined using beam's eye-view (BEV). It is possible to prescribe dose to a point, isodose curve, isodose surface, or dose level on a dose volume histogram (DVH).

The treatment planning process is outlined in Table 3.

4.3 Brachytherapy Treatment Planning and Dosimetry

With the exception of surface plaques and other implants with fixed geometry, execution of a brachytherapy treatment can deviate substantially from the treatment plan. Therefore, two calculations are often required: planning calculations to determine the distribution and activity of sources, and verification calculations to determine the treatment time from actual distribution of sources.

Traditional systems such as Manchester (Meredith, 1967), Quimby (Quimby and Castro, 1953), Paris (Pierquin et al., 1978) and Stockholm (Walstam, 1954) consist of rules for implanting the target resulting in an acceptable dose distribution and absence of excessive dose to large volumes. These traditional systems or computerized brachytherapy systems should be used in VRTOG protocols.

With the possible exception of radioactive eye plaques and other surface plaques, radiography or CT must verify the position of the implants. Table 4 outlines steps involved in brachytherapy treatment delivery.

5.0 Summary

All components of the evaluation of the patient must be documented in the patient's permanent record. A separate radiation oncology record is encouraged. The record should include signalment, initial history and findings on physical examination, histopathology reports, laboratory tests, diagnostic imaging studies and pertinent surgical procedures, photographs and anatomic drawings, measurements of tumor volume, medications prescribed, treatment set-up instructions, daily treatment logs, physics, treatment planning and dosimetry data, progress notes, summaries of treatment and reports of follow-up examinations. All data used in planning the specific treatment for a patient should be immediately available for review. These include: anatomic drawings, copies of appropriate visual imaging examination, radiographs from simulation of treatment, computation of beams and dose patterns, treatment beam verification films and records of physical measurements. Each treatment must be charted at the time of each application of ionizing radiation and include daily and cumulative doses. The results of treatment, with documentation of the status of the tumor and sequelae, must be assessed for every VRTOG patient.

Table 1. Quality Assurance of Cobalt-60 Units

Daily	
Door interlock	
Radiation room monitor and audiovisual monitor	
Laser alignment and distance indicator (ODI)	tolerance[1]-2mm
Weekly	
Operating indicator lights outside and inside teletherapy suite	
Safety interlocks	
Emergency off at control panel and on treatment couch	
Monthly	
Mechanical check	
Light/radiation field coincidence	tolerance-3 mm
Field size indicator	tolerance-2 mm
Gantry and collimator angle indicator	tolerance-1 degree
Latching of wedges, trays	
Annually	
Check of source positioning	tolerance-3 mm
Dosimetry	
Output constancy	tolerance-2%
Field size dependence of output	tolerance-2%
Central axis dosimetry (TAR/PDD)	tolerance-2%
Transmission factor constancy for accessories	tolerance-2%
Transmission factor – wedges	tolerance-2%
Timer linearity /error	tolerance-1%
Output constancy vs. gantry angle	tolerance-2%
Beam uniformity vs. gantry angle	tolerance-3 mm
Safety interlocks	
Mechanical checks	
Collimator rotation isocenter	tolerance-2 mm diameter
Gantry rotation isocenter	tolerance-2 mm diameter
Couch rotation isocenter	tolerance-2 mm diameter
Coincidence of collimator, gantry, couch axes w/ isocenter	tolerance-2 mm diameter
Tabletop sag	tolerance-2 mm
Vertical travel of table	tolerance-2 mm
Field light intensity	

[1]The tolerance listed should be interpreted to mean that if a parameter either (1) exceeds the tabulated value or (2) that the change in the parameter exceeds the minimal value, then an action is required.

Table 2. Quality Assurance of Linear Accelerators

Daily	
Safety	
Door interlock	
Radiation room monitor	
Audiovisual monitor	
Dosimetry	
X-ray output constancy	tolerance[1]-3%
Electron output constancy[2]	tolerance-3%
Mechanical	
Laser alignment	tolerance-2 mm
Distance indicator (ODI)	tolerance-2mm
Weekly	
Operating indicator lights outside and inside teletherapy suite	
Safety interlocks	
Emergency off at control panel and on treatment couch	
Monthly	
Safety interlocks	
Wedge, electron cone interlocks	
Mechanical checks	
Light/radiation field coincidence	tolerance-2 mm or 1%/side[3]
Gantry and collimator angle indicators	tolerance-1 degree
Wedge position	tolerance-2 mm
Tray position	tolerance-2 mm
Applicator position	tolerance-2 mm
Field size indicators	tolerance-2 mm
Cross-hair centering	tolerance-2 mm
Treatment couch position indicators	tolerance-2mm/1 degree
Jaw symmetry[4]	tolerance-2 mm
Latching of wedges, blocking tray	
Field light intensity	

Table 2. Quality Assurance of Linear Accelerators (Page Two)

Annually

Dosimetry	
X-ray & electron output constancy[5]	tolerance-2%
Backup monitor constancy	tolerance-2%
Field size dependence of x-ray output constancy	tolerance-2%
Central axis dosimetry (TAR/PDD)	tolerance-2%
Electron central axis dosimetry (PDD)	tolerance-2%
X-ray beam flatness constancy	tolerance-2%
Electron beam flatness constancy	tolerance-2%
Output factor constancy for electron applicators	tolerance-2%
Central axis constancy (TAR/PDD)	tolerance-2%
Off-axis factor constancy	tolerance-2%
Transmission factor constancy - accessories	tolerance-2%
Transmission factor constancy – wedges[6]	tolerance-2%
Monitor chamber linearity	tolerance-1%
X-ray output constancy vs. gantry angle	tolerance-2%
Electron output constancy vs. gantry angle	tolerance-2%
Off-axis factor constancy vs. gantry angle	tolerance-2%
Arc mode	Mfrs. Specs.
Mechanical checks	
Collimator rotation isocenter	tolerance-2 mm diameter
Gantry rotation isocenter	tolerance-2 mm diameter
Couch rotation isocenter	tolerance-2 mm diameter
Coincidence of collimator, gantry, couch axes w/ isocenter	tolerance-2 mm diameter
Coincidence of radiation & mechanical isocenter	tolerance-2 mm diameter
Tabletop sag	tolerance-2 mm
Vertical travel of table	tolerance-2 mm

[1]The tolerance listed should be interpreted to mean that if a parameter either (1) exceeds the tabulated value or (2) that the change in the parameter exceeds the minimal value, then an action is required. The distinction is emphasized by the use of the term constancy for the latter case.
[2]All electron energies need not be checked daily, but all electron energies are to be checked at least once weekly.
[3]Whichever is greater. Should also be checked after change in light field source.
[4]Jaw symmetry is defined as difference in distance of each jaw from the isocenter.
[5]A constancy check with a field instrument using temperature/pressure corrections.
[6]Most wedge transmission factors are field size and depth dependent.

Table 3. Treatment planning process and related QA procedures For external beam radiotherapy

Process	Related QA Procedures
Positioning and immobilization	Port films, laser alignment
Patient data acquisition	CT, MR, x-ray QA Accuracy of contouring
Data transfer to treatment planning system	QA of system
Definition of target volumes as stipulated by protocol	Peer review
Dose prescription as stipulated by protocol	Peer review
Computation of dose distribution and treatment time	QA of treatment planning system & treatment machine.
Verification of field size	Port film
Blocks, beam modifiers	QA for system, port film

Table 4. Brachytherapy treatment parameters

Endpoint	Procedure	Timing
Accuracy-OR implant	Direct observation	During procedure
Prescription accuracy	Consistency of loading & prescription w/ disease stage. Chart treatment plan.	First _ of treatment
Treatment plan	Calculation of plan & check for accuracy/consistency	First _ of treatment
Implant removal	Patient surveyed Final source inventory	At removal By next day
Review treatment	Verify treatment time	After completion
Record, QA audit	QA, treatment & radiation safety records complete	After completion