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 intercurrent 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: 1-2 mm

### 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
  - 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

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1The 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-2 mm

**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-2 mm/1 degree
- Jaw symmetry\(^4\): tolerance-2 mm
- Latching of wedges, blocking tray
- Field light intensity
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<td>Dosimetry</td>
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<td>X-ray &amp; electron output constancy(^5)</td>
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<td>Backup monitor constancy</td>
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<td>Field size dependence of x-ray output constancy</td>
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<td>Central axis dosimetry (TAR/PDD)</td>
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<td>Electron central axis dosimetry (PDD)</td>
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<td>X-ray beam flatness constancy</td>
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<td>Central axis constancy (TAR/PDD)</td>
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<td>Transmission factor constancy – wedges(^6)</td>
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<td>Monitor chamber linearity</td>
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<td>X-ray output constancy vs. gantry angle</td>
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<td>Collimator rotation isocenter</td>
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<tr>
<td>Tabletop sag</td>
</tr>
<tr>
<td>Vertical travel of table</td>
</tr>
</tbody>
</table>

\(^1\)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

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

### Table 4. Brachytherapy treatment parameters

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