MANAGEMENT OF RADIOTHERAPY PATIENTS WITH IMPLANTED CARDIAC DEVICES

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WHAT IS IN THIS PRESENTATION?
- Types of ICDs and ICPs.
- Current guidelines – protocol (TG-34).
- What are the issues with cardiac device and radiation deliveries?
- Review of literature since TG-34 area.
- Failures – case reports and scattered guidelines.
- Sensitivities and potential failures.
- Cardiac devices and RT patients.
- Dose estimation. During RT processes.
- Recommendations.

PRIMARY DEVICES INVESTIGATED
- Implanted cardiac pacemakers – ICPs
- Implanted cardioverter defibrillators - ICDs
  - Single-chamber dual-chamber biventricular
- ICDs
- ICPs

TG34: Management of Radiation Oncology Patients with Implanted Cardiac Pacemakers (1994)

MAJOR ISSUES WITH CARDIAC DEVICES AND RADIOTHERAPY EQUIPMENT
- In spite of availability of TG-34 and other reports in literature, major discrepancies still exist among manufacturers’ recommendations and wide variations exist among RT facilities regarding patient management and guidelines.
- Contradictory information exist: some devices have undergone deleterious effects at 0.15Gy (0.2Gy/min) while others have shown tolerance up to 20Gy or more dose?
- Interference with EM components, (partial) exposure to direct radiation, exposure to scattered radiation within the patient, other??
- Dose rate study

FROM MED PHYS LISTSERVS

Dose study

Influence of high-energy photon beam irradiation on pacemaker operation

- Reports
- Studies
- Devices
- Tolerance

In essence, what is the dose rate to the patient when using high-energy photon beams for treatment? Is there any data on the tolerance of pacemakers to different dose rates?
Recent Review Articles

The ICD should always be located outside the radiation field.

Program the ICD immediately to “monitor only” before each radiation treatment fraction. After consultation with the patient’s cardiologist, consider switching the ICD to “monitor” only in the event of radiation failure. It is sometimes used to treat further pump function.

Monitor the ICD and ECG in a high-quality personnel safety environment.

The ventricular rhythm analysis might consider combining (a) these safety measures if it is consistent with the patient’s cardiologist and the responsible clinical physician.

Radiotherapy-induced Single-event upset

Recent Review Articles

Effects of Scatter Radiation on ICD and CRT Function

Background: Effects of direct radiation on implantable cardioverter defibrillator (ICD) and cardiac resynchronization therapy (CRT) patients have been studied. However, the effects of indirect radiation are not clear. The results of analysis on management of patients with implantable cardioverter defibrillator with multichannel ablation therapy are based on studies mostly involving human volunteers. We sought to evaluate the effects of scatter radiation on implantable cardioverter defibrillator (ICD) and cardiac resynchronization therapy (CRT-ICD).

Methods: We exposed 12 ICDs and CRT-ICDs to 2 Gy of scatter radiation from a 6-MV photon beam. Devices were monitored with ECG and event markers pre- and post-radiation treatment. After each fraction, upon completion of the radiation course and with intelligent analysis of the pre- and post-radiation markers. A retrospective review of the radiation treatment was performed. All devices were placed outside the radiation field. No device was placed within the radiation field. There were 13 patients with devices undergoing radiographic treatment for post-cardiac device implantation. All patients were radiated to a total dose of 2 Gy over a period of 30 days. Actuarial survival rate of patients undergoing radiation was noted.

Results: ECG changes were noted in 2 ICDs and 1 CRT-ICD. There was no evidence of ventricular tachycardia or rhythm disturbances. There were no episodes of device burn, inappropriate sensing or therapy, or changes in programmed parameters. Patients were found to be well, with no evidence of radiation-induced symptoms.

Conclusions: Device exposure or multifaceted association with radiation therapy likely represents an unimportant, rare occurrence. While we have no clear correlation with risk factors for radiation therapy, we recommend close monitoring of patients undergoing radiation therapy.

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The Cardiac Pacemaker Patient

**Might the Heart Be Directly Hit?**

Radiotherapy Course: The patient received radiotherapy as an outpatient. Figure 1 shows the target in the suprasternal notch. During each fraction we performed an ECG and observed the rhythm on a stripchart recorder. The different target was marked with a needle; the radiation beam was delivered by linear accelerators. The patients were treated in a room and on a bed by the same fraction. The pacemaker function was monitored before, during (2 weeks later) and after the radiation course. We observed cardiac arrhythmias in the right side of the right atrium without symptoms. As a result of the patients' symptoms, the pacemaker function was normal. The pacemaker function was abnormal after every fraction, but the tachycardia remained, which is usually an indicator of heart failure. The pacemaker function was then normal. After the radiotherapy course, the magnetic field was switched to a high level. All the systems worked without symptoms. At the next control, the magnetic field was switched off. All systems worked without symptoms. The pacemaker function was normal, which is usually an indicator of heart failure. The pacemaker function was normal. The patient has been in complete remission since then.

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**CASE REPORT**

**Defibrillator reset by radiotherapy**

Dennis H. Lau, Lauren Wilson, Martin K. Stiles, Bobby John, Shabidhlar, Eday Dimitri, Anthony G. Brooks, Glenn D. Young, Paul references:

**Table 1. Case Reports of Implantable Cardioverter/Defibrillator Failure**

<table>
<thead>
<tr>
<th>Reference No.</th>
<th>Type of Failure Diagnosis</th>
<th>Type of Device</th>
<th>Consequence</th>
<th>Implication</th>
</tr>
</thead>
<tbody>
<tr>
<td>1995</td>
<td>Implantable cardioverter/defibrillator failure</td>
<td>New</td>
<td>2.0 Gy scattered dose ICD</td>
<td>1 Gy scattered dose ICP</td>
</tr>
</tbody>
</table>
CATASTrophic MALFUNCTION of ICP (IT's programming code was significantly corrupted) after neutron therapy, at a dose level of 900 cGy.

NEW TASK GROUP – AAPM TG 203

- Permanent damage from accumulated dose: circuitry is degraded in proportion to accumulated dose:
  - Decrease of output amplitude
  - Increase current drain (not obvious - can lead to sudden failure within months post RT)
  - Erroneous or failed sensor operation (including heartbeat sensing functions)

- Upsets in memory or logic circuits caused by neutrons: SOFT ERRORS:
  - Changes in stored values in memory or transient changes in microprocessor circuitry
  - May not be functionally reversible
  - Reset of the device to default parameters
  - Rare cases where reset may delay for hours or even weeks past RT

- Transient interference from high-dose-rate x-rays (not EMI):
  - Inappropriate sensing of device that lead to ICD shock
  - Non-existent pacing output
  - Reset or other effects

- Electromagnetic interference (EMI) are minimal and of transient nature:
  - ICDs: May sense the field as myocardial potential
  - Inappropriate re-programming
  - Shut off lead switches
  - Triggering of output

- SOURCES OF POTENTIAL MALFUNCTIONS FOR ICDs & ICPs DURING RT PROCESSES
  - Imaging for treatment planning (CT mostly).
  - Imaging for Image Guidance (CT, Rad., EMI)
  - RT treatment delivery (photons, protons, neutrons, particles, other)
  - Use of high energy photons, E>10 MV?
  - Dose rate?
  - IMRT, SBRT, VMAT, FFF beams, etc.
  - Other...

PERIPHERAL DOSES IN PHOTON BEAMS
Dose estimation: Photon out-of-field dose

- Wedges
  - Physical wedges: increase out of field dose by 2-4 times (Boccia et al., 1995, Int J Radiat Oncol Biol Phys)
  - Dynamic or universal wedges

Dose decreases exponentially away from edge of field.

- MLC
  - Secondary MLC: no impact on out-of-field dose (Boccia et al., 1995, Int J Radiat Oncol Biol Phys)
  - Tertiary MLC is extra shielding: decrease out of field dose by 30-50% (Stern, 1999, Med Phys)

Treatment planning:

- Contour the cardiac device (if possible: leads, body, electrodes).
- Select appropriate treatment technique: modality, energy, beam angles, etc.
- Maximize distance of device from beam(s) borders: only scattered radiation to the device.
- Utilize independent collimators, dynamic wedging, MLCs, etc: to reduce dose to device.
- Determine device dependence of patient.
  - Risk of serious injury or death due to sudden device failure

- What about IMRT?

- What about SBRT and filter-free beams?

Dose estimation: Proton out-of-field dose

- How much dose equivalent is there?

- Conventional photon therapy:
  - More dose near treatment field
  - Comparable dose beyond 10-20 cm from field edge

- Challenges in Dosimetry:
  - Lack of high energy response
  - Unique machines

Check list for patient management

- Initial Consultation
  - CIED alert added to patient’s chart
  - Copy of CIED card made and filed in patient’s chart
  - Appointment with Cardiac Electrophysiology (EP) scheduled

- Simulation Check
  - Patient was evaluated by EP to verify dependence on device
  - Verify CIED alert added to patient’s chart
  - Verify treatment planning directive completed by physician
  - Note added to planning directive to only use 6X photons and avoid wedges where possible
  - Contact vendor for dose limit recommendations
Planning check
- Verify only 6X photons used for treatment

Dose to pacemaker > 2 Gy (7)
- Inform Rad-One physician
- Contact EP to inform them of dose and discuss monitoring strategy
- Move device
- Adjust monitoring frequency
- Schedule EP follow-on-set for all treatment fractions
- No monitoring necessary

Verify imaging field does not irradiate CIED
Read dosimeter and generate summary of reading for physician.

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Thank you