RO-ILS CASE STUDY 20

CHALLENGES IN ELECTRON TREATMENT:

Promoting Accurate Treatment Delivery through Enhanced Verification Process

Introduction:

Electron treatments are particularly useful for treating tumors close to the skin surface because of their limited range in tissue, allowing targeting of superficial tumors and sparing of normal, deeper tissue.[1] Additionally, electrons are commonly used to boost dose to a target that has already been treated with other forms of radiation. Although the need for electrons remains, this technique accounts for a relatively small percent of the average clinical patient load, and thus the potential for error is increased because of low volume.

Despite continued use of electrons in radiation therapy practices, imaging advancements associated with other treatment techniques, such as photon and proton treatments, have not been applied to electron radiation therapy.[2] The processes of electron cutout creation, verification and delivery of electron treatments has largely remained unchanged. Electron treatment is the only modality for which geometric verification of the treatment field is not routinely radiographically imaged, a process which is routine for photon and proton treatment. This point is addressed in RO-ILS Q4 2016 report, noting, "Modern photon radiotherapy targeting is also commonly verified with portal or advanced imaging. Such imaging for photons serves as a second check on targeting for both the therapists at the treatment console, and the physician reviewing alignment images. Treatment teams should recognize that such a second check does not readily exist for electron radiotherapy."

Given that imaging verification is not always feasible or appropriate for electron treatment verification, reliance on a skin rendering or beam's eye view (BEV), for comparison against light field project on skin, in addition to photographs and setup templates are often used. The BEV is a 2D view of the treatment area showing the shape of the field and orientation of the beam relative to the patient. It often includes information such as the field size, source to skin distance (SSD) and anatomical reference marks to assist with accurate setup and delivery of treatment. The BEV printout is used to both create the electron cutout used to shape the beams specified during treatment planning, and create the setup transparency which allows the treatment team to draw the light field on as it would be projected on the patient's skin.

Event Overview:

A patient undergoing radiation treatment for breast cancer was planned for an electron cone down to the cavity. Two BEV printouts were provided for creation of the electron cutout (printout at 95cm SSD) and transparency for the electron field to be traced on skin (printout at 105cm SSD). The BEV printouts were accidentally switched by the dosimetrist which resulted in the electron cutout being poured at 105cm SSD (~10% too large), and the transparency being drawn at 95cm SSD (~10% too small). The physicist did not check the SSDs on the BEV printouts. The patient received one fraction of the cone down treatment with the electron cutout being too large. To account for the electron field not matching the intended field, lead blocking was used so that the light field matched the transparency on the patient's skin, per the intended plan.

Contributing Factors:

1. **Procedural Issues**
    a. *Inadequate quality assurance and quality control; Failure to execute planned action*
    The BEV printouts generated for cutout and transparency were switched which resulted in downstream errors in cutout and transparency creation. The physicist overlooked checking the SSDs on the BEV printout.

    b. *Lack of information*
    The cutout was not labeled with the SSD at which it was poured. Had the SSD been documented, it would have provided an opportunity to identify the discrepancy between the SSD at which the cutout was poured against the SSD on the printout.

2. **Organizational Management**
    a. *Relevant policy nonexistent*
    There was no process in place to check that the SSDs on the printout matched the SSD on the transparency and cutout.

Lessons Learned/Mitigation Strategies:

1. **Multi-step Verification**
   Precise delivery of an electron treatment field requires multiple layers of verification to assist with error mitigation. This can be achieved through a combination of redundant and independent checks.

    - **Physicist Verification:** Confirm the SSD on the printout matches the SSD used to create the cutout.
    - **Dosimetrist Handoff:** Highlight the SSD on the printout given to radiation therapists.
    - **Therapist Verification:** Confirm the highlighted SSD aligns with the planned SSD when creating the treatment transparency.
    - **Dosimetrist Final Check:** Verify the accuracy of the created transparency.
    - **Physician Approval:** Review the electron treatment field on skin at the treatment machine using the BEV/skin rendering as a reference.

2. **Documentation**
   Documentation is essential because of the reliance on accurate SSD measurements for both electron cutout creation and setup transparency, which may involve different SSDs. Documentation of SSD on both the electron cutout and the transparency is critical for reference compared to the BEV printout.

3. **Limitation of Image Guidance**

   Image guided radiation therapy (IGRT) has the potential to reduce treatment errors through imaging the patient in the treatment position and comparing to the planned reference image. Radiographic verification of the electron field could provide an opportunity to confirm the planned treatment field matches the planned delivery. The electron cone and cutout can be barriers to field verification that is commonplace for photon and proton treatment.

4. **Reducing Treatment Setup Variation**

   The use of immobilization devices like vac loc bags can significantly reduce treatment setup variation in electron therapy. These devices help ensure the patient is positioned consistently for each treatment, which is crucial for maintaining the accuracy of the electron beam delivery. Immobilization devices can be helpful for reproducibility, minimizing pitch and roll, and reducing the risk for misalignment.

Conclusion:

Electron treatment requires creation and verification of treatment fields both within the treatment planning system and with external cutouts. This additional step of cutout creation requires multiple points of verification to assist with accurate delivery of the treatment field. Furthermore, verification of electron field placement on the patient is limited in terms of image verification and is reliant on use of visual inspection of the field on skin using BEV/skin rendering. IGRT has become mainstream practice in treatment delivery for photon and proton radiation therapy but has not been commonly applied to electron radiation therapy.[3] While IGRT for electron treatment can be helpful for positioning, on its own is not sufficient for field verification, and it introduces adding imaging dose without added benefit. Finally, surface guided radiation therapy can be considered for electron treatment setup alignment when the SSD is at a distance that allows the field to be in camera range.

Given the reliance on human verification at multiple steps in the creation of electron fields, accurate delivery of this treatment type continues to be susceptible to error. The electron treatment technique is represented more in dosimetrically impactful events relative to the aggregate number of events as reported to the RO-ILS database per the Dosimetrically Impactful Events Themed Report. RO-ILS Q4 2016 report shared some critical incidents that reached the patient, including one case where the electron cutout was not properly aligned to the target. Despite the challenges associated with this treatment technique, electrons continue to be of clinical value in the treatment of superficial tumors. This event underscores the need for a comprehensive multi-step verification process for electron treatments given the lack of image guidance.

SAFETY CHECK

What verification steps are in place for electron treatments in your practice?

References:

1. Elledge ChR, Alcorn SR. Treatment planning in palliative radiotherapy. Palliative Radiation Oncology. Published online 2024:65-74.
2. Qi XS, Albuquerque K, Bailey S, Dawes S, et al. Quality and safety considerations in image-guided radiation therapy: An ASTRO safety white paper update. *Pract Radiat Oncol.* 2023;13(2):97-111.
3. Ramm U, Köhn J, Rodriguez Dominguez R, et al. Feasibility Study of patient positioning verification in electron beam radiotherapy with an electronic portal Imaging Device (EPID). *Physica Medica.* 2014;30(2):215-220.