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Breast quality assurance

Predictors of breast radiotherapy plan modifications: Quality assurance rounds in a large cancer centre

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ABSTRACT

Background and purpose: This study describes the process and outcomes of breast radiotherapy (RT) quality assurance (QA) rounds, seeking to identify variables associated with plan modifications.
Materials and methods: Real-time data were prospectively collected over 2 years. Descriptive statistics determined the proportion of cases requiring no (A), minor (B), or major (C) modifications, which were then subjected to univariate and multivariate analyses.
Results: A total of 2223 breast cancer QA cases were reviewed; 47 cases (2.1%) underwent a minor, and 52 cases (2.3%) required a major modification. Common changes included boost, volume, seroma, and bolus. On univariate analysis, regional nodal irradiation (RNI), tumour size, and axillary node dissection were significantly associated with major modifications. Upon multivariate analysis, the only independent predictor was RNI (OR 2.12, $p = 0.0075$). For patients with no RNI, <2 cm tumours, no axillary lymph node dissection, and no boosts ($n = 420$); the likelihood of category C was only 1.4%.
Conclusions: It is feasible to conduct QA review for all breast cancer cases prior to commencing RT. Patients undergoing RNI had a higher likelihood of plan modifications; a group with low risk of modification was identified, which could direct future re-structuring of QA rounds.
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Radiation therapy (RT) is one of the major modalities in cancer management, wherein half of all patients will be treated using either curative or palliative intent. This has been documented in Canada, wherein 100,000 courses of radiotherapy were delivered for 186,400 cancer patients in 2012 [1]. In Australia, 52% of all patients with a diagnosed malignancy required RT during the course of their disease [2].

Radiotherapy delivery is a complex process, requiring specialized equipment and a multi-professional team, including radiation oncologists (ROs), medical physicists, and radiation therapists (RTs). Achieving local control with minimal doses to normal tissues is a primary objective of RT. Variations in treatment can arise from clinical decisions, the contouring of macro- and microscopic target volumes and at-risk structures, set-up errors, organ motion, and adequate target coverage [3]. Inter-professional and inter-institutional contouring variations have been demonstrated for breast, head and neck, lung, and prostate cancers [4–7]. Even within standardized guidelines and protocols, significant variations in RT plans exist, with such deviations leading to deleterious consequences [5,8,9].

The peer review process in RT quality assurance (QA) has been shown to detect errors that can be corrected prior to delivery of the first treatment. One of the earliest studies was reported by Brundage et al., demonstrating that deviations from standard protocol were observed in 7.7% of over 3000 patient cases spanning an 8-year period [10]. This rate was independent of the RO's experience, but was an important process for continuous quality improvement. An Australian study, using the Royal Australian and New Zealand College of Radiologists (RANZCR) auditing tool, reported a similar correction rate of 3.8% [11]. Likewise, a Canadian study reported that 1% of its reviewed plans required modification [12]. In this study of 1247 cases, it was noted that tumour site, and fewer years of experience of the practising RO were the only variables associated with modifications [12].

A recent survey of 14 community-based outpatient cancer centres in Ontario demonstrated that there was uniform agreement on

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the importance of conducting QA rounds; however, there were significant variations in the proportion of curative cases being reviewed, as well as the timing of such reviews; the number of participating ROs was cited as a significant potential challenge [13]. With this background, the objectives of our current report are to describe the process and outcomes of our own institutional breast cancer QA rounds, and identify clinical factors that were associated with RT plan modifications, in order to inform our own future approaches to this important process.

Materials and methods

Within the Radiation Medicine Program (RMP) at the Princess Margaret Cancer Centre (PM), all patients are treated according to established guidelines (Appendix 1, Supplementary material). Breast tangents are delivered using an automated intensity-modulated RT technique [14], using a regimen of 4240 cGy in 16 fractions. When the lymph nodes are treated, the fractionation is altered to 5000 cGy in 25 fractions to include the supraclavicular, with or without the axillary apex. When indicated, a 3-field non-coplanar boost of 1000 cGy in 5 fractions is delivered, targeting the seroma cavity. As part of the planning process, patients with left-sided breast cancer were treated using a controlled deep-inspiration breath hold technique if their cardiac dose volume histogram (DVH) exceeded institutional guidelines [15].

Our RMP guidelines also stipulate that all RT plans receiving radical doses are peer reviewed by a multi-professional group of ROs, medical physicists, radiation therapists, and trainees. The one-hour breast QA rounds are conducted once weekly, organized by a Clinical Specialist Radiation Therapist (CSRT) and the Radiation Therapy Breast Site leader. Each week, a comprehensive list is generated of all the newly-diagnosed breast cancer patients requiring adjuvant RT, compiled from the oncology information (Mosaiq, Elekta, Sunnyvale, CA), and the patient electronic record (EPR) system. This list contains a number of patient, tumour, and treatment factors in order to facilitate the evaluation of the treatment plan (Table S1, Supplementary material). Patient factors include the patient name, medical record number (MRN), and age. Tumour factors include the histology, tumour size, tumour grade, presence of lymphovascular invasion (LVI), nodal involvement, margin status and receptor information. Treatment factors include the type surgery, administration of systemic chemotherapy, or hormone therapy, the RT treatment site (breast ± regional lymph nodes), dose prescription, the need for a boost to the seroma, responsible RO, and RT start date. The list of cases to be discussed is prioritized so that the more complicated patients such as those with locally-advanced disease, and breast/chestwall and regional nodal irradiation (RNI) plans are reviewed first, followed by tangential breast/chestwall plans, concluding with boost plans.

This format for weekly QA rounds has been sustained for 5 years (2009–current), allowing for peer review of up to 30 patients within each session. Peer review of the treatment target(s), as well as dosimetry characteristics of each plan are conducted using the treatment planning system (Pinnacle[3], Philips Healthcare, Fitchburg, WI), and the final treatment plan is peer evaluated to ensure compliance with institutional guidelines. The evaluated characteristics include the prescribed dose including the inclusion of a boost, target contours (seroma), field placement, organs at risk (OAR) contours, dose distribution, and the final DVH. Multidisciplinary consensus is achieved through discussion; if the treatment plan fails to meet guidelines, or there are unresolved queries, the responsible RO will respond to the recommended changes, and this is documented in the treatment chart. The review outcomes for each patient are prospectively captured, including queries as well as modifications to the treatment plan.

For the current study, all radical cases, defined as a total dose of at least 4000 cGy were captured from January 1st, 2010 to December 31st, 2012. Each case was reviewed, and categorized as requiring no (A), minor (B), or major (C) modifications as per Lefresne et al. [12] (Fig. 1). A minor (B) modification was defined as a suggestion to consider for a future, similar case; a major (C) modification was defined as one which required an actual change in the RT plan. Clinical variables which were considered *a priori* to be associated with more complex treatments, as well as a higher risk for modifications were evaluated. Univariate and multivariate logistic regression were applied to each variable to determine associations with modifications. Stepwise algorithm was applied for model selection in multivariate analysis; odds ratios (ORs), and 95% confidence intervals (CIs) were calculated. Two-sided testing was applied with statistical significance level as 0.05. All statistical analyses were conducted using SAS 9.3 (SAS Institute Inc, Cary, NC).

Results

A total of 2223 breast cancer QA cases were reviewed over this 24-month period; 2124 cases (95.6%) were not modified; 47 cases (2.1%) underwent a minor (B), and 52 cases (2.3%) required a major modification (C). The reasons for the B and C categorizations are outlined in Table 1. Within all the changes in the category of Group B (47 cases); more than half (55%) of these suggestions related to clinical treatment decisions such as: the requirement for a boost (13/47 = 28%), the use of bolus (4/47 = 8.5%), use of RNI (6/47 = 13%), total dose, or fractionation (3/47 = 6.4%). Technical reasons accounted for the remaining issues (16/47 = 34%) such as target coverage (9/47 = 19%), seroma contouring variability (4/47 = 8.5%), as well as doses exceeding normal tissue tolerance (3/47 = 6.4%).

For cases categorized in group C (major modification), 44% (23/52) of these adjustments involved treatment decisions such as the requirement for a boost (11/52 = 21%), the use of bolus (9/52 = 17%), and RNI (3/52 = 6%). Technical reasons accounted for slightly more than half of these significant adjustments (28/52 = 54%), such as target coverage (7/52 = 13%), seroma contouring (11/52 = 21%), and normal tissue tolerance (10/52 = 19%). An example of a group C modification is illustrated in Fig. 2, wherein after the QA review, the volume of heart encompassed in the modified treatment plan was reduced significantly from 43.7 cc to 3.2 cc.

In terms of timing of significant plan modifications (Group C; Fig. 3), the majority or 62% (32/52) of corrections were successfully executed prior to commencement of RT (although 3 patients experienced a 1-day delay in their start date). In approximately one-third of instances (15/52 = 29%), corrections were achieved within the first four RT deliveries; in only 10% of instances (5/52) were

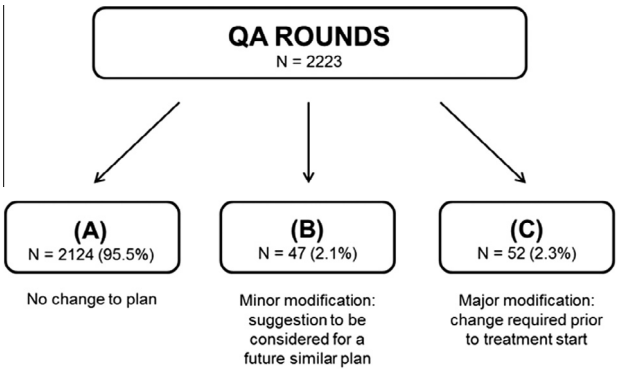

Fig. 1. Distribution of the 2223 peer-reviewed cases, classified as requiring no (A), minor (B), or major (C) modifications (according to [12]).