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Research article

Evaluation of delineating the target volume by radiation therapists in breast cancer patients

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A R T I C L E   I N F O

A B S T R A C T

Aim: Breast radiotherapy accounts for a significant workload in radiotherapy departments. In 2015 it became clinical practice at the Netherlands Cancer Institute for radiation therapists (RTTs) to delineate the clinical target volume of the breast tissue (CTVbreast) and in 2017 axilla level I-II (CTVln12) according to a delineation atlas. All RTTs were trained and got individual feedback. The aim of this retrospective study was to investigate the variation between the CTVbreast with or without CTVln12 delineated by a trained group of radiation therapists and the clinical adjusted delineations by the radiation oncologist/-physician assistant (RO/PA), in a large group of patients treated between January 2017 and June 2020.
Materials and Methods: 1012 computer tomography based delineations of CTVbreast and 146 of CTVln12 were collected from January 2017-June 2020. The RTT and RO/PA delineations were compared using the Dice coefficient and the 95th percentile Hausdorff Distance (95%HD). Statistical significance of the differences was tested using a Mann-Whitney test.
Results: Differences in CTVbreast delineations were small. A median Dice score of 1.00 for all years, where 83% of the patients had a Dice score > 0.99. For CTVln12 the magnitude of edits made by RO/PAs decreased over time, with the Dice increasing from a median of 0.87 in 2017 to 0.90 in 2020 (p = 0.031). The 95%HD decreased from a median of 0.93 cm in 2017 to 0.61 cm in 2020 (p = 0.051).
Conclusions: This retrospective study shows that trained dedicated RTTs are capable in delivering the same quality delineations as RO/PAs. The low variability supports the increasing role of RTTs in the contouring process, likely making it more time efficient.

Introduction

Radiotherapy techniques for breast cancer have evolved over the years. 3D based treatment planning is the standard care of breast cancer in many departments. Modulated Planning techniques such as static gantry intensity modulated radiotherapy (IMRT) and volumetric arc therapy (VMAT) are routinely used for breast cancer patients. Accurate identification and delineation of the target volume is essential in both IMRT and VMAT planning where there is a steep fall off in dose outside high dose area [1]. Therefore, the target volume needs to be delineated.

Breast radiotherapy accounts for a significant proportion of the workload of many radiotherapy departments. In a typical workflow the radiation oncologist (RO) or breast cancer dedicated physician assistant (PA), who is a medical care professional that independently and structurally takes over defined medical tasks from the RO, delineates the clinical target volume in breast cancer patients. However, the role and responsibility of the radiation therapists (RTTs) in clinical target and organs at risk (OARs) delineations has been increasing in recent years. A survey conducted during the ESTRO meeting in Copenhagen 2011 revealed that in Europe 55% of RTTs routinely contour the OARs, and that 19% of RTTs always contour the target volume together with the RO [2].

Contouring of breast target volumes has been associated with considerable uncertainty and variability [3]. Standardized contouring protocols, the use of radio-opaque wires during simulation [1] and the use of atlas based automatic generated structures have helped [4]. The variability in CTV contouring for breast cancer patients between RO and RTT has been investigated in a small study with non-clinical data and was found to be low [5]. It has also been shown that with appropriate training, the RTT has a high potential to complete the tumor bed contouring after breast-conserving surgery with the use of clips, as part of the multidisciplinary radiotherapy team [6].

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By delegating the task of delineation from the RO/PA to the RTT, the planning process is expected to become more time efficient. This hypothesis, if verified, could help to further transfer tasks and optimize the radiotherapy treatment process, both for breast cancer or potentially other disease sites.

In January 2015 it became clinical practice at The Netherlands Cancer Institute (NKI) for trained and dedicated RTTs to delineate the clinical target volume of the breast tissue (CTVbreast) in breast cancer patients. From January 2017 RTTs also began delineating additional lymph node area axilla level I-II (CTVln12).

The aim of this retrospective study was to investigate the variation between the CTVbreast with or without CTVln12 atlas based contours delineated by a trained group of RTTs and the clinical adjusted delineations by the RO/PA, in a large group of patients treated between January 2017 and June 2020.

Materials and Methods

Patient data

For this study we selected early staged breast cancer patients treated on the CTVbreast with or without CTVln12 between January 2017 and June 2020. A total of 1012 CTVbreast and 146 CTVln12 CT based contour sets were analysed. The delineation set consisted of two structures: CTV_RTT based on delineation completed by RTTs and CTV_RO based on a copied structure from the RTT, that was used as a starting point to confirm or adjust if necessary by the ROs/PAs, see Fig. 1a and b. CTV_RO was then used as the clinical target volume.

The data was retrieved from the hospital clinical database and the study was approved by the Institutional Review Board. (IRBd20-235). Informed consent was waived because of the retrospective nature of the study.

Simulation protocol

All delineations were made on planning CT scans (Siemens Healthcare, Germany) with a slice thickness of 3 mm. The scan region was from chin to two vertebrae under the glandular breast tissue, obtained with patients in supine position with both arms raised above their head, using a breastboard (Macromedics MBLXI, The Netherlands). The palpable breast tissue and scar were marked with a thin radio-opaque wire by the RTT before scan acquisition. Patients treated for the left breast were scanned in voluntary deep inspiration breathhold.

Training of RTTs

In December 2014 a group of 15 specialized CT RTTs at NKI received training in delineation delivered internally in the insti-

tute. This training consisted of an instruction lesson delivered by an experienced RO and hands on training using a patient set of 5 left and 5 right sided breast cancer cases followed by an individual and group evaluation of the contoured CTVs. The ESTRO consensus guideline on target volume delineation was used [7], see specification in paragraph 2.4.

To continue the learning process after clinical introduction, an individual feedback system was integrated in the daily workflow. The contours completed by RTTs were copied and reviewed by the responsible RO/PAs. If necessary the RO/PA adapted the copied structure and confirmed with a fellow RO member of the breast team. A quality checklist item in Mosaiq was created (Elekta AB, Sweden, Stockholm), informing the RTT to evaluate the copied and adjusted structure, providing personal feedback.

In December 2016 the same group of RTTs were trained to also delineate the CTVln12 [8]. The same training program and feedback system were used. In January 2017 it became clinical practice for RTTs to also delineate CTVln12.

Over the years the group of RTTs was expanded to a total of 20 RTTs. New RTTs received the same training as the original group. All trained RTTs were included in the study.

Target volume delineation

Delineation of the CTVbreast was performed according to the ESTRO consensus guideline on target volume delineation for elective therapy of early stage breast cancer [7]. Delineation of CTVln12 was performed according to institute implementation of the ESTRO consensus guidelines [8]. In this adapted protocol the delineation prescription is adapted according to surgical axillary dissection i.e. the medial border is defined halfway at the minor pectoral muscle, the cranial border is defined at the veno-arterial branch.

For each patient an atlas based auto segmented CTVbreast structure, consisting of the whole breast, was used as a starting point in the radiotherapy contouring workflow (Mirada Medical's Workflow Box™) [4]. The automatic generated CTVbreast structure was reviewed and adapted by the RTT. Where clinically indicated
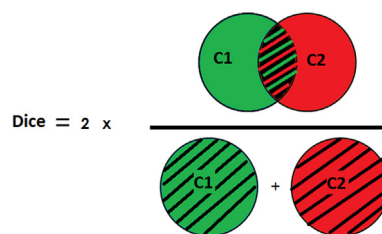
Fig. 2. Dice coefficient, where C1 and C2 correspond to two different contours, clinical target volume radiation delineated by the therapist (CTV_RTT) and clinical target volume delineated by the radiation oncologist (CTV_RO).
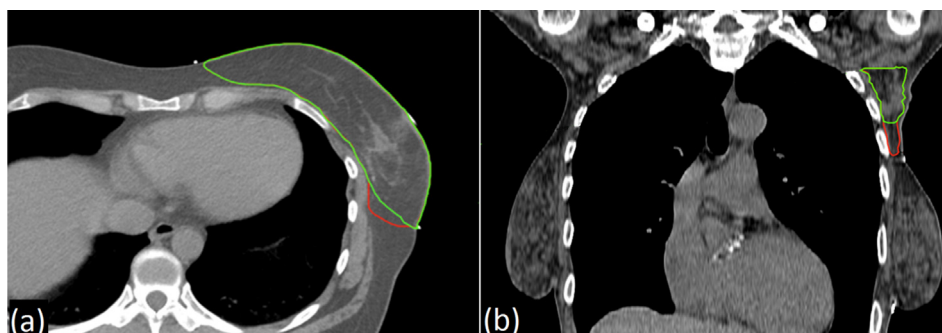
Fig. 1. Example of delineations of (a) CTVbreast and (b) CTVln12. In green the delineation of the radiation therapist (RTT) and in red the delineation of the radiation oncologist (RO). (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

CTVln12, which was not automatically generated, was manually delineated from scratch. For the delineation of the CTVbreast the radio-opaque wire could be used as an aid.

Data analysis

We compared the delineations of the RTT and the clinically accepted indicated by the RO/PAs. To assess the geometrical similarity between the two contours, we used two metrics: the Dice score and the 95th percentile Hausdorff distance (95% HD). The Dice score is defined in Fig. 2, where C1 and C2 correspond to two different contours, CTV_RTT and CTV_RO. The Dice score indicates the overlap volume of two structures relative to their average volume. A Dice of 1 indicates perfectly overlapping structures. The 95% HD is defined as the 95th percentile of all surface distances, calculated bi-directionally from the two contours, which gives insight over the near-maximum distance between contours. We also determined the percentage of contours that had been manually edited by the RO/PAs.

To statistically assess differences between metric distributions, a Mann-Whitney test was used. The p-value of 0.05 was taken as the threshold for significance.

Results

Patients

The number of analyzed patients per year is summarized in Table 1. In total 1012 delineation sets of CTVbreast were analyzed of which 365 were created in 2017, 267 in 2018, 254 in 2019 and 126 in the first half year of 2020. For CTVln12 a total of 146 delineations sets were analyzed of which 37 were created in 2017, 38 in 2018, 47 in 2019 and 24 in the first half year of 2020.

Variability between RO and RTT

The percentage of contours that have been manually edited by the RO/PAs is summarized in Table 2. On average 45% of the delineations were adjusted by the RO/PA for CTVbreast. Over the years a decrease in percentage of adjustments was seen, starting with 49% in 2017, 48% in 2018, 46% in 2019 to 39% in the first half of 2020, corresponding to a total decrease of 10% for CTVbreast. In 9 of the 1012 cases (0.9%) the adjustments were>1 cm, based on patient specific deviations with respect to the guideline.

The distributions of Dice and 95% HD for CTVbreast are depicted in Fig. 3, to express the geometrical similarity and the magnitude of the adjustments made by the RO/PAs. The Dice score had a median value of 1.00 in all 4 years. Over the years the percentage of patients with Dice score > 0.99 increased, starting with 78% in 2017, 84% in 2018, 85% in 2019 and 86% 2020. The interquartile range (IQR) was 0.00 in 2017, 2018, 2019 and 0.01 in 2020. The
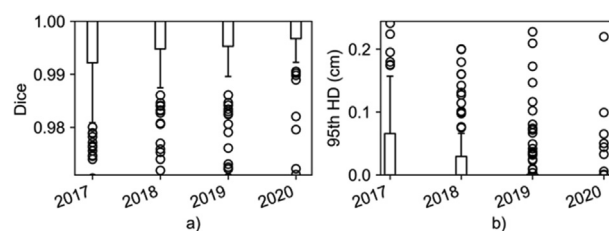

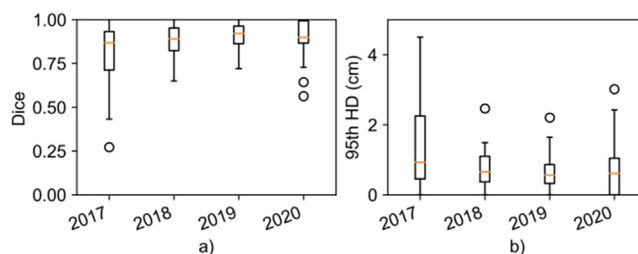**Fig. 3.** a) Dice and b) 95% HD (in cm) for CTVbreast.

Fig. 4. a) Dice and b) 95% HD (in cm) for CTVln12.

95% HD had a median of 0.00 cm in all years (IQR of 0.07 cm in 2017, 0.03 cm in 2018, and 0.00 cm in 2019 and 2020).

The magnitude of the edits made by RO/PAs on the RTT delineations for CTVln12 has overall decreased over the years. Between 2017 and 2020 the difference between the distributions is statistically significant for the Dice score and close to significant for the 95% HD (p-values 0.031 and 0.051, respectively).

The distributions of the Dice and 95% HD for CTVln12 are depicted in Fig. 4. The Dice had a median of 0.87 (IQR 0.22) in 2017, 0.89 (IQR 0.13) in 2018, 0.92 (IQR 0.10) in 2019 and 0.90 (IQR 0.13) in 2020. The 95% HD had a median of 0.93 cm (IQR 1.80 cm) in 2017, 0.66 cm (IQR 0.72 cm) in 2018, 0.56 cm (IQR 0.53 cm) in 2019 and 0.61 cm (IQR 1.10 cm) in 2020.

Discussion

OAR and CTV delineation is an essential step in complex planning techniques. CTV delineation can be a time consuming process for ROs. In order to decrease the workload on ROs and make treatment preparation more efficient, RTTs can be an asset by taking over this task. This retrospective study shows that dedicated RTTs are capable of delivering the high quality delineations for breast CTV contouring. The results showed low variability between RTT and RO/PA of CTVbreast delineations with a Dice of 1.00 in clinical practice for 1012 patients. This result confirms the hypothesis of Balumalai et al. that RTTs could potentially assume the role of

Table 1
Number of analyzed patients per year.

	2017 Jan-Dec	2018 Jan-Dec	2019 Jan-Dec	2020 Jan-Jun
CTVbreast	365	267	254	126
CTVln12	37	38	47	24

Table 2
Percentage of contours that have been manually edited by the radiation oncologists (ROs) or physician assistant (PA).

	2017 Jan-Dec	2018 Jan-Dec	2019 Jan-Dec	2020 Jan-Jun
CTVbreast	49	48	46	39
CTVln12	86	92	87	75

CTV contouring in clinical practice based on 30 breast test cases in a non-clinical training setting [5].

In this study 39–49% of the CTVbreast delineations have been adjusted by the RO/PA. In general these delineation adjustments were very small. Some level of inter-observer variability in contouring is inevitable, even by ROs, as reported by Struikmans et al. [9]. In only 1% of the CTVbreast cases 'large' adjustments (>1cm) were made. These adjustments were made based on patient specific medical considerations and thus do not fit our workflow based on anatomical boundaries using a contouring atlas only. All cases where delineation adjustments were smaller than 1 cm were considered clinically irrelevant and not further studied.

To the best of our knowledge, there are no other studies reporting on variability of CTVln12 delineations by RTTs. The clinical dataset, a total of 146 patients in this study, shows that the variability for CTVln12 in 2017 with a Dice from a median value of 0.87 improved to a more constant Dice with a median of 0.89 in 2018, 0.92 in 2019 and 0.90 in 2020. The difference between the distributions of 2017 and 2020 is statistically significant (p = 0.031), complementing our personal feedback system. All delineation adjustments by the RO or PA were provided as personal feedback and reviewed by the individual RTT. The feedback system and RTT commitment to develop delineation skills resulted in low variability between RTT and RO delineations. This supports the feasibility of RTT-led CTVln12 delineation.

CTVbreast delineation had retrospectively a higher Dice and lower 95%HD than CTVln12, indicating a better performance for CTVbreast delineations. The main reason is that the anatomical borders for CTVbreast are more clear. Another possible reason is fewer patients require CTVln12 delineation, meaning RTTs have less exposure and less experience delineating this structure.

Visual inspection of the patients with a 95% HD>1 cm for CTVln12 showed that the caudal boundary was structurally drawn shorter by RTTs than by the RO/PAs (Fig. 1b). This was not clearly described in the guideline. Another explanation is that there were some clinical scenarios where variability was more marked, such as in patients with large axillary seromas or deformations due to surgery.

The use of a contouring protocol, training and personal feedback may have contributed to the low variability. Li et al. [10] reported that the observed variability may be related to differences in opinion regarding target volume boundaries as well as approaches for incorporating treatment set-up uncertainty and dosimetric limitations. A protocol that attempts to standardize the approach and, hence, force groups to overcome their differing opinions, leads to greater uniformity.

We recommend to use standard guidelines for all patients, to insure a clear protocol, which decrease the chance of errors. Based on our results, this approach should be sufficient for 99% of patients.

With regards to our clinical workflow, RO/PA could be biased because they evaluate the delineation of the RTT instead of delineating from scratch. This could potentially have contributed to the small variations in this study.

By delegating the task of delineation to the RTT the timelines for RT planning in the patient pathway can become more efficient as 1) the RO/PA only needs to check the delineation and adjust it if necessary, instead of delineating the whole structure(s) and 2) RTTs can design the patient care path, to ensure that CTV and OAR delineation is completed on the same day or shortly after the planning CT which is more efficient for the RT process, in the assumption that RTTs are more available. The whole planning process becomes RTT led, which makes it more flexible and time efficient.

Conclusions

This retrospective study shows that dedicated and trained RTTs are capable of delivering the same quality delineations as RO/PAs. Low variability was reported in CTV contouring according to delineation atlas of breast and axilla level I-II for breast cancer radiotherapy, between the dedicated trained RTTs and the ROs/PAs. The use of standardized protocols, training and personal feedback systems have contributed to the positive results and the improvement over the years.

The low variability supports the increasing role of RTTs in the contouring process to reduce the workload of the ROs and by delegating the delineations tasks to RTTs the planning process is likely to become more time efficient.

Besides the increased time efficiency this delegation influence the role and skill of the RTTs and this positive development has the potential to expand to other sites in the future.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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