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Short communications and technical notes

A decision tool for radiographer-led abdominal image-guided stereotactic ablative body radiotherapy – Experience from a single institution

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ABSTRACT

A decision tool for radiographer-led image-guided radiotherapy (IGRT) using cone-beam CT (CBCT) for abdominal stereotactic radiotherapy was developed and successfully implemented in a single department. The confidence of 7 therapeutic radiographers when undertaking online CBCT review increased, and the pooled median online match time was reduced by 1 m 8 s. While this may be advantageous for abdominal SABR, further evaluation of this work in a larger cohort is required to validate these results.

Introduction

A high degree of accuracy is required for stereotactic ablative radiotherapy (SABR) to abdominal sites due to the high dose per fraction and proximity of critical structures. In addition, image-guided radiotherapy (IGRT) using cone beam computed tomography (CBCT) can be challenging due to poor contrast within the abdomen, especially with motion-associated artifacts [1]. Uncertainties in CBCT matching can lead to variation in overall match between users which can lead to an increase in the length of time before treatment delivery [2]. The time interval between imaging and treatment delivery should be kept as short as possible to minimise the risk of intrafraction motion changes [3,4]. In our department an oncologist is required to be present for each fraction to assist with and confirm the match for SABR treatments, due to a higher dose per fraction than conventional treatments. Therapeutic radiographer-led IGRT for abdominal SABR can help reduce the time burden on the oncologist, and increase patient workflow efficiency [5]. There are radiographer-led IGRT decision flowcharts available for other anatomical sites including cervix [5], however to our knowledge this is the first published tool for abdominal SABR. This evaluation aims to assess how the implementation of a decision tool impacts radiographer confidence in reviewing abdominal CBCTs online for SABR delivery, and whether use of the tool impacts the online CBCT review time.

Methods & materials

A decision tool was developed (Fig. 1) to guide online matching and aid with decision making for abdominal SABR. A development team was comprised of one clinical oncologist (MH), one hepatobiliary (HPB) specialist radiographer (MD), and four 'expert' radiographers (SAM, SP, ZJ, KMG), all who were experienced in SABR IGRT. A modified traffic light system approach was selected, based on work previously described by Alexander et al. [5] for cervix IGRT. The tool was completed based on previous IGRT experience within our institution. This decision tool was saved as a dynamic document, uploaded within each patient's individual digital record in the local record-and-verify system (ARIA V15.7, Varian Medical Systems, Palo Alto, California), and utilised for each fraction by the treatment radiographers. Decisions and additional comments, where required, were recorded in the patients' IGRT document, also stored in ARIA.

Patients were immobilised in a custom vacbag and an abdominal compression belt (Civco Medical Solutions, Coralville, Iowa). Plans were generated on a 3D contrast-enhanced computed tomography (CT) scan, with an internal target volume (ITV) generated from a 4DCT conducted within the same protocol. Planning target volume (PTV) margins were 5 mm isotropically. SABR treatment was delivered according to existing standard practice in 3–5 alternate daily fractions using two treatment arcs on a Truebeam STx Linac (Varian Medical Systems). IGRT was performed with CBCT, which was reviewed online, and translational

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shifts applied prior to treatment delivery by the treating radiographers as per standard practice. The consultant oncologist (MH) and one radiographer representative from the development team were present prior the implementation of the decision tool, and only one radiographer representative of the development team was present at each fraction if required for problem-solving post implementation. All CBCT images were reviewed and approved offline by the oncologist before the next fraction in both cohorts to ensure the quality of clinical matches, as per our department's standard practice.

Prior to implementation, radiographers on treatment units delivering abdominal SABR were given an informal 30-minute training session by the HPB specialist radiographer delivered in groups of 3–4 people on using the tool. Staff taking part had not undergone any other relevant didactic or practical training prior to this evaluation except having already achieved abdominal IGRT competence within the department. A questionnaire was administered to these radiographers within a single week, to assess experience and confidence when matching abdominal SABR cases on a five-point scale (one being very unconfident, 5 being very confident). The same questionnaire was administered again within one week after the five-week implementation period. All questionnaires were completed anonymously to ensure candid responses. The online review time, defined here as the duration of time between CBCT acquisition and commencement of treatment as reported on the record and verify system (Offline Review, V15.7, Varian Medical Systems), was recorded for each fraction. The time also includes application of couch shifts, and selection of the treatment beam in the record and verify application. This method was selected as it was less task-intensive on the unit during the treatment process and removed the potential for accidental omission of setting a timer.

Results

Six consecutive abdominal SABR patients were included in this service evaluation: four liver, one adrenal gland, and one lymph node. Eleven consecutive patients treated prior to implementation were retrospectively included for comparison: nine liver, one abdominal lymph node, and one metastasis in the pancreas. Diagnoses were a mixture of primary hepatocellular carcinoma (HCC) and oligometastases from other sites, including colorectal cancer (Table 1). In total, 49 and 26 fractions were delivered for the pre-implementation and post-implementation groups, respectively.

Online CBCT results are presented in Fig. 2 below. Median online

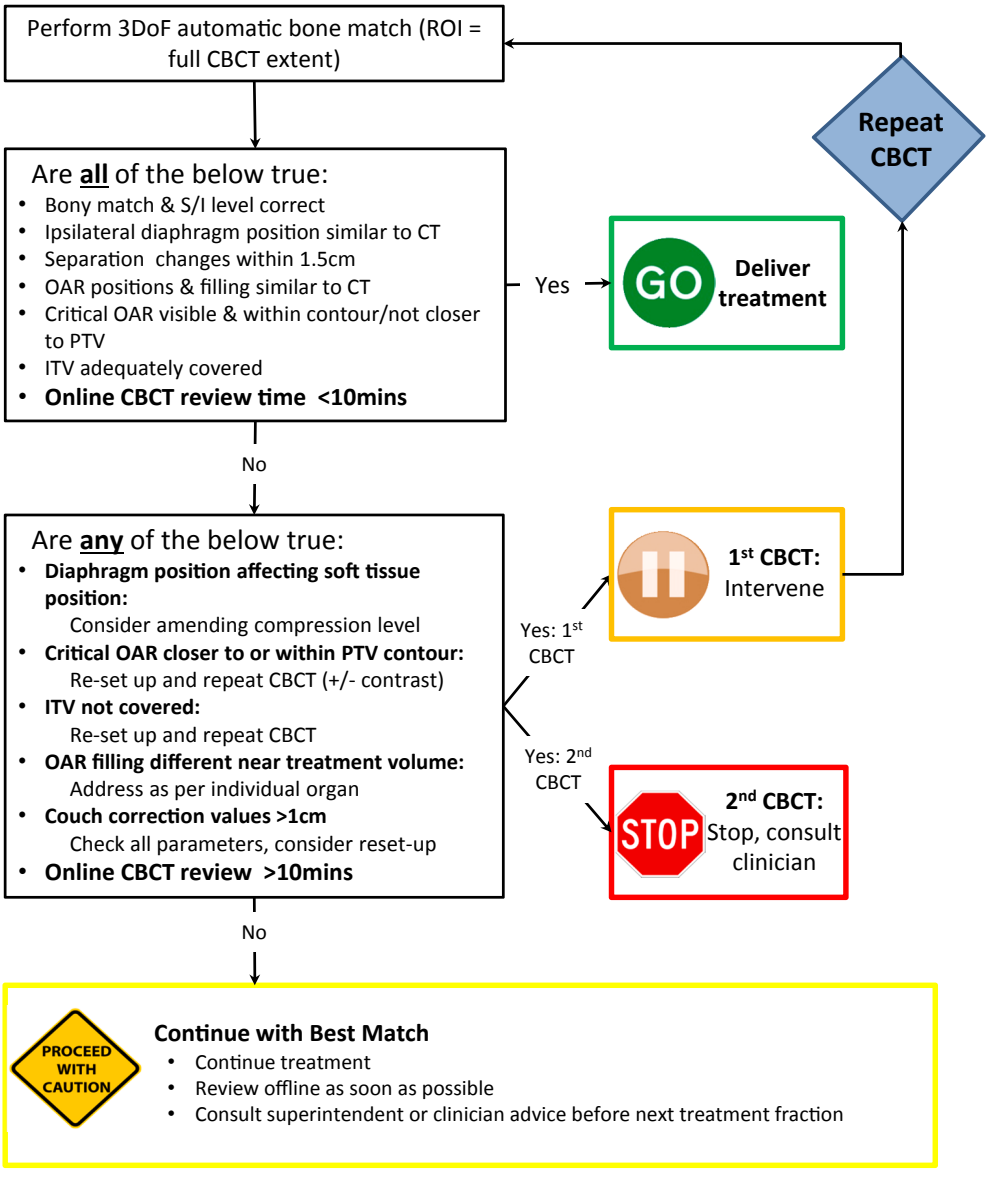

Fig. 1. Abdominal SABR IGRT decision tool flowchart.

Table 1
Description of treatment site and fraction (#) information for patients pre- and post- implementation of the decision tool showing treatment site. M = Metastasis, P = Primary.

Pre-implementation (n = 11)		
Patient	**Site**	**Number of #**
1	Liver (M)	5
2	Node (M)	3
3	Pancreas (M)	3
4	Liver (M)	5
5	Liver (M)	5
6	Liver (P)	5
7	Liver (M)	3
8	Liver (M)	5
9	Liver (M)	5
10	Liver (P)	5
11	Liver (P)	5
Post-implementation (n = 6)		
Patient	**Site**	**Number of #**
1	Node (M)	3
2	Liver (M)	5
3	Liver (M)	5
4	Adrenal (M)	3
5	Liver (P)	5
6	Liver (P)	5

CBCT review time in the pre-implementation group was 07 m 47 s (range 04 m 58 s–15 m 21 s) for 11 patients. This was reduced to 06 m 39 s (range 4 m 20 s–9 m 32 s) in the six patients after implementation. One patient in the pre-implementation was re-set up and had re-CBCT on one fraction to increase the level of abdominal compression, and one patient in the post-implementation was re-set up and had re-CBCT on one fraction to improve overall position based on initial CBCT. There were no delivered fractions in the post-implementation group where the oncologist disagreed with the online radiographer-led match.

14 radiographers participated in the initial survey and 7 in the post-implementation survey over a period of 5 weeks. Radiographer's responses regarding confidence are shown in Table 2. The radiographers in the second survey were the same as in the first, however not all of the initial respondents were available to answer the second questionnaire. 64% of the respondents rated their confidence as a 4 or above in the pre-implementation phase, and 100% reported the same post-implementation.

Discussion

This technical note describes an institutional service evaluation of the implementation of an abdominal IGRT decision tool for SABR to improve efficiency and promote a radiographer-led IGRT workflow across a range of abdominal sites. There was a notable reduction in online match time using the IGRT decision tool, and this is potentially meaningful clinically in terms of treatment accuracy. For effective IGRT, the time interval between imaging and treatment should be short as possible to minimise the risk of intrafraction motion changes [3,4], this is particularly pertinent for abdominal SABR. For example, craniocaudal liver baseline drifts of 2 mm have been seen on intrafraction CBCT over an average acquisition time of 1 m 25 s [6]. Similarly, craniocaudal baseline drifts of 3.9 mm have been reported for longer time intervals (median 12 m 16 s, range 4 m 56 s–21 m 25 s) [7].

In the present evaluation, use of the decision tool reduced the overall mean online CBCT review time within a small patient cohort. This may be partly attributable to the use of the decision tool, however the overall increased awareness of online review times for the implementation may have contributed to this. The minimum match time between the pre-and post-implementation groups were relatively similar, although crucially,

Table 2
Radiographer questionnaire responses for confidence in identifying set-up intervention with and without the IGRT decision tool.

How confident do you feel in identifying what set-up intervention is required in order to proceed with treatment?						
Pre-implementation (n = 14)						
Very unconfident	1	2	3	4	5	Very confident
	0	1 (7%)	4 (29%)	7 (50%)	2 (14%)	
Post-implementation (n = 8)						
Very unconfident	1	2	3	4	5	Very confident
	0	0	0	7 (87.5%)	1 (12.5%)	

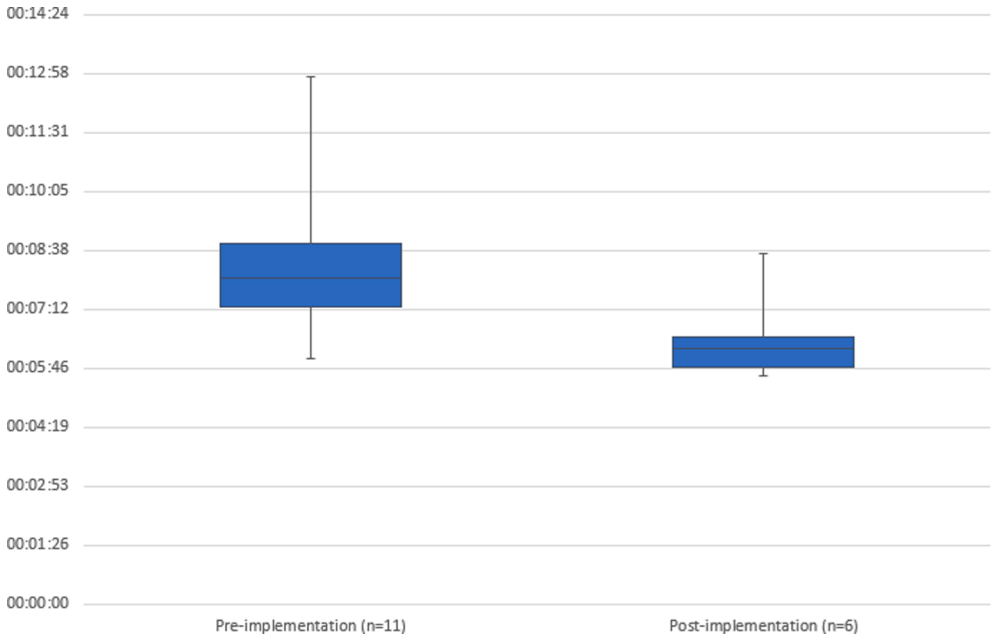

Fig. 2. Box-and-whisker plot of online CBCT review times for the pre-implementation and post-implementation cohorts.

the overall group maximum online match time was reduced post-implementation. This tool will be utilised on an ongoing basis within the department to guide online CBCT review for abdominal SABR patients as well as those receiving conventional radiotherapy to the pancreas or oesophagus.

While the quality of the radiographer match was not compared with that of the oncologist, there were no instances of a 'stop' decision being made by radiographers using the IGRT tool, nor of the oncologist disagreeing with matches offline. Utilising the skills and expertise of radiographers, while balancing the complexity of abdominal SABR, means there is more time available for the oncologist to perform other clinical duties, and improved efficiency of the treatment workflow. In the era of COVID-19, fewer people present in the control room also meant it was easier for staff to perform social distancing [8].

There is increasing awareness of the skills and strengths of radiographers in performing more complex tasks within the radiotherapy pathway, such as carrying out IGRT activities including adaptive radiotherapy and research and development [5,9,10]. In gastric radiotherapy, good interobserver agreement between radiographers and a clinician have been seen [11]. The confidence of radiographers improved after the implementation of the IGRT decision tool, potentially due to having an objective tool for guidance. Providing radiographers with this tool empowers them to carry out advanced duties usually done by physicists or oncologists [12]. However, as questionnaires were completely anonymous it was not possible to assess individual radiographer's change in confidence.

The limitations of this evaluation are the small cohort sizes, in particular that of the post-implementation group, which was due to clinical limitations, therefore validation of these results is required in a larger cohort. The heterogeneity of anatomical sites between the two patient cohorts may have affected the level of IGRT complexity, and future studies should stratify patients according to site. Additionally, as no 'STOP' or 'proceed with caution' events were recorded in the present evaluation, it is difficult to ascertain the performance of the tool in these scenarios. In future, exact timing of the online image review process will be useful to provide more accurate match time results exclusive of other tasks such as application of couch shifts, and work should be undertaken to further improve online matching efficiency. The number of staff who completed questionnaires was relatively small, and not all respondents from the initial questionnaire were able to answer the second, due to working from home and sick leave due to the COVID-19 pandemic. As questionnaires were completed anonymously, it is not possible to ascertain individual changes in radiographer confidence, which may have contributed a degree of bias.

Conclusion

Use of the online IGRT decision tool reduced mean online CBCT review times in this evaluation. Radiographer's confidence in reviewing CBCT for abdominal SABR was improved by a combination of a short training session and use of an IGRT decision tool, leading to a more radiographer-led abdominal SABR service in our institution. Similar frameworks may benefit radiographer-led IGRT for SABR and non-SABR treatments for other sites in the future. Further investigation of this IGRT tool in larger patient cohorts is required.

Declaration of Competing Interest

The authors declare the following financial interests/personal relationships which may be considered as potential competing interests: 'Mairead Daly is supported by a Cancer Research UK Centres Network Accelerator Award Grant (A21993) to the ART-NET consortium (salary). All other authors no competing interests to declare'.

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This work was conducted as part of a department governance-approved service evaluation.

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