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Assessment of deep inspiration breath hold (DIBH) amplitude and reduction in cardiac dose in left breast cancer patients

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A B S T R A C T

Introduction: The primary aim of this study was to examine the impact of deep inspiration breath-hold (DIBH) amplitude on subsequent mean heart dose and V30 during radiotherapy. The secondary aim was to investigate if patient age influenced DIBH amplitude.

Method: A retrospective study of 30 patients with left-sided breast cancer was completed. Patients were randomly selected from the total number of patients dual scanned in free breathing (FB) and DIBH over a 2-year period. Plans were retrospectively virtually simulated and statistical analysis performed.

Results: All patients achieved decreased V30 and mean cardiac dose using DIBH. A positive correlation was found between DIBH amplitude and cardiac V30 dose reduction ($p = 0.007$, $R = 0.48$). Ratio of amplitude increase from FB to DIBH and cardiac V30 reduction was positively correlated and statistically significant ($p = 0.04$, $R = 0.38$); Ratio of amplitude increase of at least 15 times FB achieved 100% V30 dose reduction, however this was also achieved with ratio increase as low as 6.25 times FB. A statistically significant positive correlation was identified between DIBH amplitude and mean cardiac dose reduction ($p = 0.003$, $R = 0.523$). No correlation was found between patient age and amplitude ratio increase ($p = 0.602$, $R = -0.099$).

Conclusion: A 100% reduction in cardiac V30 can be achieved with a DIBH amplitude increase of 15 times FB. A full reduction can also be achieved at much lower levels (6.25 times FB in current study); however there appears to be no pre-determining patient factors to identify this. DIBH amplitudes of 1 cm–4 cm reduce cardiac mean dose by at least 50%.

Introduction

Due to the anatomical position of the heart, patients treated with radiotherapy for left sided breast cancer are at a greater risk of cardiac morbidity due to radiation exposure of cardiac tissues.[1] It is widley accepted that any achievable reduction in cardiac irradiation will aid the reduction of long-term side effects.[2] However it is often unavoidable to exclude all cardiac tissues and structures when treating left sided breast cancer.[3] Radiotherapy delivery using deep inspiration breath hold (DIBH) is one recognised method of achieving this.[4–8]

Many studies have indicated a significant reduction in cardiac irradiation using DIBH compared to standard radiotherapy techniques for left-sided breast cancer patients.[4–8] A large, single centre study ($n = 319$) found a 70% ($p > 0.0001$) reduction in V20Gy (volume of cardiac tissue receiving over 20Gy) when free breathing (FB) was compared with DIBH (7.8%–2.3% respectively).[9] V40Gy (volume of cardiac tissue receiving over 40Gy) and mean heart dose were also statistically significantly ($p > 0.0001$) reduced by 91% and 48% respectively when the DIBH technique was used.

These results were consistent with a study by Hayden, Raines and Tiver[7] who identified a cardiac V30Gy (volume of cardiac tissue receiving over 30Gy) reduction from 7.1% to 2.4% when DIBH was compared to FB ($n = 30$). Both studies did state that there appeared to be no predicting factors to indicate whether an individual patient will benefit from DIBH.[7,9]

While the benefits of DIBH are well acknowledged,[4–7] problems such as breath hold level reproducibility, verification and patient co-operation are limiting factors.[5] Audio and visual coaching has been found to be effective in standardising patients' amplitude between fractions.[5,10] However, this has expensive resource and training implications and can increase scanning, treatment and set-up time due to the addition of a training session prior to scanning or multiple breath holds to deliver treatment.[5] Due to additional time

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and resource implications it may be necessary to identify cases where maximum benefit from DIBH techniques can be achieved. It has been shown that DIBH can be successfully delivered without the use of additional resources and patient monitoring systems,[4] however there are currently no studies that investigate amplitude levels associated with DIBH, and any resulting correlations in DIBH benefit.

The primary aim of the study was to investigate the impact of breath hold amplitude on subsequent cardiac V30 and mean heart dose in women treated for a left sided breast cancer in relation to the use of DIBH technique during radiotherapy. The V30 and mean heart dose were chosen as these represent standard dose constraint measures used in clinical practice. The secondary aim investigated if patient age influenced DIBH amplitude; there was concern that older patients may not be able to achieve the same amplitude of breath hold as younger patients.

Method

A retrospective study including patients treated in the previous two years was completed. All patients included in the study underwent two planning scans (one free breathing FB scan and one Deep Inspiration Breath hold DIBH scan).

Ethical considerations and data protection

As the study was retrospective, there were no ethical risks to the patient as the study could not influence or impact the patient's treatment. Patient confidentiality and privacy were maintained throughout with Computerised Tomography (CT) scans and breathing traces given an anonymous identifier. The study was approved and supported by the hospital trust and Sheffield Hallam University.

Patient cohort

The sample size was calculated using correlation co-efficient linear regression which indicated the sample size required a total of 30 patients to identify statistical significance. Patients were randomly selected from the total number of patients scanned in both FB and DIBH using a random number generator. A total of 62 eligible patients were assigned ascending consecutive numbers; 30 numbers were then identified from the random number generator, the patients with the matching number were included in the study.

Radiotherapy procedure

Patients were scanned on an inclined breast board, using 3 mm slices on a 16-slice Philips Big Bore CT scanner (Philips Healthcare, Andover, MA). Due to capacity and resource implications, DIBH scans were usually acquired during a separate appointment from the FB scan. It is acknowledged this may be a limitation of the study, however this was performed due to logistics and resource limitations. Patient position for DIBH scan was reproduced to match that of the FB scan. A minimum of three practice breath holds were performed to ensure patients understood the instructions, could maintain breath hold for the required time and that breath hold level was consistent. Varian Real-time Position Management (RPM) (Varian Medical Systems, Inc, Palo Alto, CA) was used to record and monitor breathing.

Treatment planning

A single experienced planning radiographer retrospectively virtually simulated plans on Prosoma planning software (MedCom, Darmstadt, Germany). Plans were produced on the FB and DIBH CT scans using standard field borders to cover the breast tissue. For patients requiring supraclavicular fossa (SCF) irradiation, field borders described by Wheatley et al.[11] were used, as followed by the IMPORT high protocol.[12] Pinnacle version 9.8 (Philips Medical Systems, Fitchbourg, WI) was used for heart contouring, planning and dosimetric comparison. The heart was contoured following the guidelines from the FAST Forward protocol.[13]

A dose of 40Gy in 15 fractions over 3 weeks using 6 MV or 10 MV photons was prescribed, corrections were applied for tissue heterogeneity and treatment plans were optimised with 3D dose compensation with wedges or segments for dose homogeneity. Planning was comparable with other studies[13,14] such that all plans produced were within the guidance of ICRU 62[15]:

The RPM trace from the planning scan was used to determine the amplitude of normal breathing and that of DIBH (See Fig. 1). It is acknowledged that the true amplitude of breath is not known for the FB scan as RPM was not used during the FB scan. However,

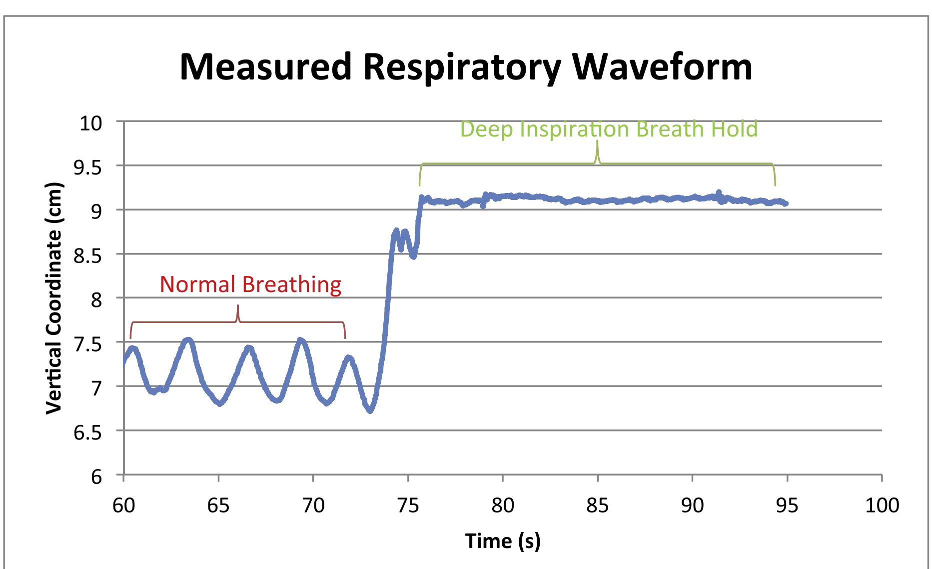

Figure 1. Example RPM trace showing normal breathing and deep inspiration breath hold.

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