# Comparing Chest and Abdominal Patient Monitoring and Visual Feedback Systems for Deep Inspiration Breath Hold: Results from the BRAVEHeart Clinical Trial

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## INTRODUCTION

As a technique to reduce heart dose for left-sided breast cancer patients, deep inspiration breath hold (DIBH) has shown great success, with Nissen et al. reporting reduction to the median heart dose of 48% [1].

Visual feedback greatly improves the reproducibility and stability of breath holds [2]. However, there are currently several competing monitoring systems available, ranging from spirometry-based active breath management to passive monitoring with marker block or surface monitoring technology.

The less invasive, passive systems tend to be preferred by patients, but there is insufficient evidence yet to conclude whether direct patient surface monitoring is superior to abdominal marker block-driven systems and which region of the patient is best to monitor.

This work compares breath hold accuracy for a chest surface monitoring system, "Breathe Well", and an abdominal marker block monitor, Varian "RPM".

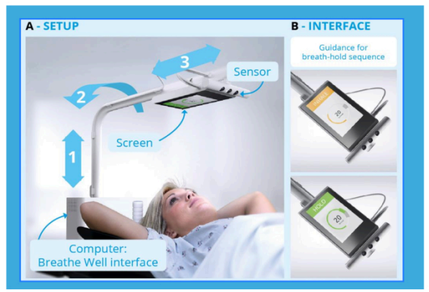


***Fig. 1.*** *The Breathe Well chest surface monitoring system: A) Setup of the visual feedback device on the treatment couch. B) Patient screen with breath hold position visualisation and instructions.*

## METHOD

Patients are recruited and randomised (1:1) into either the Breathe Well or RPM arm. The patient is trained to manage DIBH with the allocated device. If successful, patients manage their breath holds during simulation and treatment with the allocated system; if unsuccessful treatment is given with free-breathing.

During treatment, cine EPID images are collected. Post-treatment, the chest wall position is automatically extracted and compared to the planned position on the DRR to give the ground truth chest wall movement. Accuracy of the monitoring system is determined by comparing the externally monitored movement to this ground truth.

**The primary hypothesis is that the accuracy of chest surface monitoring will be superior to the abdominal block monitoring system.**

Patient and staff questionnaires are collected to assess usability of the Breathe Well system compared to RPM. Treatment time is recorded to assess whether surface monitoring is quicker to set up than the monitoring block.

13 out of 40 patients have been recruited – we present the interim accuracy analysis.

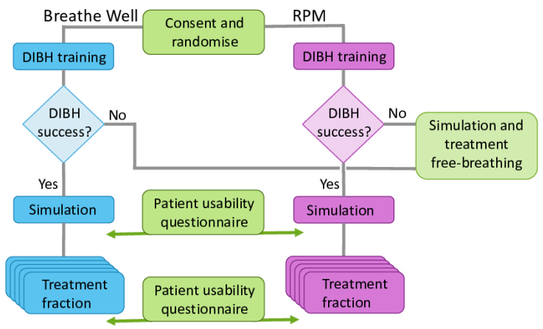


***Fig 2****. BRAVEHeart trial workflow*

## RESULTS

Interim analysis: Results from the first 13 patients recruited were analysed.

**Key Result:**

- ❑ Accuracy was equivalent for the two systems.

**Monitoring system accuracy**

$$A = \sum_{i=1}^{n} |Amplitude(t_i) - GroundTruth(t_i)|$$

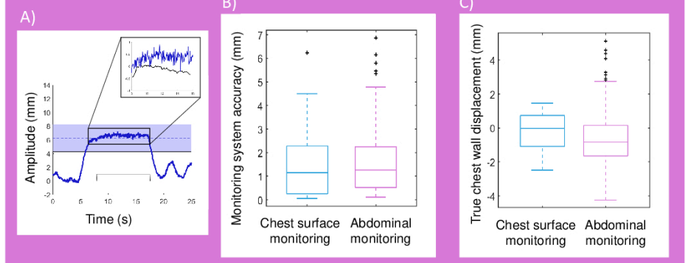


***Fig. 3. The accuracy of the monitoring system per breath hold*** *was defined as the average difference between the monitored motion amplitude and the ground truth chest wall motion amplitude relative to planned position on the DRR extracted from cine EPID.*

*A) Representative example of breathing trace from monitoring system showing breath hold (blue), and comparison of amplitude to ground truth (black) during the breath hold. B) Monitoring system accuracy per breath hold for each system. C) Treatment delivery – average ground truth chest wall displacement per breath hold for each system.*

**Additional Results:**

**Reproducibility**

$$R = \max\{d_i\} - \min\{d_i\}$$

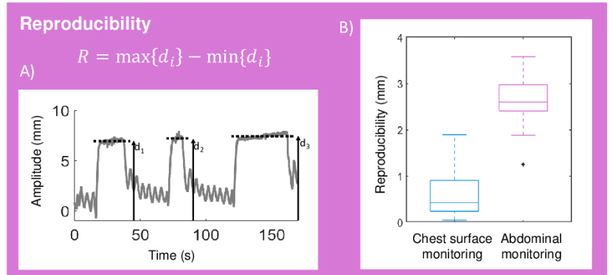


***Fig. 4. DIBH reproducibility is defined as the maximum difference in mean breath hold depth across a treatment fraction.***
*A) Definition of reproducibility from [3]. B) Measured reproducibility for the two DIBH monitoring systems.*
*Reproducibility was smaller for the chest surface monitoring system indicating it may be easier for patients to better reproduce chest filling between breath holds with this system than with abdominal monitoring.*

**Stability**

$$S = \max\{|m_i|\ \Delta t\}$$

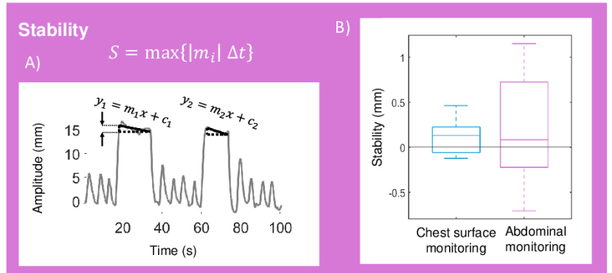


***Fig. 5. Stability measures the position variation within each breath hold.***
*A) Definition of stability as defined in [3]. B) Measured stability for the two DIBH monitoring systems.*
*The average for each system was close to zero, with no statistically significant difference between the two, though the variance was less for the chest surface monitoring system.*

## CONCLUSIONS

- ❑ The mean accuracy of both systems was equivalent, indicating that both chest surface and abdominal monitoring reflect true chest wall motion equally well.
- ❑ The reproducibility of breath holds was improved for patients using the chest surface monitoring system.
- ❑ The stability of both systems was equivalent, but with a smaller standard deviation for the chest surface monitoring system.

## CONTACT INFORMATION

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## REFERENCES

1. Nissen HD, Appelt AL. *Radiother Oncol* 2013; **106**: 28–32. DOI: 10.1016/j.radonc.2012.10.016
2. Cerviño LI, Gupta S, Rose MA, Yashar C, Jiang SB. *Phys Med Biol.* 2009; **54**(22): 6853–6865. DOI: 10.1088/0031-9155/54/22/007