The Design and Fabrication of a Dynamic Anthropomorphic Thorax Phantom

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INTRODUCTION

- **Lung cancer** has become the most common cause of cancer death in recent years. For the inoperable lung cancer patients, **radiation therapy** is the preferred treatment modality.
- Chest movement will affect the accuracy of **radiation dose delivery**, there are few phantoms for **quality control of dose delivery** and thoracic **deformable image registration (DIR)**.

AIM

- To design and fabricate a **dynamic anthropomorphic thorax phantom** that can simulate the anatomical structures and chest movement using **tissue-equivalent materials** and 3D printing technology.

METHOD

The dynamic anthropomorphic thorax phantom includes **anatomical structures and power control devices.**

- We used an anonymous patient' CT images to reconstruct 3D anatomical structures on Mimics software to generate STL files, and all files were post-processed and digitally modeled in the Meshmixer software.
- The materials equivalent to the human thorax structure were made and assembled to form the anatomical structures.
- One tumor simulator and ten markers for DIR validation were embedded into the phantom.
- The power control device was composed of stepper motor, cylinder and display screen.

RESULTS

- The main anatomical structures of this phantom were similar with those of the real part of the human body (Figure 1 and Figure 2).
- This phantom was scanned by a Philips CT scanner. The CT values of the anonymous patient and phantom were measured using the software corresponding to the CT machine in the same workstation. The average CT value of **normal tissue** in the phantom was 54HU; the average CT value of **bone** was 254HU; the average CT value of **tumor simulator** was 66HU (Figure 2.c).
- The average CT value of **markers** were 1359HU. This CT value make the markers **distinguishable** and **doesn't** bring serious **artifacts** when imaging (Figure 2.b and Figure 2.c).
- The thorax phantom can accurately simulate human body **breathing movement** and **the corresponding anatomical changes of chest.** The lung ventilation and respiratory rate can be programmed and controlled by pressing buttons. The total lung capacity of the phantom can be ranged from 4000ml to 6000ml. The respiratory rate of the phantom can be ranged from 1bpm to 24bpm.

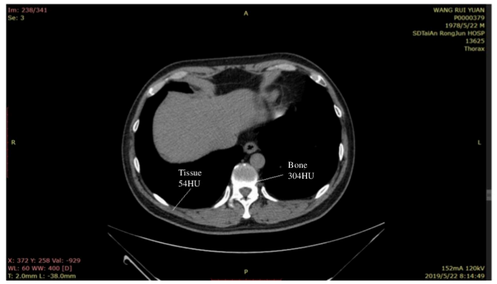
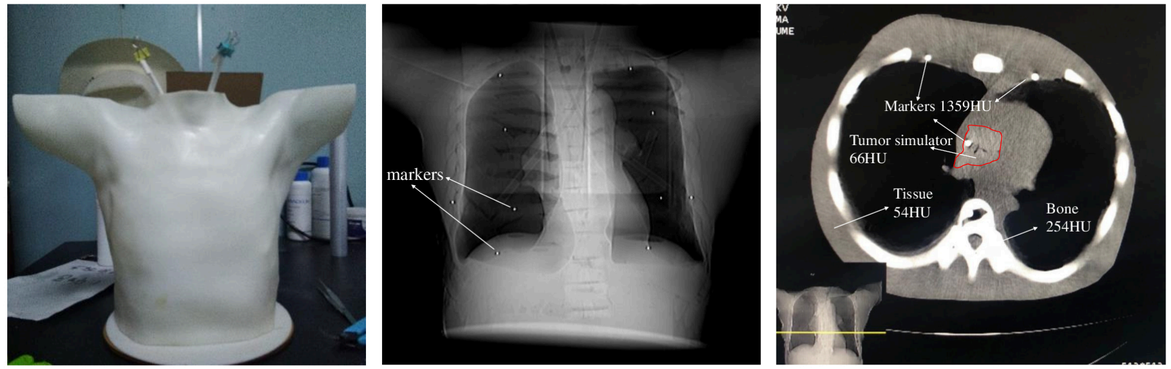


Figure 1. One CT image slice of the anonymous patient.



(a) (b) (c)

Figure 2. The photograph (a), X-ray photograph (b), and one CT image slice (c) of the dynamic thorax phantom.

CONCLUSIONS

- The anatomical structures of this phantoms had **similar CT values** with those of real human body. This phantom can simulate the **breathing movements** and the corresponding **anatomical changes** of chest.
- The dynamic anthropomorphic thorax phantom can be used **for dose verification in radiotherapy** and **DIR.**

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