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# Deliverable 2.7

# Six segmented thorax phantoms

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| **Lead partner:** | HMGU |
| **Author(s):** | Maria Zankl |
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# 1. Introduction

Deliverable 2.7 ("Six segmented thorax phantoms") is part of Task 2.2 "Optimisation in fluoroscopically-guided interventional procedures", and especially a part of Subtask 2.2.1 "Patient dose estimation in fluoroscopically-guided procedures".

Six individual voxel phantoms have been developed using high-resolution chest CT image data provided by the clinical partners in WP2: three female and three male phantoms, for each gender representing patients of slim, standard and obese body size. The following organs of interest were segmented in each phantom: lungs, heart, oesophagus, breast, bones, and skin.

Normalised organ and tissue doses will subsequently be determined using the radiation transport programme package EGSnrc (Kawrakow, 2009) for the above-mentioned organs and tissues located in the primary exposed volume for cardiac ablation procedures.

# 2. Content

## 2.1 Image data sets

OvGU has made available six chest CT data sets for Subtask 2.2.1, and these data sets were segmented. The chest CT data were from three male and three female patients, and the statures were slim, normal, and obese, respectively.

## 2.2 Organs segmented

The following organs were segmented in all phantoms:

- Bones
- Breast
- Heart
- Lungs
- Oesophagus
- Skin

In addition to the original project plan, the following items were introduced as well:

- Adipose tissue
- Air inside the airways
- Muscles

This was considered meaningful to reflect the different densities and attenuation properties of these tissues for the organ dose calculations that are being planned with these phantoms. All the organs that have not been explicitly segmented have been assigned the same tissue properties as muscle.

## 2.3 Further improvements

Red bone marrow is among the tissues with a higher sensitivity to ionising radiation. To allow a more reliable calculation of the dose to red bone marrow, the skeleton was further subdivided into bones and bone groups having different bone marrow content and cellularity (ICRP, 1995). Marrow cellularity is the fraction of the marrow that is haematopoietically active (and gets its red colour from the large numbers of erythrocytes (red blood cells) being produced) and, hence, radiation sensitive. This fraction is decreasing with increasing age, and it is different for different bones and bone groups. The following bones and bone groups in the chest phantoms were, therefore, distinguished:

- Arm bones
- Clavicles
- Ribs
- Scapulae
- Spine
- Sternum

## 2.4 Next steps

The six segmented chest phantoms will be used for organ dose calculations for cardiac ablation procedures. The results of these calculations are due in Month 42.

# 3. Conclusions

Six individual voxel phantoms have been developed using high-resolution chest CT image data provided by the clinical partners in WP2: three male and three female phantoms representing patients of slim, standard and obese body size. The following organs of interest were segmented in each phantom: lungs, heart, oesophagus, breast, bones, and skin. Adipose tissue, air inside the airways, and muscles were separated as well, and the bones were subdivided into six different bones and bone groups having different marrow content and cellularity.

The six thorax phantoms can be downloaded from the following website:
http://medirad-project.eu/storage/app/media/results/D2.7/Phantoms.rar

Normalised organ and tissue doses will subsequently be determined for the above-mentioned organs and tissues located in the primary exposed volume for cardiac ablation procedures.

# 4. References

ICRP, 1995. Basic anatomical and physiological data for use in radiological protection: the skeleton. ICRP Publication 70. Ann. ICRP 25(2).

Kawrakow, I., E. Mainegra-Hing, D. W. O. Rogers, F. Tessier and B. R. B. Walters (2009). The EGSnrc code system: Monte Carlo simulation of electron and photon transport. Ottawa, National Research Council of Canada (NRCC).