Development of 3D Geometry of the Ovine Thorax for Finite Element Modeling

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Introduction

The long-term goal of this study is to develop a finite element (FE) computational model of an ovine thorax for the study of Behind Armor Blunt Trauma (BABT). We present a CT scanning and geometry development method used in the generation of 3D CAD for the animal model.

Methods, Scanning

All scanning was conducted under WFU IACUC A20-161. CT scan data was acquired of two male Katahdin sheep, 25-30 kg, in sternal recumbency using a Siemens Somatom Definition Flash CT scanner at the Wake Forest Baptist Medical Center Clarkson Campus. The scan used a wedge-3 filter, exposure time of 500 ms, slice thickness of 0.6 mm, and a matrix of 512 x 512. Contrast agent (1mL/lb Omnipaque 350) was delivered at a rate of 2 mL/s using a power injector through the cephalic vein. Scans were taken at baseline, 20 s, 80 s, and 5 min post contrast to accentuate arterial and portal/venous structures.

Methods, Geometry

Geometry was focused on structures of interest in BABT study from a single animal: the ribcage, sternum, spine, humerus, scapula, costal cartilage, heart, lungs, vasculature, abdominal organs, soft tissue envelope, and skin. Anatomical features were segmented using Mimics v. 23 (Materialise, Leuven, Belgium) and post processed using Geomagic Studio v2014 (3D Systems, Rock Hill SC) to acquire polygonal surfaces. All segmenting was completed using the 20s post contrast scan. Masks were created using the semi-automatic dynamic region grow function and then manually edited against image data using multi slice edit. Following geometry development preliminary comparisons to the human thorax were made using the GHBMC M50-O v. 6.0 male thoracic model.

Results

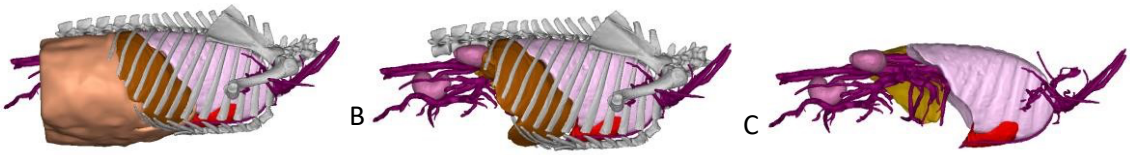
Resulting scans had roughly 1900 images for each time point, and were reconstructed for bone (B60f, sharp) and soft tissue (B30f, medium smooth) contrast. The visibility of the heart, lungs, right kidney, and liver in the soft tissue reconstruction at 20s post contrast can be seem in Table 1. A rendered sagittal image of the animal is shown in Figure 1, and segmented structures excluding the outer surface can be seen in Figure 2.

Comparative Analysis

Because these animals will be used as human surrogates in BABT studies, comparative gross morphological differences between the sheep and average adult human male were made. The ovine rib cage measured 206.7 mm in LR width and 234.9 mm in AP breath at the level of vertebrae T9 as opposed to 407.5 mm and 238.9 mm respectively for the human model. Sheep have 26 ribs compared to 24 in the human rib cage. The total lung volume of the sheep was 34.4% smaller than the human lung volume and the aortic diameter of the sheep was 51.6% smaller. Comparative gross anatomy is a first step to understanding mechanical metrics which will be extracted from future modeling efforts. The long-term goal of this study is the development of a dynamic FEA model of the ovine thorax for improved FE based injury metrics via comparison to experimental outcomes, and to perform *in-silico* testing of body borne countermeasures.

Figure 1: A 3-dimensional sagittal view of the CT scan collected 20s post contrast with bone reconstruction.

Table 1: Visibility of select organs for the 20s post contrast tissue reconstructions of the sheep scans. The lung images were taken using a lung window to highlight the details inside the lungs, all other images were taken using the default grayscale window.



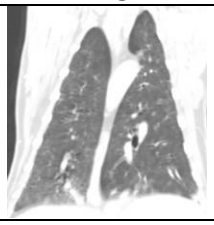
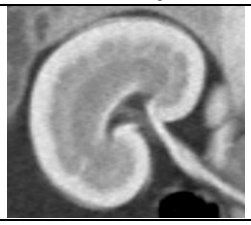
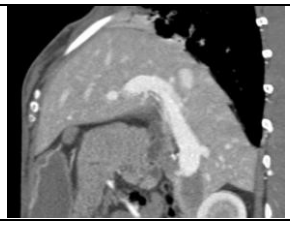
Heart	Lungs	Kidney	Liver
			

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Figure 2: Figure of the segmented structures included in the model. A has all of the structures. B has the rumen removed. C. has the skeleton removed.

Acknowledgements

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