Methodology for Assessing the Force Response and Kinematics of an Eviscerated Ribcage Undergoing Anterior Loading

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ABSTRACT

As computational models of the human thorax become more sophisticated, understanding structural coupling and deformation sharing throughout the ribcage becomes increasingly necessary. The present study develops a method to investigate these characteristics through a study of the kinematics and force-deflection response of the ribcage under highly-localized anterior load. Three cadavers were denuded and eviscerated, with only the intercostal muscles remaining, and mounted upright with the spine fixed. Each test consisted of loading one of the following locations on the rib: the costochondral (CC) junction, 5cm lateral to the CC junction, and halfway between the CC junction and costo-sternal joint for each rib. Additionally, two points on the sternum were also loaded. Bilateral tests were then performed, each loading both the right and left CC junctions of ribs 1 through 6. A quasi-static (2mm/sec) displacement was applied to each loading point, nominally at 15% of the rib depth, and the reaction force at the loading point was measured. For each test, the deformation of the ribcage was recorded by digitizing 56 points on the ribcage (with a Faro Arm) at both the unloaded and loaded state. A total of 94 unilateral and bilateral tests were performed.

Preliminary results show varying degrees of thoracic coupling dependent on the sites of loading. In general, loading of the sternum resulted in large deflections throughout the ribcage (Figure 2). Ribs adjacent to the loading site experienced 87±5% and 78±5% (average ± standard deviation) of the maximum resultant deflection for upper and lower sternum loading, respectively. In contrast, loading of individual ribs resulted in less deflection of the ipsilateral adjacent ribs, the adjacent sternum measurement sites, and the contralateral ribs (e.g. 67±9%, 41±9%, and 32±3% of the maximum deflection, respectively, for loading of the 4th rib). These results suggest that the costal cartilage may play an important role in the distribution of deformation, structural recruitment, and consequent load sharing throughout the ribcage under anterior load.