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Oral Presentation Abstract Submission

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Title of Presentation Hierarchal Clustering for the Identification of Distinct Rib Fracture Patterns: A Novel Big Data Utility for Clinical Studies

Background

Treatment and prognosis of chest wall injury has been suspected to be dependent on the location, quantity, and patterning of rib fractures. There exists only limited data about the rib fracture patterns, which is often limited to number of individual ribs fractured, segmentality of those fractures, or overall number of fractures. Analysis of rib fracture patterns may account for other locoregional fractures, but a method for quantitative analysis is needed that can maintain geospatial fidelity to ensure appropriate clinical validity. A cross-disciplinary approach leveraging statistical techniques commonly used in the field of high throughput genetics may present an opportunity for detailed chest injury comparisons.

Methods

Prospectively kept Chest Injury International Database (CIID) data was reviewed for patients presenting with multiple rib fractures following injury. Rib fractures were described as per current taxonomy [1] by rib number, one of five positions on the rib from anterior to posterior, and displacement. A corresponding five by twelve matrix could then be created to describe fracture site frequency in each geographic location. Data was collected and organized into paired conditions with non-overlapping cohorts (example patients undergoing operative rib stabilization versus non-operative management).

RStudio (Cary, NC, USA) and R packages 'ComplexHeatMap' and 'mclust' were used to analyze rib fracture matrices.[2,3] Frequencies were assigned a color gradient corresponding to frequency and a heat map was produced. Hierarchal clustering with Euclidean distancing was utilized to detect associations between locations of rib fractures while maintaining fidelity to the geographic loci of each rib. Hierarchal clustering yielded dendrograms with clusters of highly associated rib fractures. Bayesian Information Criterion (BIC) was utilized to determine the optimal number of clusters that contained association for rib fracture patterns. Rib fracture location and clustering for cohorts were compared.

Results

Hierarchal clustering outcomes were displayed as dendrograms that demonstrated clusters for the most highly associated rib numbers to be fractured together for a given condition. Secondarily, rib fractures were clustered by the most highly associated anterior-posterior geographic location. BIC analysis determined that there were two or three optimal clusters for the examined rib fracture dendrograms. The dendrogram for the operative cohort demonstrated that the most highly clustered association was anterolateral and lateral ribs 3, 4, and 5 being simultaneously fractured [Figure 1]. The dendrogram for the non-operative cohort demonstrated that the most highly clustered association was lateral and posterolateral ribs 5, 6, and 7 being simultaneously fractured.

Conclusion

Hierarchal clustering has been historically utilized in molecular genetics to detect distinct gene expression patterns while accounting for relative distances of gene loci. Here we show hierarchal clustering may be a useful tool for determining patterns of association in clinical disciplines which require similar loci fidelity, such as fracture patterns in chest wall injury as captured by the CIID.

1. Edwards JG, Clarke P, Pieracci FM, et al. Taxonomy of multiple rib fractures: Results of the chest wall injury society international consensus survey. J Trauma Acute Care Surg. 2020;88(2):E40-E45. doi:10.1097/TA.0000000000002282
2. Gu Z, Eils R, Schlesner M (2016). "Complex heatmaps reveal patterns and correlations in multidimensional genomic data." Bioinformatics. doi: 10.1093/bioinformatics/btw313.
3. Scrucca L, Fop M, Murphy TB, Raftery AE (2016). "mclust 5: clustering, classification and density estimation using Gaussian finite mixture models." The R Journal, 8(1), 289–317. https://doi.org/10.32614/RJ-2016-021.