Deep Learning for Automatic Landmark Localization in CTA for Transcatheter Aortic Valve Implantation

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PURPOSE

Fast and accurate automatic landmark localization in CT angiography (CTA) scans can aid treatment planning for patients undergoing transcatheter aortic valve implantation (TAVI). Manual localization of landmarks can be time-consuming and cumbersome. Automatic landmark localization can potentially reduce post-processing time and interobserver variability. Hence, this study evaluates the performance of deep learning for automatic aortic root landmark localization in CTA.

METHOD AND MATERIALS

This study included 672 retrospectively gated CTA scans acquired as part of clinical routine (Philips Brilliance iCT-256 scanner, 0.9mm slice thickness, 0.45mm increment, 80-140kVp, 210-300mAs, contrast). Reference standard was defined by manual localization of the left (LH), non-coronary (NCH) and right (RH) aortic valve hinge points, and the right (RO) and left (LO) coronary ostia. To develop and evaluate the automatic method, 412 training, 60 validation, and 200 test CTAs were randomly selected. 100/200 test CTAs were annotated twice by the same observer and once by a second observer to estimate intra- and interobserver agreement. Five CNNs with identical architectures were trained, one for the localization of each landmark. For treatment planning of TAVI, distances between landmark points are used, hence performance was evaluated on subvoxel level with the Euclidean distance between reference and automatically predicted landmark locations.

RESULTS

Median (IQR) distance errors for the LH, NCH and RH were 2.44 (1.79), 3.01 (1.82) and 2.98 (2.09)mm, respectively. Repeated annotation of the first observer led to distance errors of 2.06 (1.43), 2.57 (2.22) and 2.58 (2.30)mm, and for the second observer to 1.80 (1.32), 1.99 (1.28) and 1.81 (1.68)mm, respectively. Median (IQR) distance errors for the RO and LO were 1.65 (1.33) and 1.91 (1.58)mm, respectively. Repeated annotation of the first observer led to distance errors of 1.43 (1.05) and 1.92 (1.44)mm, and for the second observer to 1.78 (1.55) and 2.35 (1.56)mm, respectively. On average, analysis took 0.3s/CTA.

CONCLUSION

Automatic landmark localization in CTA approaches second observer performance and thus enables automatic, accurate and reproducible landmark localization without additional reading time.

CLINICAL RELEVANCE/APPLICATION

Automatic landmark localization in CTA can aid in reducing post-processing time and interobserver variability in treatment planning for patients undergoing TAVI.