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Automatic identification and reconstruction of the right phrenic nerve on computed tomography

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Introduction
Damaging the right phrenic nerve (PN) constitutes a significant risk during atrial fibrillation (AF) ablation procedures using balloon techniques for pulmonary vein isolation (PVI). Visual localization of the right PN could substantially reduce this risk.

Purpose
The aim of this study was to develop an algorithm for automatic detection of the right PN on computed tomography (CT) scans.

Methods
An automatic algorithm was constructed, using image processing techniques to identify the right PN. High-resolution coronary CT images were used for optimal results. The algorithm consists of automatic detection and segmentation of the right atrium (RA), right ventricle (RV), left atrium (LA), pulmonary veins (PVs), and aorta on each individual CT slice, after pre-processing the CT images for noise reduction. Edge detection on these segmented data is then used to delineate a zone of interest comprising the right PN on all subsequent CT slices. Contrast stretching is applied on this zone of interest and pixel density histograms are constructed, identifying possible locations of the right PN as regional maxima on adjacent CT slides. Using a modified 3D version of a ‘random sample consensus’ algorithm, the PN is identified by constructing the best fitting curve through this 3D cloud of regional maxima.

Results
Our automatic algorithm was tested on a series of 27 patients. The location of the right PN could be determined for 24 patients (89%). The algorithm failed in 3 cases due to anatomic anomalies. Comparing the automatic PN location with manual detection of the PN on 24 patients, a median accuracy of 3.5 mm was achieved. Results were successfully validated by pace-mapping in 2 patients.

Conclusion
An automatic computer algorithm was successfully constructed, enabling identification and reconstruction of the right PN on high-resolution coronary CT scans in 89% of cases, with a median error margin of 3.5 mm. Automatic detection of the right PN could be particularly helpful at reducing phrenic nerve injury during AF ablation procedures.