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Inter-Operator Segmentation Variability Induces High Premature Ventricular Contractions Localization Uncertainty at the Heart Base

Narimane Gassa¹, Jess Tate², Machteld Boonstra³, Beata Ondrusova⁴, Jana Svehlikova⁴, Rob MacLeod², Nejb Zemzemi¹

¹ Centre Inria de l'Université de Bordeaux, Talence, France – ² University of Utah, Salt Lake City, United States – ³ University Medical Center Utrecht, Almere, Netherlands – ⁴ Institute of Measurement Science, Slovak Academy of Sciences.



Background

Electrocardiographic imaging (ECGI) has become a valuable non-invasive technique for diagnosing and treating cardiac arrhythmia. It involves using body surface potentials and anatomical models with specific electrode positions to estimate the heart's electrical activity. However, solving the inverse problem in ECGI requires an initial step of image segmentation and mesh generation. It's crucial for accurate ECGI but its success may be dependent on the operator's expertise and the segmentation method.

Objective

Our main purpose is to evaluate the effect of the inter-operator segmentation variability on the PVC localization.

Method

- For a singular subject, the consortium of ECGI received 10 distinct cardiac segmentations from operators in different institutions, with the purpose of examining the impact of segmentation.

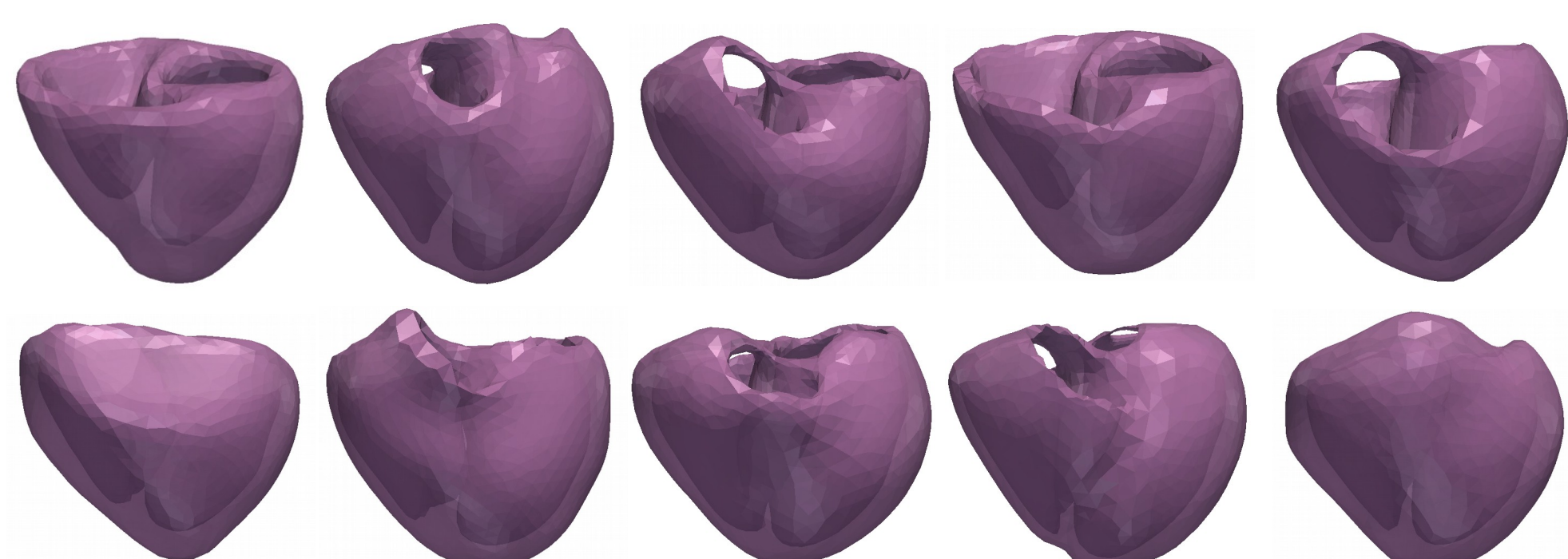


Figure 1. Original segmentations

- In this study, we solve the inverse problem in electrocardiography to find the source activation given the body surface potentials (BSPs) **twice**. For the first test case, we solve ECGI for each cardiac segmentation and its corresponding BSP. In the second test case, we use one geometry and its corresponding BSP as a reference to solve ECGI for all geometries.
- We used eight stimulation protocols distributed as follows: left and right ventricular free walls (LV, RV), apex, left and right ventricular outflow tract (LVOT, RVOT), septum, and two locations at the left and right heart base (LVB, RVB).

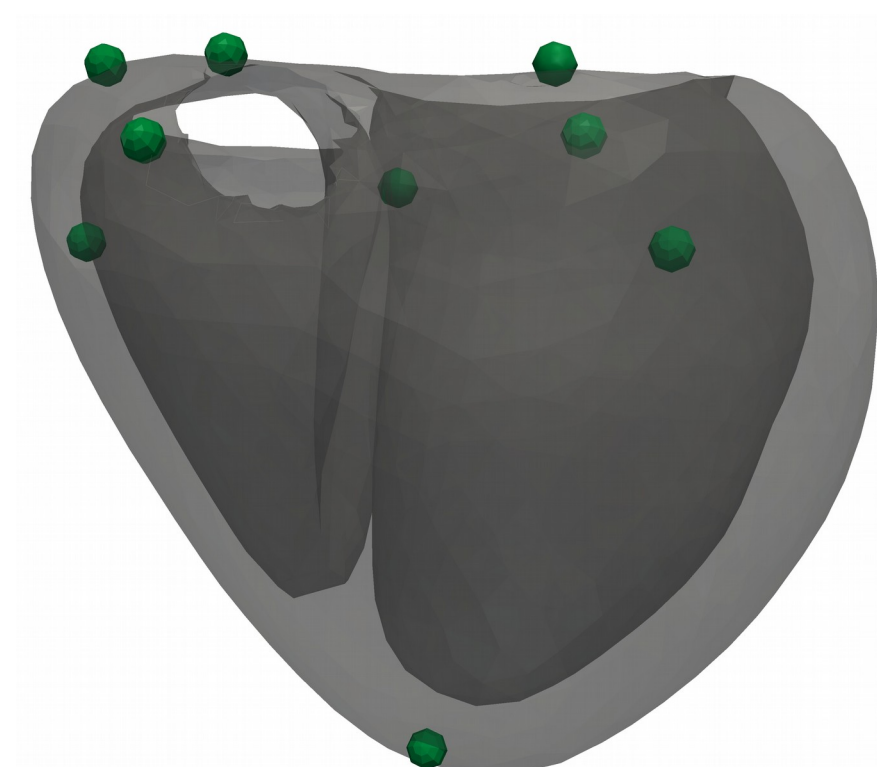


Figure 2. Stimulation sites

Results

We analyze quantitatively the segmentation variability and compute the Dice coefficient between each pair of segmentation (Figure 3).

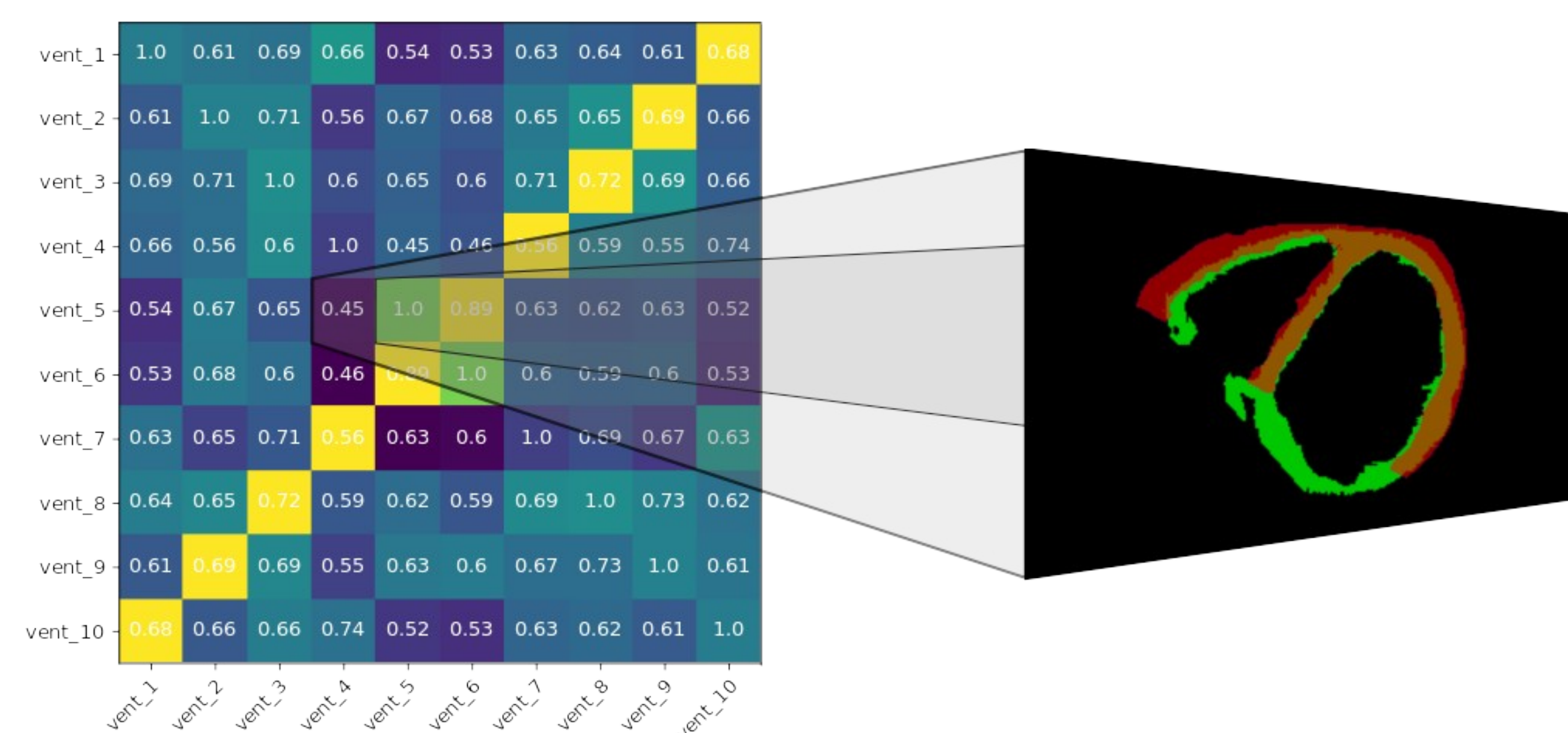


Figure 3. Dice coefficient between each pair of segmentation

We perform reconstruction of the heart surface potentials and the corresponding activation maps for each solution and stimulation protocol. Using these activation maps, we identify the earliest activation sites (EASs).

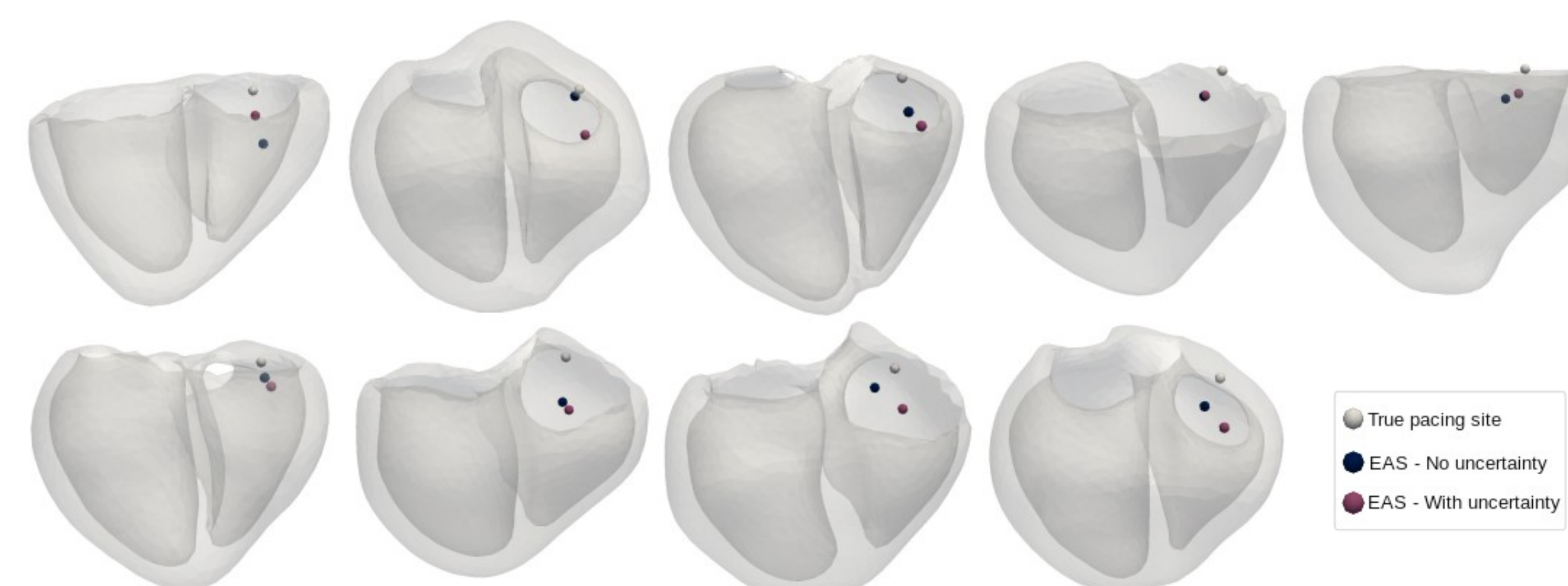


Figure 4. Distribution of ECGI based EASs with and without geometry uncertainty for an RVB stimulation.

Conclusion

- The localization of PVC can be significantly affected by the variability in segmentation, particularly in the RVOT, LVOT, RVB, and LVB. Our analysis suggests that the increased uncertainty in source detection can be attributed to the greater variability in segmentation at the base of the heart
- It is important to note that variability in cardiac segmentation can affect the interpretability of ECGI in clinical applications. Therefore, we highly recommend conducting segmentation with utmost care, particularly at the base of the heart.

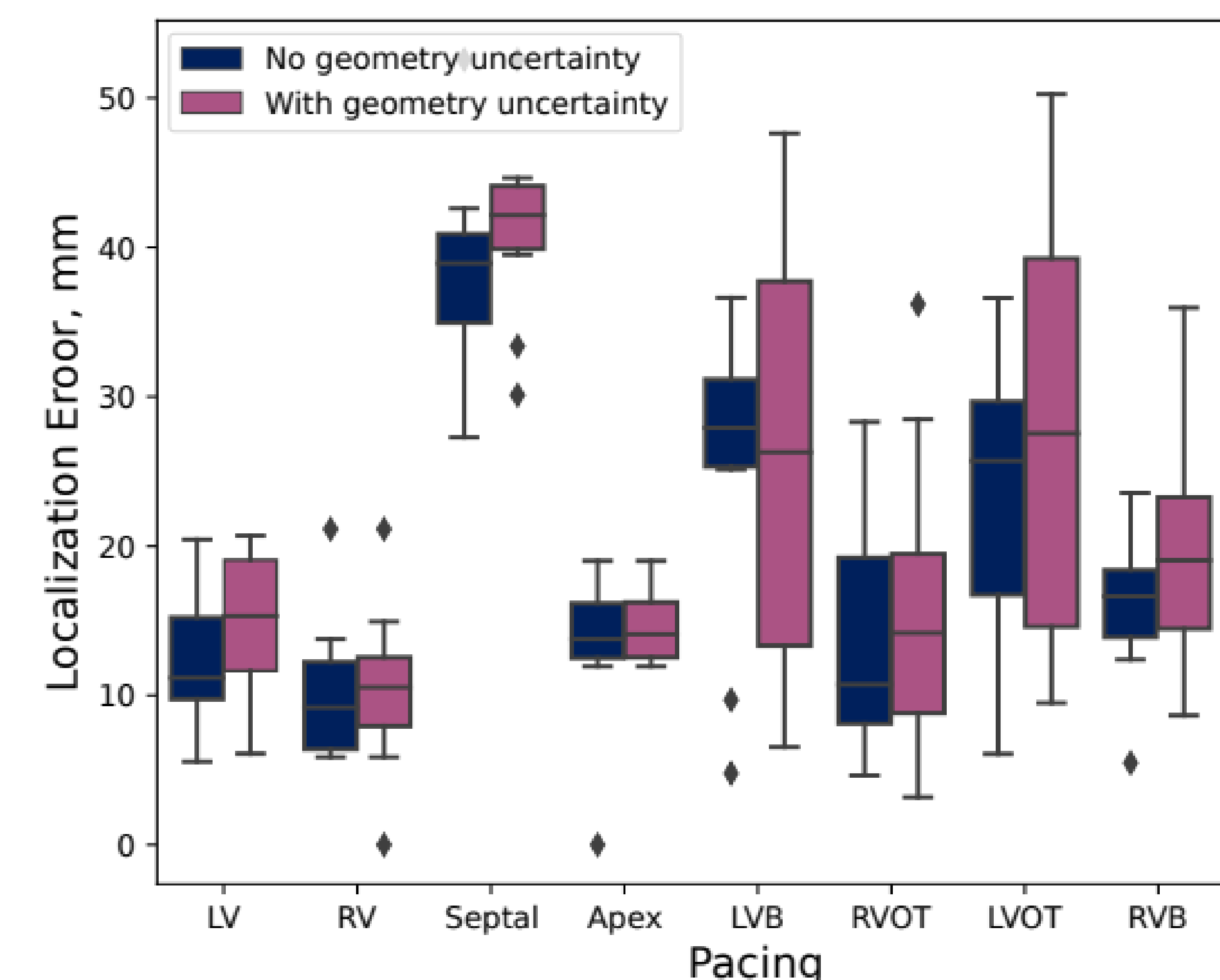


Figure 5. Box plots of the distribution of Localization Error (LE), in millimeter, across the different pacing sites.

	LV	RV	Septal	Apex	LVB	RVOT	LVOT	RVB
Test A : No geometry uncertainty	12	10	38	13	24	14	23	15
Test B : With geometry uncertainty	14	10	41	14	25	15	27	19

Table 1. Average LEs obtained with (first row) and without (second row) geometry uncertainty.

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