

Image Guidance for Tricuspid Valve Repair

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Western



MOTIVATION

- Tricuspid valve regurgitation is the back flow of blood through the tricuspid valve.
- Previously labelled as ‘the forgotten valve’, tricuspid valve and its repair surgeries are becoming more prominent.
- MitraClip valve repair is an ultrasound-guided procedure to clamp the leaflets to stop regurgitation.
- Conventional ultrasound techniques provide poor imaging of the tricuspid valve, leading to long surgery time.

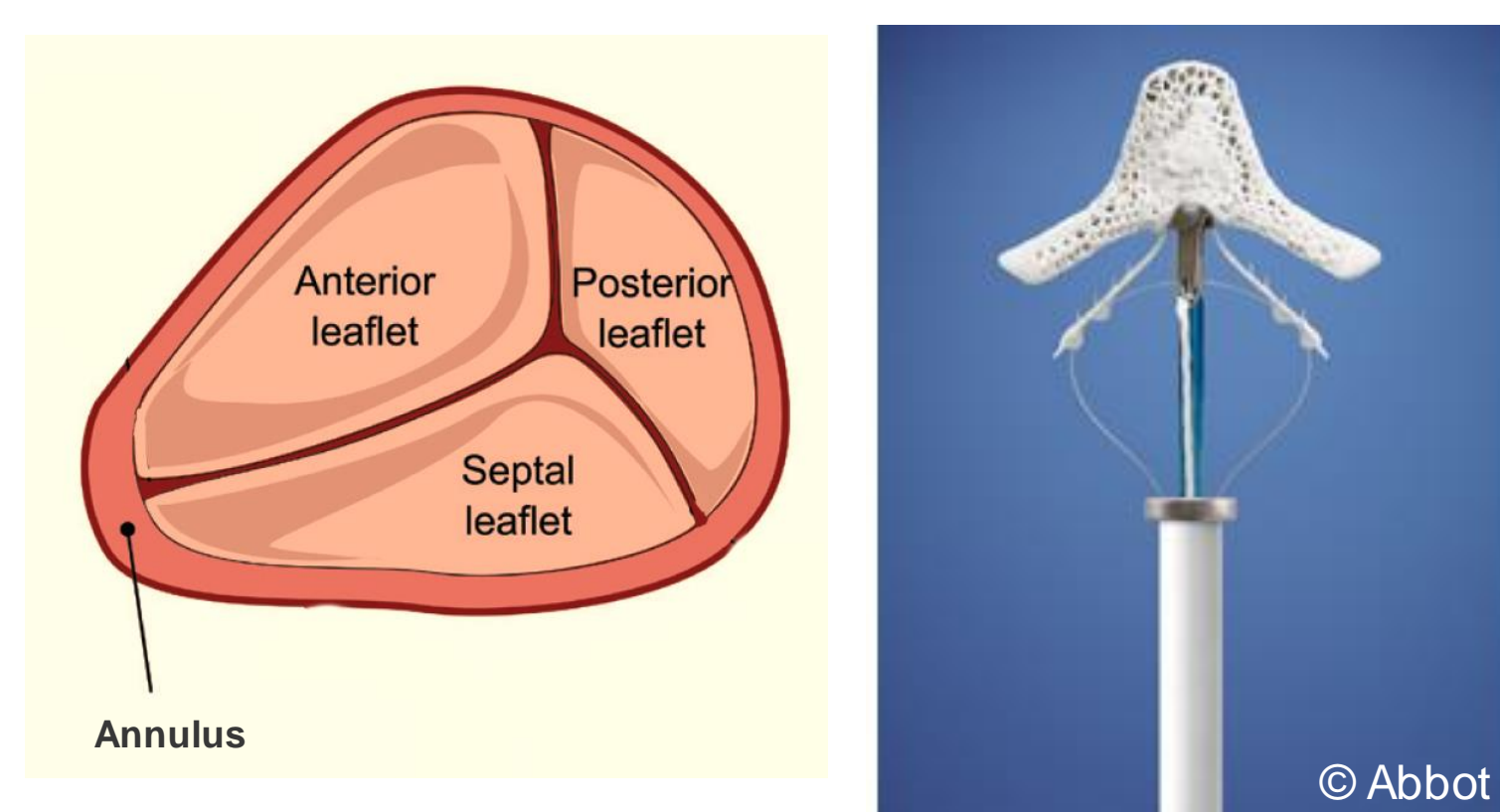


Figure 1. Tricuspid valve anatomy and MitraClip tool

BACKGROUND

INTRA-CARDIAC ECHOCARDIOGRAPHY (ICE)

- An ultrasound imaging modality used to guide cardiac interventions.

COLOR DOPPLER IMAGING

- Allows visualization of the blood flow direction.

CONAVI FORESIGHT ICE IMAGING

- Provides 2D Doppler images and 3D radial ICE images with
 - A 360° field of view
 - High speed
 - High resolution

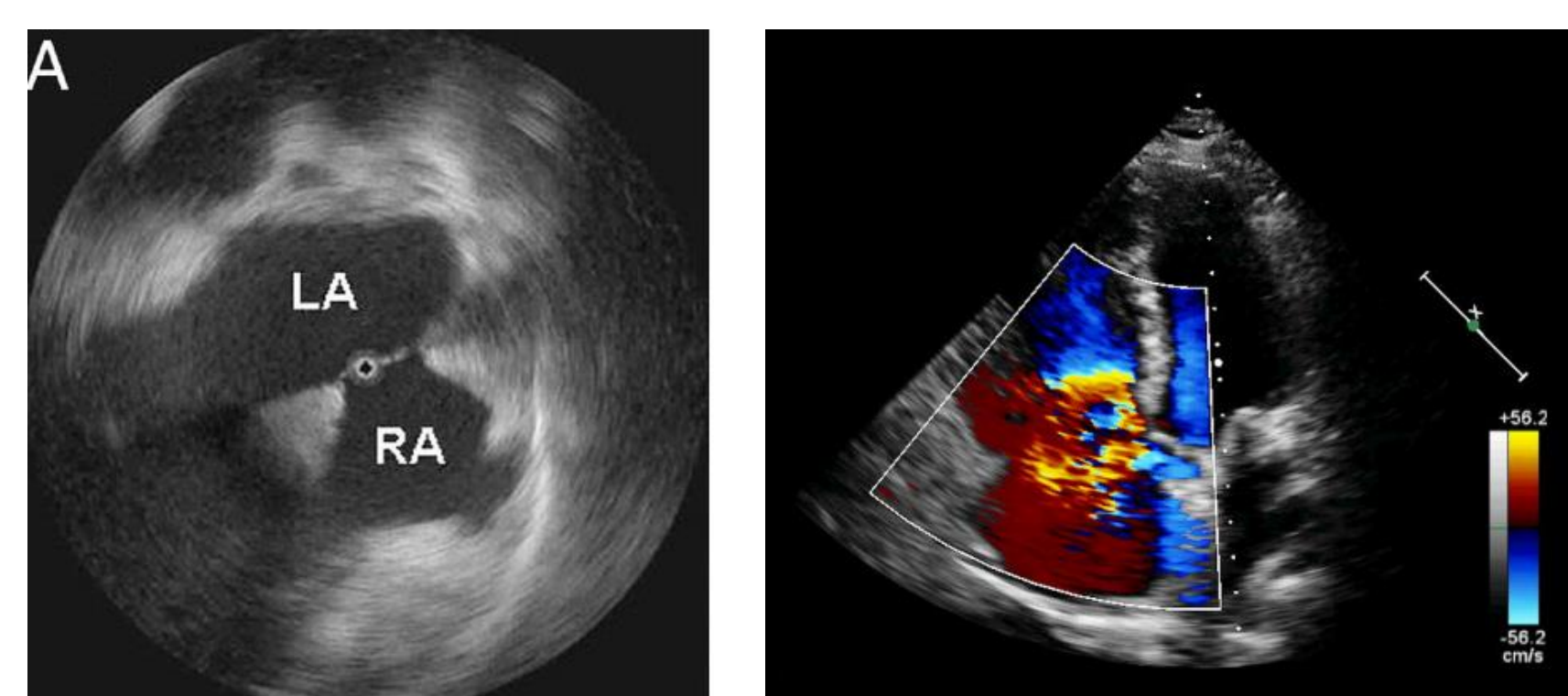


Figure 2. (A) Radial ICE image and (B) Color Doppler seen on a Phased Array ICE Image [2]

OBJECTIVE

To identify regurgitation site on a tricuspid valve by overlaying a 3D model of the valve obtained from ultrasound on the Doppler image

METHODS

PROPOSED SURGICAL WORKFLOW

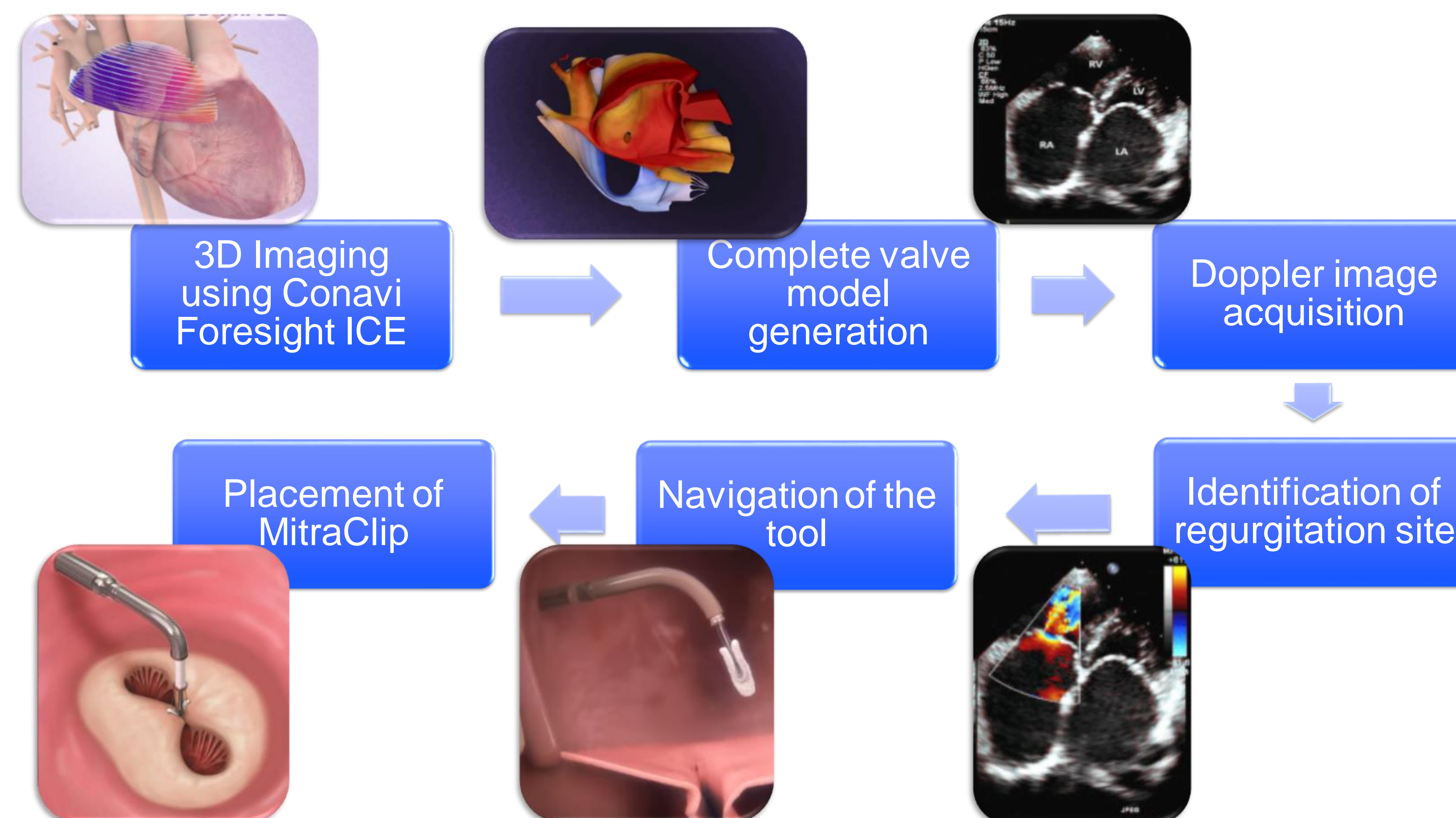


Figure 3. Block diagram of the new proposed surgical workflow

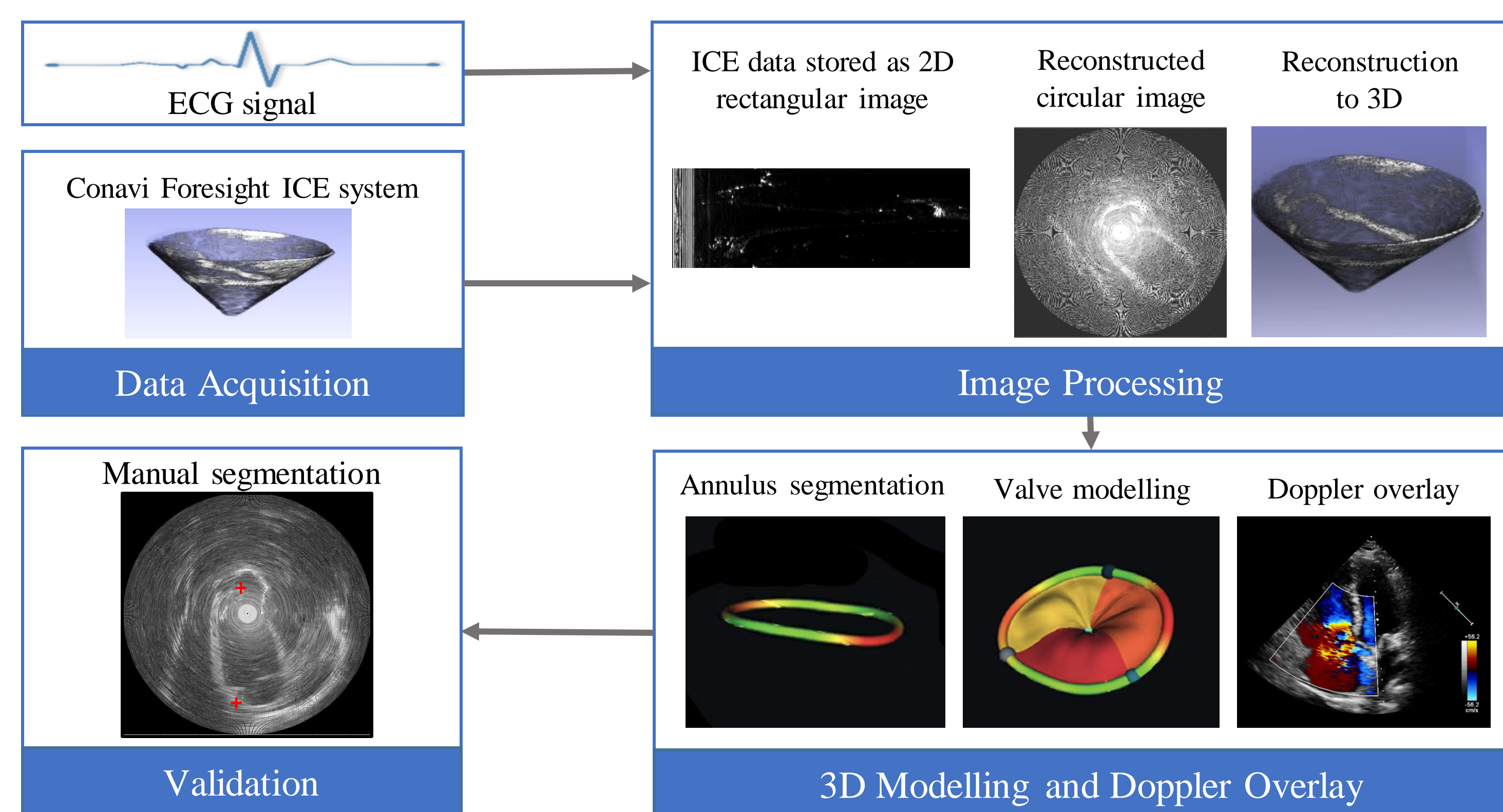


Figure 4. Workflow diagram for the identification of regurgitation site

DATA ACQUISITION

- A silicon-based model of tricuspid valve and left ventricle is placed inside a beating heart phantom.
- 3D images of the valve are obtained from the Conavi Foresight ICE system.
- Electrocardiography (ECG) gating is used for temporal synchronization.
- Electromagnetic tracking is used for spatial alignment of the images.

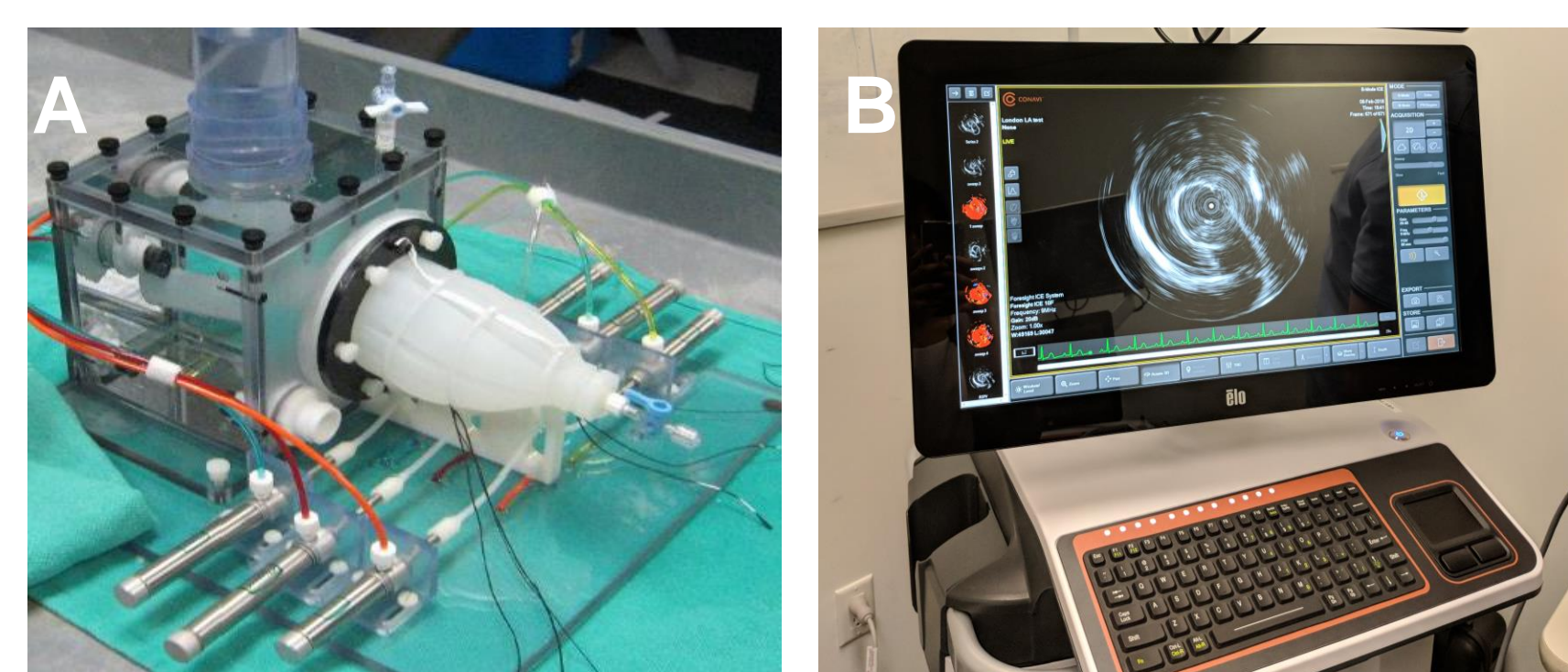


Figure 5. (A) Silicon model in a beating heart phantom and (B) Conavi Foresight ICE system

IMAGE PROCESSING

- Reconstruction of 3D conical surface image from 2D rectangular image data.
- Remove artefacts caused by resampling in Cartesian and spherical coordinates.

IMAGE SEGMENTATION

- 3D ICE volumes will be stitched together to view the valve completely.
- The tricuspid valve annulus and three leaflets will be segmented using 3D Slicer.
- A 3D virtual model will be generated and overlaid with Doppler color imaging to identify the regurgitation site.

VALIDATION

- Comparison with manual segmentation of tricuspid valve by expert anesthesiologist.

RESULTS

- The anatomical and functional features of tricuspid valve will be obtained using Conavi foresight ICE system.
- Fig. 6 shows the expected 3D model. The model, when combined with Doppler, will show the leaflets causing regurgitation.

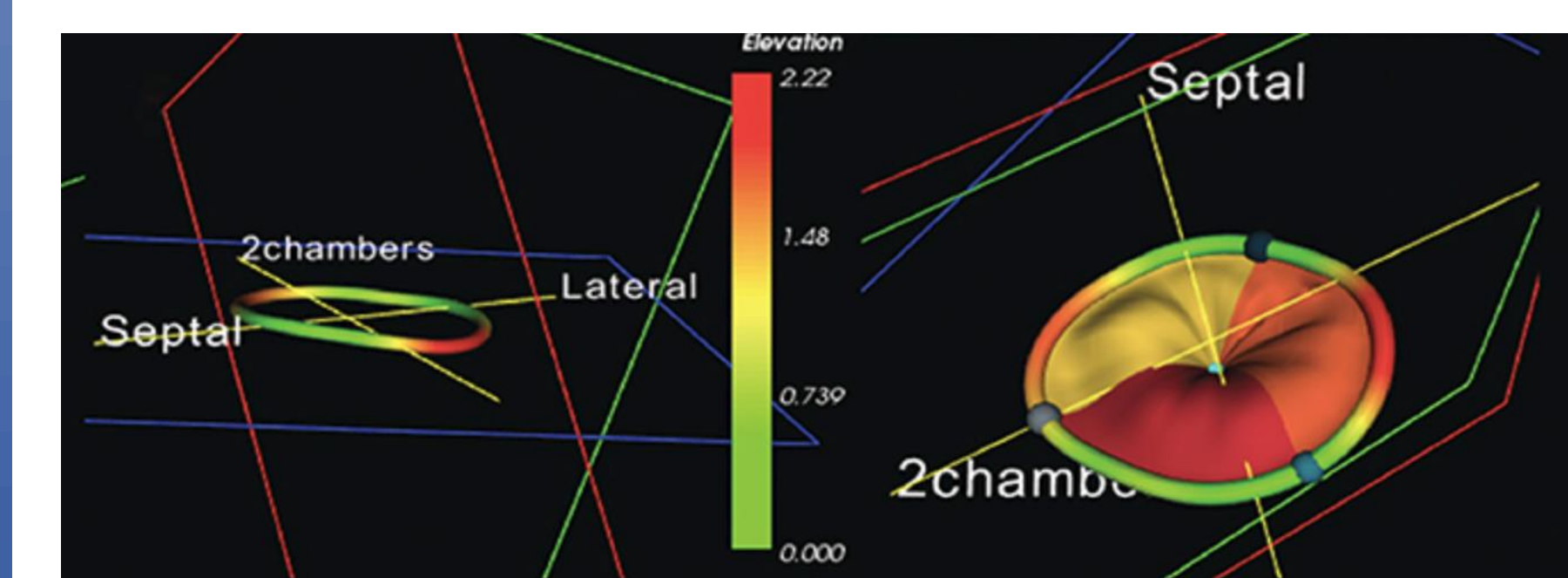


Figure 6. Simulated expected segmentation of tricuspid valve annulus and leaflets [4]

CONCLUSIONS

- In this study, we propose a novel workflow for the identification of regurgitation site during tricuspid valve repair surgery.
- ICE images taken by Conavi Foresight ICE system are used to generate a 3D model and then combined with color Doppler.
- This work will potentially:
 - Better identify the regurgitation site
 - Decrease surgery time
- Future work includes:
 - Using Conavi ICE to help navigate the tool inside the heart
 - Using real-time 2D side viewing ICE for the positioning of MitraClip on the leaflets

REFERENCES

- [1] B. Courtney and N. Witcomb, "Data display and processing algorithms for 3D imaging systems," US9786056B2, 2017.
- [2] C. Aggeli et al., "Echocardiographic imaging of tricuspid and pulmonary valve abnormalities in primary ovarian carcinoid tumor," Cardiovasc. Ultrasound, 2010.
- [3] C. E. Hansing and G. G. Rowe, "Tricuspid insufficiency. A study of hemodynamics and pathogenesis.," Circulation, vol. 45, no. 4, pp. 793–799, 1972.
- [4] D. Muraru, E. Surkova, and L. P. Badano, "Revisit of Functional Tricuspid Regurgitation: Current Trends in the Diagnosis and Management," Korean Circ. J., vol. 46, no. 4, p. 443, Jul. 2016.

ACKNOWLEDGEMENTS

Thanks to Dr. B. Neagu, Dr. D. Bainbridge, Dr. F. P. Li and W. Xia for their invaluable discussion. Funding support is acknowledged from CIHR, NSERC, CFI and ORF

