Intrinsic magnetic resonance characterization of acute ventricular RF ablation lesions

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INTRODUCTION

- RF ablation is an effective therapy for VT, but unfortunately has high arrhythmia recurrence rates even after procedures deemed to be successful [1].
- Contrast-enhanced MRI clearly detects lesions but contrast is highly variable, affected by the contrast agent kinetics [2].
- It has been previously demonstrated that intrinsic-contrast MRI (without the use of a contrast agent) can accurately depict the characteristics of RF lesions generated with the CARTO-XP system [3].
- **We aim to probe the inherent MR properties of ablation lesions in the acute stage, using an MR-guided EP system.**

METHODS

A total of 6 endocardial lesions were created in 3 healthy pigs. Bipolar electrograms (EGMs) were recorded before, during, and after ablation. Ablation was followed by an MRI study to characterize the intrinsic properties of ablated tissue *in vivo*.

Experimental Setup

- MR-compatible catheters were used to record EGMs and ablate.
- The catheter was localized with respect to cardiac anatomy using a real-time MRI technique.
- We used visualization software Vurtigo [4] to fuse real-time catheter tracking with anatomical MR "roadmap" images.

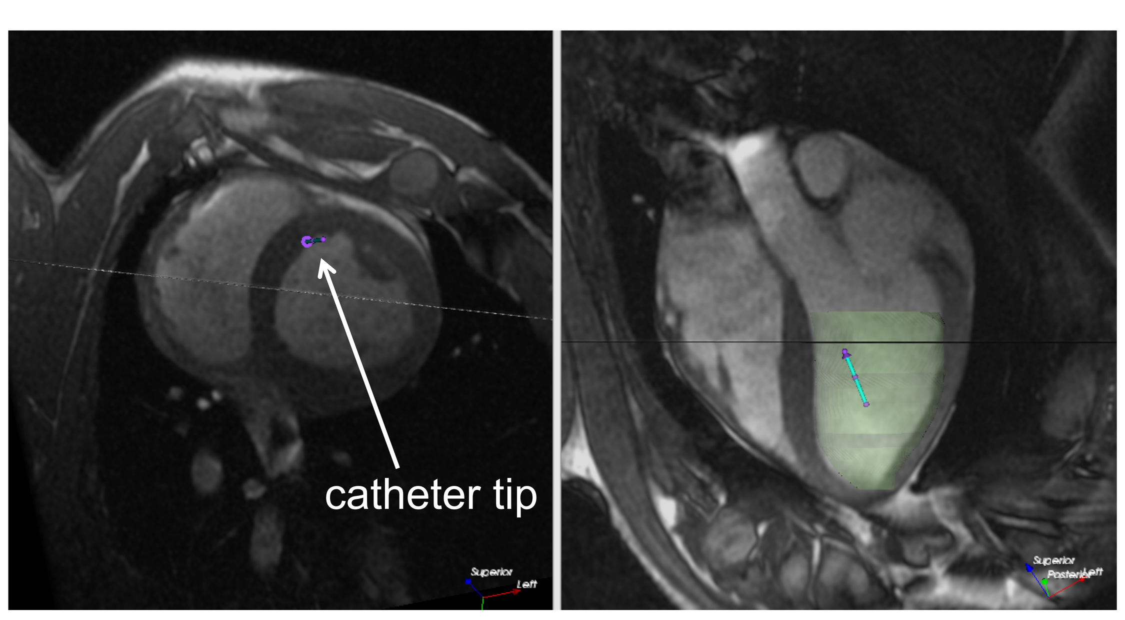

Fig. 1: Real-time MR-guided catheter navigation, displayed using Vurtigo. Short-axis and long-axis roadmap MR images are shown on left and right respectively.

Ablation

- The operator navigated the catheter to a location advantageous for imaging.
- The operator confirmed catheter contact with the endocardium based on Vurtigo visualization, EGM amplitude, and tactile feedback.
- 30-40 W delivered for 45-60 s

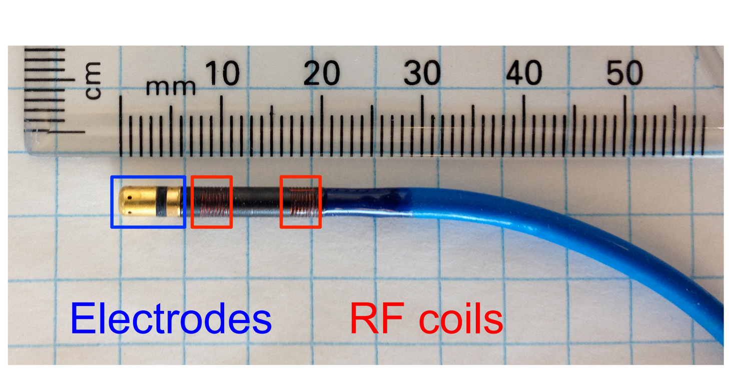

Fig. 2: MR-compatible catheter (provided by Imricor Medical Systems). Bipolar EGMs are sensed by the electrodes, while the RF coils enable localization within the MR scanner.

METHODS (CONT'D)

MRI Study

- Inversion-recovery steady-state free precession (IR-SSFP) intrinsic-contrast MR imaging sequence was used to visualize ablation lesions. Previously demonstrated, the size of lesion necrotic cores measured from IR-SSFP images and gross pathology are strongly correlated [3].
- T2-prepared SSFP intrinsic-contrast sequence was used to identify regions of edema. The presence of edema causes T2 (an intrinsic magnetic relaxation property) to lengthen substantially.
- IR-SSFP & T2-prepared sequences were repeated during 1 h after ablation to characterize any size or contrast changes in the lesion core or edema.

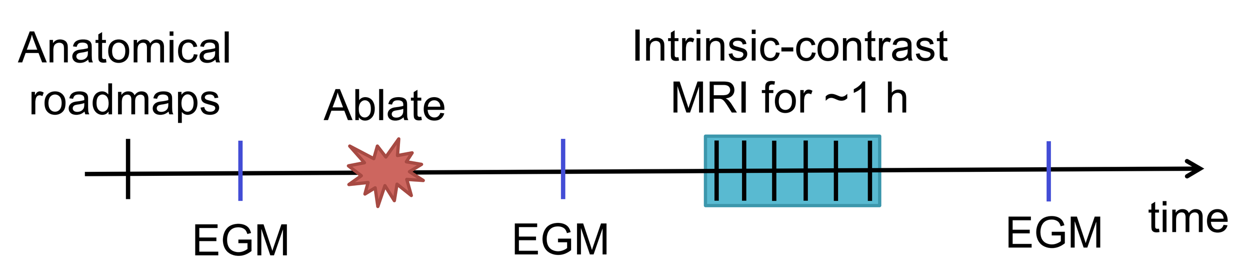

Fig. 3: Imaging protocol timeline after ablation.

RESULTS

- EGM amplitude decreased by 45 ± 20% during ablation.

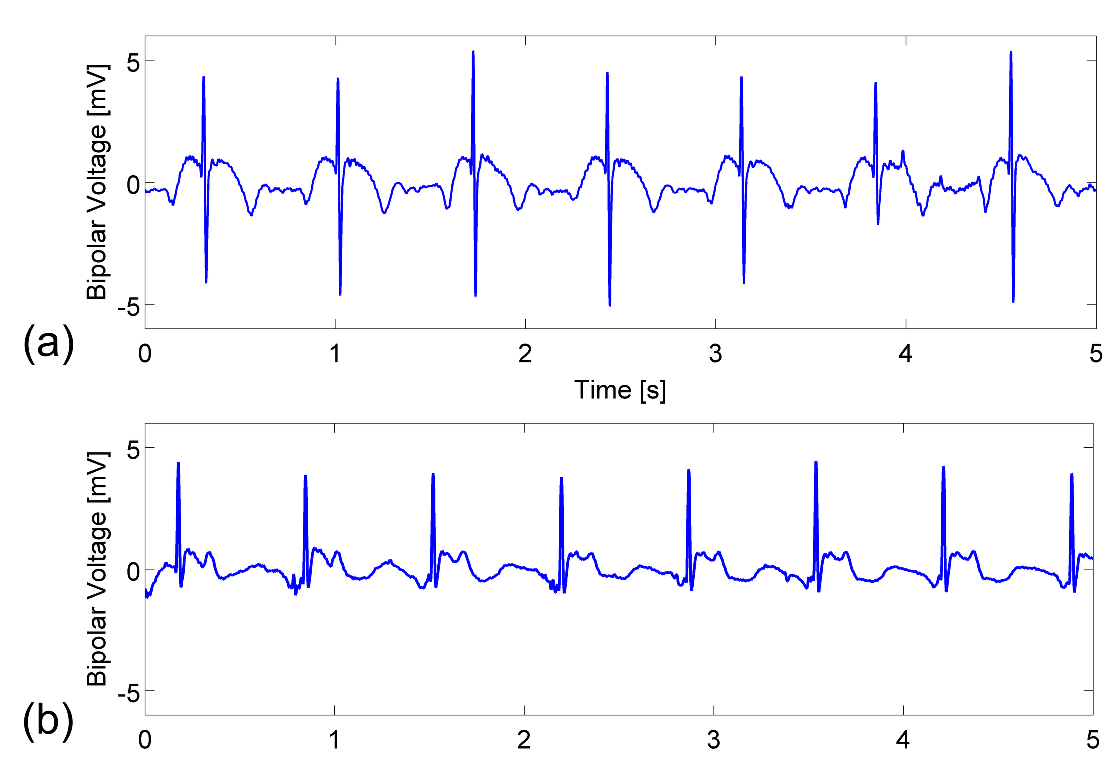

Fig. 4: Bipolar EGMs acquired (a) immediately before ablation and (b) immediately after an ablation, holding the catheter in a consistent position throughout.

- IR-SSFP images acquired <5 min after ablation showed the necrotic lesion cores.
- We inferred from the EGM amplitude decrease that the heating was sufficient to cause necrosis, confirmed by gross pathology.

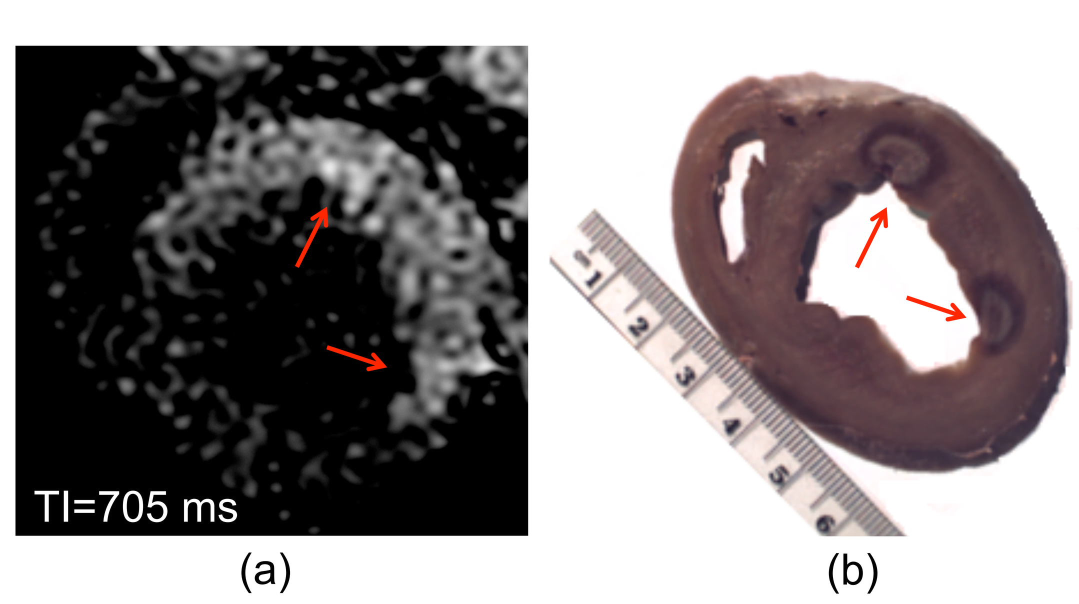

Fig. 5: (a) IR-SSFP image depicting 2 lesions within 25 min (upper lesion) and 3 min (lower lesion) after ablation. (b) corresponding gross pathology showing the same lesions.

RESULTS

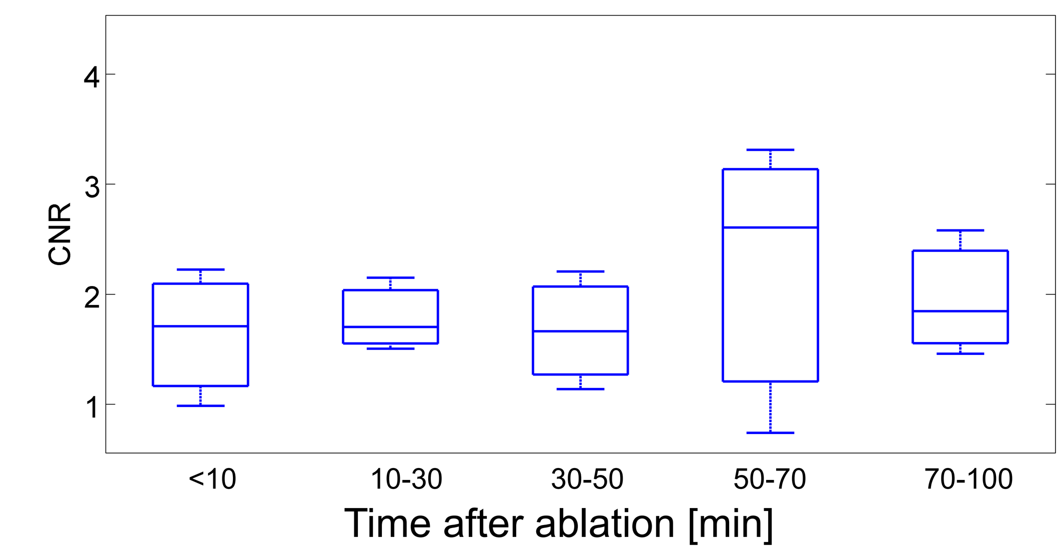

Fig. 6: Lesion core CNR (from 4 lesions in 2 pigs), visualized by IR-SSFP MRI during 100 min post-ablation. CNR was consistent (mean 1.9 ± 0.7) with statistically insignificant difference between all time intervals (p>0.5).

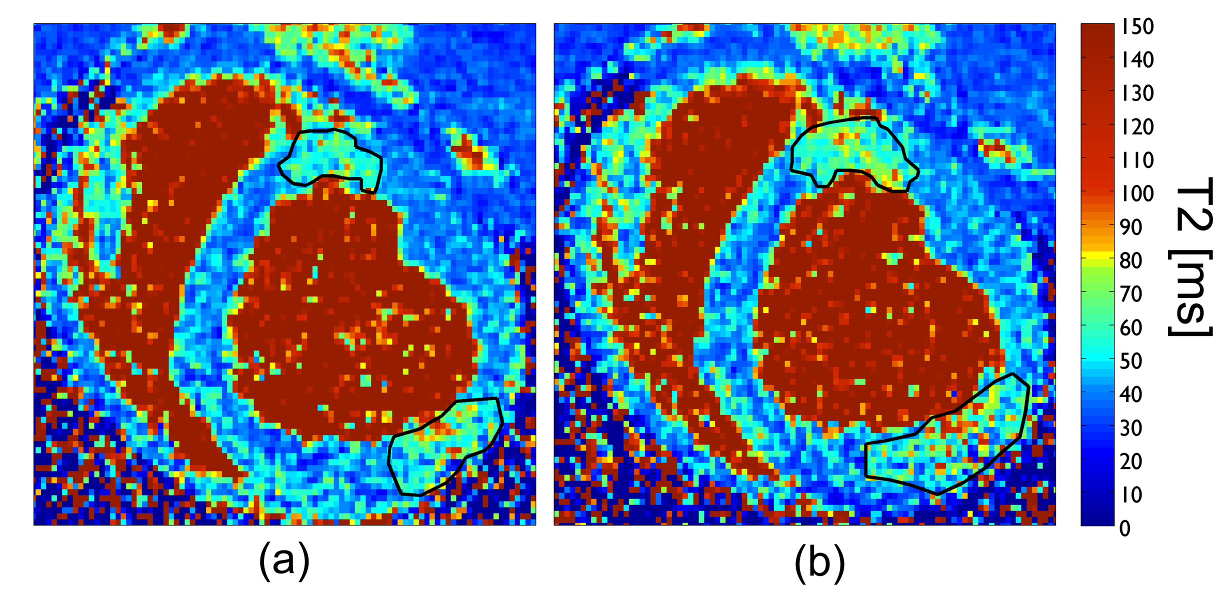

Fig. 7: T2 maps highlight edema. Black outlines delineate edematous regions induced by 2 separate RF ablations. (a) and (b) were acquired at 30 min & 60 min after ablation, respectively. Between 30-60 min the edema associated with the top lesion grew by 50% and T2 increased by 11%.

DISCUSSION & CONCLUSIONS

- Previous work [2,3] has focused on MR lesion characterization well after ablation (typically >1 h afterward). Our MR-guided catheter guidance system enables image acquisition within minutes of ablation.
- **Stable lesion contrast (0-100 min after ablation) suggests that the core of thermal damage is established immediately upon ablation and MR properties do not change markedly during this time.**
- **Conversely, in preliminary results (2 lesions from 1 pig) the edema was observed to develop both in size and T2 over this time interval.**
- We conclude that intrinsic-contrast MRI is a feasible method for rapid visualization of RF lesions, consistently highlighting the lesions at various times during the MR-guided ablation procedure.

Future work

- Next studies will aim to establish the relationship between the region of thermal injury visualized by MRI and the region of electrically-unexcitable myocardium.

REFERENCES

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