L16 Electroporation for treatment of cardiac arrhythmias

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Duration of the experiments: 120 min
Max. number of participants: 12
Location: Electrophysiology room, UMC Ljubljana
Level: Basic

PREREQUISITES

Participants will be asked to change into clean surgical gown to enter the room during sterile procedure. No other specific knowledge is required for this laboratory practice.

The aim of this laboratory practice is to show a live and pre-recorded cases of treatment of cardiac arrhythmias with electroporation (Pulsed field ablation - PFA).

THEORETICAL BACKGROUND

Pulsed field ablation (PFA) is an emerging, effective, cardiac ablation modality for treatment of atrial fibrillation based on electroporation [1]. PFA offers increased safety in comparison with radiofrequency ablation (RFA) and cryoablation due to reduced collateral damage to the surrounding tissue that otherwise can result in esophageal fistula, phrenic nerve palsy, and pulmonary vein stenosis [2]. Furthermore, it is the unprecedented speed of applications and ease of achieving acute pulmonary vein isolations (PVIs) that is clinically attractive. This approach induces immediate abolishment of bipolar intracardiac electrograms (iEGMs), which in part was responsible for the enthusiasm of early adopters of PFA technology as an alternative to thermal methods for cardiac ablation. However, even with subtherapeutic PFA applications, the affected cardiac cells can transiently lose their abilities to generate and/or propagate action potentials, as evidenced by immediate disappearance of the sharp depolarization components in bipolar iEGMs. Therefore, the amplitude reductions and morphology changes of bipolar iEGMs are not a reliable predictive indicator of successful ablation even though they may still serve as a relative indicator of acute success of ablation [3]. This leaves the operator essentially without any objective feedback during the procedure about the likelihood of a successful ablation to achieve a durable transmural lesion. Therefore, operators currently rely on the prescribed ablation protocols that are based on clinical and preclinical evidence to be successful in achieving PVI.

EXPERIMENT

In UMC Ljubljana we currently have 5 (of 6 approved in EU) PFA systems to treat cardiac arrhythmias. Three systems are clasified as single shot, with which we can treat atrial fibrilation in a procedure called pulmonary vein isolation. The other two systems are more versatile and can also be used to treat other cardiac arrhythmias i.e. ventricular tachycardias. In the expermient one live case and at least three prerecorded cases will be shown to demonstrate our rutine clinical practice.

In all procedures 3D mapping system will be used to guide PFA catheters and to mark PFA lesions (Figure 1). For proceudural guidance also intracardiac ultrasound (ICE) is used. Bipolar and unipolar iEGM changes following PFA treatment (Figure 2) will be investigated as an attempt to investigate the ability to distinguish between transmural and nontransmural lesions. The success of differentiating lesion transmurality would potentially provide us with intraprocedural guidance that we are currently lacking.

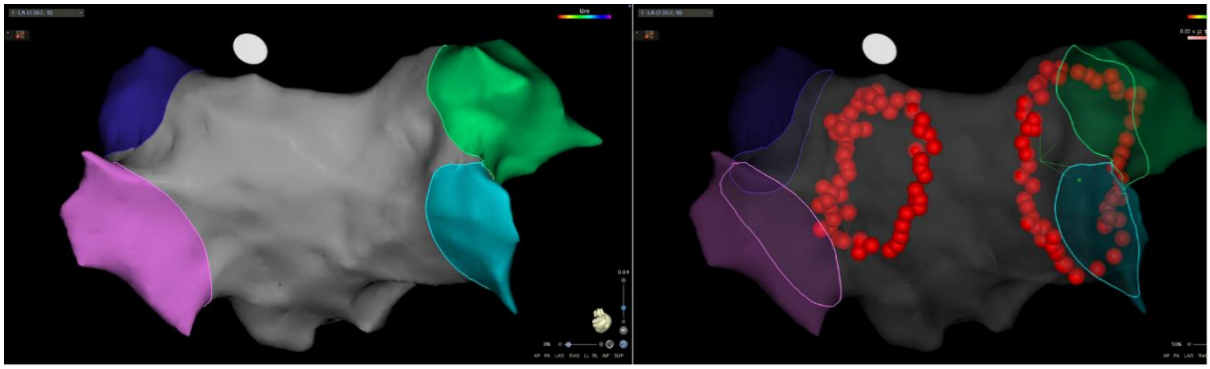

Figure 1: Example of a wide antral encirclement ablation procedure. Red dots represent single-point ablation lesions in two antral isolation lines around the exit points of the left and right pulmonary veins. The posterior view of the left atrium anatomy with colored pulmonary veins (dark blue: left superior pulmonary vein, pink: left inferior pulmonary vein, green: right superior pulmonary vein, light blue: right inferior pulmonary vein).

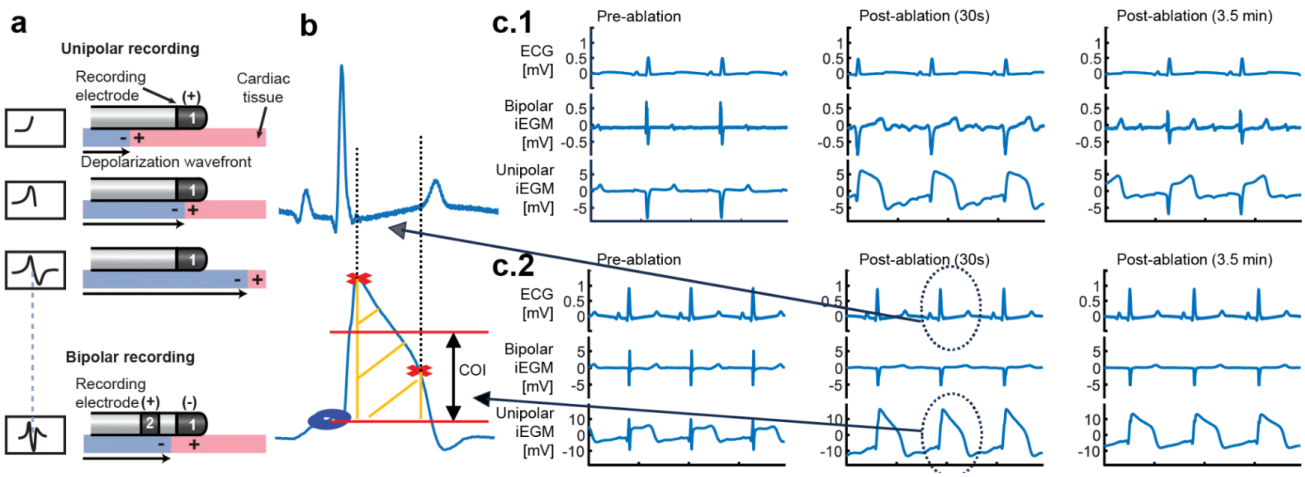

Figure 2: Evaluation of iEGMs changes after PFA. (a) Schematic drawing of unipolar and bipolar iEGM recording generation. (b) Calculation of the current of injury (COI) parameter from unipolar iEGM signals. Blue circles: baseline value measured before the QRS. Red crosses: the start and the end of the area under the curve (AUC - shaded area) window, based on criteria described in the methods. The COI parameter (black arrow) was defined as the AUC divided by the AUC window width. (c) Examples of concrete signals recorded at two different ventricular sites treated with two different doses of PFA and shown for three different time points (pre-ablation, 30 s post-ablation and 3.5 min post-ablation). (c.1) Example 1: a lower dose (1300 V, 4 trains); (c.2) Example 2: a higher dose (1500 V, 8 trains) [4].

REFERENCES:

[1] Chun K.-R. J., Miklavčič D., Vlachos K., Bordignon S., Scherr D., Jais P., Schmidt B. State-of-the-art pulsed field ablation for cardiac arrhythmias: ongoing evolution and future perspective. *EP Europace*, 26:euae134, 2024.

[2] Reddy V. Y. et al. Pulsed field or conventional thermal ablation for paroxysmal atrial fibrillation. *N Engl J Med*, 389: 1660–1671, 2023.

[3] Štublar J., Jarm T., Mattison L., Martin B. D., Schmidt M., Jan M., Verma A., Iaizzo P. A., Sigg D.C., Miklavčič D. Intracardiac electrogram analysis may allow for prediction of lesion transmurality after pulsed field ablation of atria in a porcine model. *Heart Rhythm O2,* 6:350–361, 2025.

[4] Miklavčič D., Verma A., Krahn P. R. P, Štublar J., Kos B., Escartin T., Lombergar P., Coulombe N., Terricabras M., Jarm T., Kranjc M., Barry J., Mattison L., Kirchhof N., Sigg D. C., Stewart M., Wright G. Biophysics and electrophysiology of pulsed field ablation in normal and infarcted porcine cardiac ventricular tissue. *Sci Rep*, 14: 32063, 2024.

EXPECTED RESULTS

At the end of the procedure all 4 pulmonary veins will be checked with the electrophysiology diagnostic catheter through assessment of bipolar and unipolar iEGMs. If any residual iEGMs (dormant conduction) will be found, additional ablations will be prescribed in an attempt to reinforce PVI. If patient will not spontaneously convert to sinus (normal) rhythm, cardioversion will be performed. If patient leaves procedure in sinus rhythm, this is termed as an acute success of the procedure.

NOTES & RESULTS