

Novel laser energy applications for the treatment of cardiac arrhythmias

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Summary

Novel laser energy applications for the treatment of cardiac arrhythmias

Over the years, ablation therapy has been introduced into treatment of a variety of cardiac arrhythmias.

Traditionally, radiofrequency or cryo-devices are used to place lesions in the myocardium to interrupt specific arrhythmogenic mechanisms.

In this thesis, we investigated the use of laser energy as an ablation modality with a novel, linear, laser-ablation catheter. This steerable 8.5 Fr laser catheter allows homogeneous unilateral laser emission over a length of 20mm. Through *ex vivo* experiments with this catheter, the parameter settings were defined to achieve transmural atrial lesions.

In animal experiments, characteristics of lesion formation were investigated while at the same time assessing aspects with potential relevance for procedural safety. The cava-tricuspid isthmus was targeted for endocardial power applications under fluoroscopic guidance in these studies. Subsequently, a complete sternotomy was performed to allow epicardial ablations on both ventricles.

After the procedure, the atria and ventricles were dissected to perform macroscopic analysis of both lesion sets. Well-defined transmural linear lesions were found in the atria and lesions up to 9mm in the ventricles. We compared the lesion formation process in laser and radiofrequency energy applications to put these results into perspective. The underlying tissue coagulation principles differed strongly between both energy modalities, although both could achieve irreversible tissue damage.

The pulsed-wave laser was compared to continuous-wave application to improve the lesion formation and potentially safety of endocardial laser-ablation procedures. Therefore, we investigated the effects of pulsed-wave laser on tissue coagulation and thermally-induced blood clot formation. Pulsing reduced the absorption in superficial tissue layers, diminished the risk of blood clot formation, and prevented steam pops during ablation of fat-covered tissues.

In the final investigation, we fitted an additional optical fiber to the laser ablation catheter, allowing direct visualization of the created lesions by reflectance spectroscopy. A clear distinction could be made between treated and untreated tissue by illuminating the target site with one fiber and capturing the reflected spectrum with the additional fiber.

Overall, the catheter could create linear transmural atrial and deep ventricular lesions in the performed animal studies. The use of pulsed-wave laser applications improved the lesion formations process and reduced thermally induced blood clot formation compared to continuous-wave applications. The integration of an added optical fiber allowed spectroscopical analysis of the target site, allowing direct visualization of the lesion-formation process, supplying a useful tool to prevent lesion gaps.