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ISCHEMIA DOES NOT ALTER MYOCARDIAL FUNCTION AFTER TRANSMYOCARDIAL REVASCULARIZATION

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Background and Objectives: Transmyocardial revascularization (TMR) has been shown to relieve symptoms of ischemia but concerns regarding decreased myocardial function have limited its use.

Study Design/Materials and Methods: Nine rat hearts were isolated and perfused (37°C; 60 mmHg) with oxygenated PBS in the Langendorff set up. After 1 hour of perfusion and stabilization, 10 minutes of ischemia was instituted by stopping perfusion. TMR (10 channels) was then created through the full thickness of the myocardium using a Ho:Yag laser via a 0.6 mm core fiber (2,100 nm, 3 Hz, and 280 mJ/pulse) ($n = 5$). This was followed by another hour of perfusion and another period of ischemia. Myocardial contractility was evaluated using Frank–Starling curves generated by a strain-gauge apparatus.

Results: After the first 10 minutes of ischemia prior to TMR there was major but equivalent reduction in myocardial contractility in both groups (87.1% vs. 81.9%; P = ns). After the second 10 minutes of ischemia after TMR there was also major reduction in contractility without a significant difference between the groups (91.1% reduction in the control group vs. 94.7% in the TMR group; P = ns).

Conclusions: In the normal rat heart, TMR does not lead to reduction in myocardial function following ischemia as compared to control. This suggests that immediately after TMR there is no alteration in myocardial function under ischemic conditions.

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SOFT TISSUE ABLATION USING THE PULSE STRETCHED FREE ELECTRON LASER

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Background and Objectives: Pulsed mid-infrared (6.45 μm) radiation has been shown to cut soft tissue with minimal collateral damage (<40 μm). The goal of this research was to examine the role of the Vanderbilt Mark-III FEL pulse structure on the efficient ablation of soft tissue with minimal collateral damage at both 6.1 and 6.45 μm. The conventional Mark III FEL pulse structure consists of a 3 GHz train of picosecond micropulses within a 4–5 microseconds macropulse envelope.

Study Design/Materials and Methods: The effect of the picosecond micropulses was examined by running the native FEL pulse through a dispersive pulse stretcher in order to increase the micropulse length from 1 to 200 picoseconds. This allowed us to determine the role of the duration of micropulses on the ablation process. The ablation threshold was determined for water and mouse dermis using PROB-IT analysis of 100 individual observations. The ablation efficiency was measured on 90% w/w gelatin and mouse dermis. Ablation craters were made for 5–500 pulses and measured with OCT.

Results: The analysis showed no statistical difference for $\tau p < 100$ picoseconds; however, the ablation threshold was increased for $\tau p < 100$ picoseconds presumably due to leaving the stress confinement regime. For pulses with $\tau p < 100$ picoseconds, a reduction in the efficiency of ablation was also seen.

Conclusions: We have shown that the micropulse structure of the FEL does play a role in the ablation mechanism. This knowledge may have important consequences for the design of stand-alone laser systems to replace the FEL for clinical applications.

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PHOTOTHERMAL STUDY OF LASER-INDUCED APOPTOSIS AND NECROSIS WITH ENDOGENOUS AND EXOGENOUS NANO-ABSORBERS

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Background and Objectives: In many medical applications, laser radiation initially interacts with nano-scale chromophores or photothermal (PT) sensitizers. Our goal was to develop a PT technique to optimize laser treatment by visualizing local thermal events around single absorbing nano-targets, which may cause changes in cell metabolism, local protein denaturation, or bubble-induced cell damage.

Study Design/Materials and Methods: The PT technique is based on irradiating a cell with a pulse laser (surgical or additional tunable OPO, 420–570 nm; 8 nanoseconds; 0.1–300 μJ) and using time-resolved monitoring of temperature-dependent variations of the refractive index in the medium surrounding the nanotargets by thermolens and phase contrast imaging of a collinear probe beam.

Results: The damage threshold for RBCs, lymphocytes, and different cancer cells was dependent on cell heterogeneity, functional state, and presence of subpopulations. Even a low laser dose (<0.1 J/cm^2) caused significant modification of local cellular absorption. Correlation between PT response and damage was obtained by in-parallel conventional viability tests. Significant enhancement of apoptotic and necrotic effects was observed with introduction of gold nanoparticles (2–250 nm) into cells, which was size-dependent.

Conclusions: The PT technique is promising for laser dosimetry, guiding laser cellular surgery, studying mechanisms of laser-induced damage, particularly microbubble dynamics, and, in general, allowing optimization of selective "nanophotothermolysis" with nanoparticles.