

# Laporoscopic partial nephrectomy with blue diode, thulium fiber and hybrid lasers. In vivo trial on porcine kidney

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## Objectives

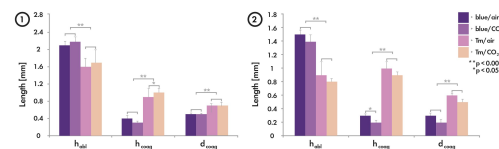
Laparoscopic partial nephrectomy (LPN) is beneficial for patients with renal cell carcinoma of clinical stage T1 and T3. The main challenge of this approach is achieving of adequate hemostasis. Dissection of renal parenchyma at Z-ischemia is usually accompanied by severe blood loss, whereas vessels clamping, which is used to prevent bleeding, may result in impairment of renal function as warm ischemia time often exceeds 25-30 minutes. Therefore, a lot of effort has been made towards the development of tools, which allow resection without hilar clamping and maintaining "clean" surgical field at minimum blood loss. In this regard, laser technologies are of particular interest, because they possess optimal cutting and coagulation properties, which can be utilized simultaneously. The aim of this study was the evaluation of the efficacy and safety of a novel blue diode laser (BDL) and thulium fiber (Tm-Fiber) laser, as well as hybrid (BDL + Tm-Fiber) laser for LPN.

## Materials and Methods

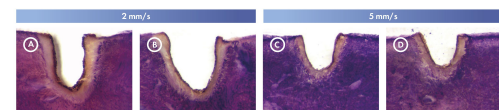
BDL emitting at a wavelength of 442 nm and Tm-Fiber laser emitting at the wavelength of 1942 nm (NTO IRE-Polus, Russia) were used. Both lasers were operated at continuous mode with the following settings: average power  $P_{av} = 20$  W, pulse energy  $E = 0.7$  J and  $P_{av} = 20-40$  W,  $E = 1 - 1.5$  J for BDL and Tm-Fiber lasers, respectively. In hybrid laser, the same laser parameters were used. Implementation of BDL in continuous mode should provide resection without carbonization. LPN was performed on a porcine model under Z-ischemia conditions. Laparoscopic lateral transperitoneal approach with 3 working and one optical ports was used.

## Results

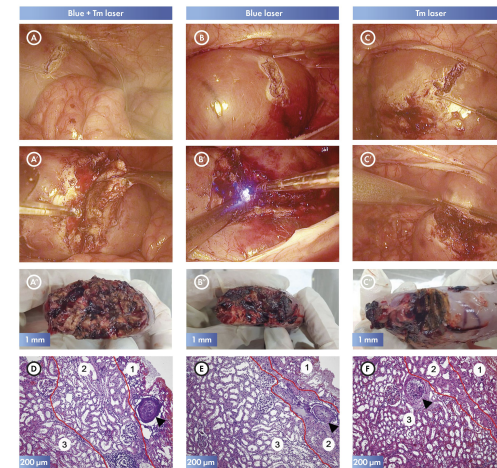
Application of BDL resulted in resection without carbonization. Skin to skin operation time and the laser application time were 37 and 10 minutes, respectively. The area of the resection surface was 5 cm<sup>2</sup>. Despite the intense smoke production, resection was feasible. Tm-Fiber laser induced strong smoke formation, pronounced carbonization, and slow cutting. Increasing laser power did not improve surgical outcome. The total operation time was 10 minutes, the time of laser implementation was 3 minutes then the operation was stopped. Hybrid laser resulted in the successful resection. Skin to skin operation time and the laser activation time were 11 and 4 minutes, respectively. The resected area was 10 cm<sup>2</sup>. Resection surface was free of carbonization. Hemostasis was clinically acceptable. However, we were not able to prevent bleeding completely at the final stage of the operation, when the large artery (>2 mm of diameter) was affected.



Statistical analysis of the cutting parameters. Cutting was obtained at fiber velocity of 2 mm/s (1) and 5 mm/s (2).  $h_{abl}$ , ablation depth,  $h_{coag}$ , coagulation depth,  $d_{coag}$ , width of lateral (superficial) coagulation.

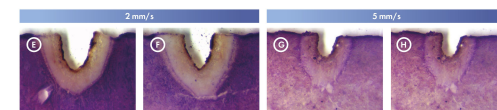


blue, CW, P=20 W  
[A-D] Histological analysis of the sagittal sections of the kidney after the blue laser treatment in air (A, C) and CO<sub>2</sub> (B, D) and at fiber velocity 2 mm/s (A, B) and 5 mm/s (C, D).



[A-C] Resection, performed with the combination of the blue and Tm lasers. Laparoscopic view at the beginning (A) and during operation (B) and kidney surface after resection (C) are shown. [D-F] Histological analysis of the resection margin after treatment with the combination of blue and Tm lasers (D), with the blue laser (E) and with Tm laser (F). 1, zone of the coagulation and carbonization, 2, zone of necrosis (the vessels and glomeruli were lost of blood), 3, zone of demarcation the prominent dysplasia and disorganization of renal epithelial cells and hyperemia of renal tissue, arrowheads indicate vessels constriction. Hematoxylin and eosin staining, simple microscopy, >100x.

↑  
Evaluation of laser-induced laparoscopic partial nephrectomy (LPN).



Tm, CW, P=20 W  
[E-H] Histological analysis of the sagittal sections of the kidney after the Tm laser treatment in air (E, G) and CO<sub>2</sub> (F, H) and at fiber velocity 2 mm/s (E, F) and 5 mm/s (G, H). Scale bars correspond to 1 mm.

## Conclusions:

✓ Hybrid (BDL + Tm-Fiber) laser into a single device may be advantageous for effective and safe LPN

✓ The combination of both lasers allows fast carbonization-free cutting

✓ The coagulative properties of the Tm-Fiber laser enable adequate hemostasis