Supplementary Document

Photoacoustic-Guided Endovenous Laser Ablation: Characterization and *in vivo* canine study

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The supplementary documents consists of the following:

1. Experimental setup of the *in vivo* ablation catheter tip tracking and real-time temperature monitoring performed in live dogs.

2. Experimental setup of the custom-designed temperature controlled spectrophotometer to measure the temperature-dependant optical absorbance of water and blood.

1. Experimental setup of the *in vivo* ablation catheter tip tracking and real-time temperature monitoring performed in live dogs.

Catheter tip tracking and temperature monitoring studies were performed in the same dogs in this study. The capabilities of PA imaging to track the ablation catheter was evaluated by placing an ablation catheter carrying the combined beam (λ = 532 nm, 200 μJ, and λ = 1470 nm, off) into the jugular vein of a dog (**Fig. 1a**). Two dogs were used for the study. The canine study protocol and the animal handling was approved by the Institutional Animal and Care Use Committee of Henry Ford Health Systems. A US gel block was used on the scanning region (**Fig. 1b-c**) to ensure acoustic coupling between the US transducer and the skin.

The ability of PA imaging to perform non-invasive sensing of the real-time temperature inside the vein of a live dog was evaluated by placing an ablation catheter carrying the combined beam (λ = 532 nm, 200 μJ, and λ = 1470 nm, 12 W) and a K-type thermocouple (**Fig. 1e**). **Figure 1e** shows the arrangement of the ablation catheter and the temperature sensor. Tumescent anesthesia was injected into regions surrounding the vein to lower the temperature and prevent damages to the perivenous tissue. Transverse and sagittal USPA images of the ablation catheter tip within the vein were acquired during ablation. The thermocouple was equipped with a data-logging system developed on a microcontroller platform.

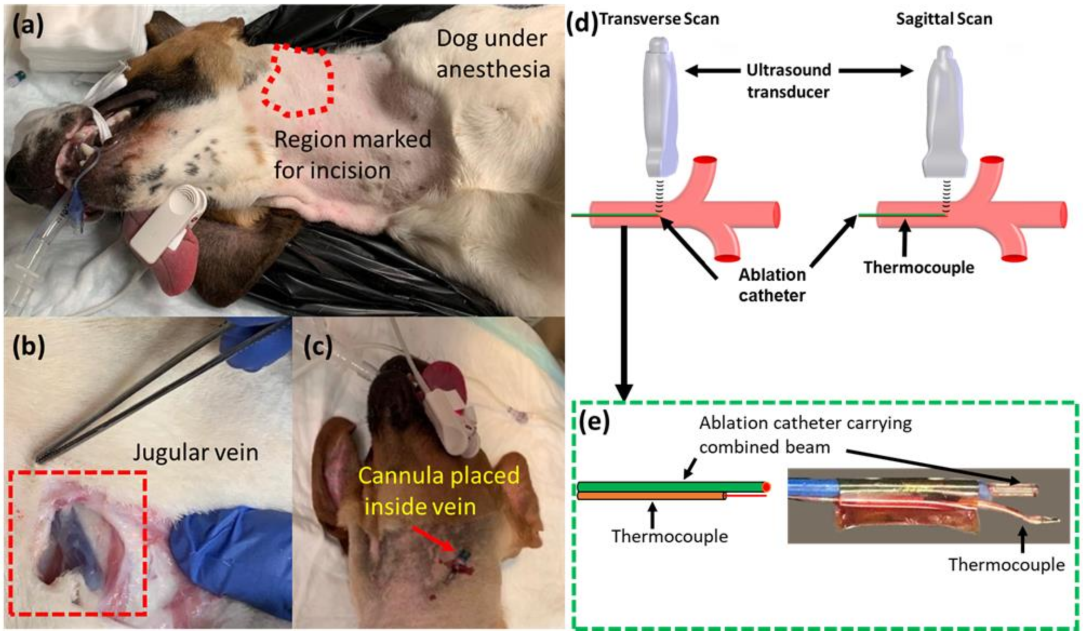

Figure 1. (a) Photograph indicating the region marked for incision for placing the ablation catheter for ablation catheter tip tracking and ablation. (b) Photograph highlighting the jugular vein (c) Photograph indicating the cannula placed inside the vein (d) Schematic diagram of ablation catheter tip tracking and real-time temperature monitoring inside the jugular vein of the canine model. (e) Schematic and photograph of the ablation catheter and the thermocouple.

2. Experimental setup of the custom-designed temperature controlled spectrophotometer to measure the temperature-dependant optical absorbance of water and blood.

The custom-designed temperature controlled spectrophotometer was developed by suspending a cuvette (path length: 10 mm, Hellma Analytics, New York, USA) filled with heparinized canine blood diluted with phosphate-buffered saline (PBS) at a 1:500 ratio. The cuvette was then heated in a homogenous fashion by a water bath **(Fig. 2)**. A K-type thermocouple (Reed Instruments, North Carolina, USA) connected to a microcontroller was used to record the blood temperature at time intervals of 0.5 seconds. The absorbance of the canine blood was calculated by measuring the incident and transmitted pulsed laser energy (λ = 532 nm) by the Beer-Lambert law [1]. The incident and transmitted energies were recorded by a power meter (PE50BF-DIFH-C, Ophir Optronics, Utah, USA).

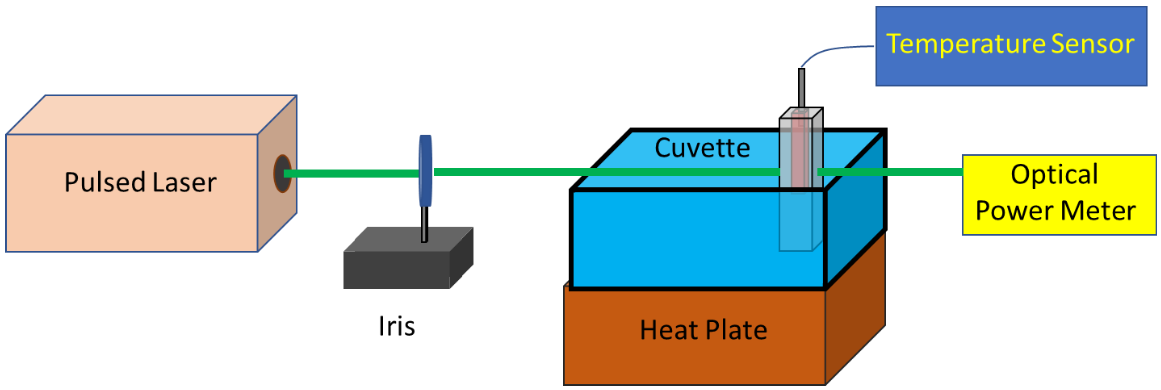

Figure 2: Schematic of the temperature-controlled absorbance measurement device.

References

[1] D. F. J. J. o. c. e. Swinehart, "The beer-lambert law," vol. 39, no. 7, p. 333, 1962.