Experimental intra-arterial ICG fluorescence video-angiography - analysing high-speed recordings using deep-learning algorithms
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Background:
Indocyanine green (ICG) facilitates the intraoperative visualization of blood vessels and vascular malformations after intravenous injection. Given the long distance intravenous ICG bolus arrives diluted, reducing the resolution of images acquired. In the present study we evaluate the feasibility and usefulness of selective intra-arterial ICG injection in a vascular rodent model.

Materials and methods:
In 20 anesthetized rats right jugular vein and left carotid artery were catheterized. Abdominal aorta with all accessible branches were exposed - alligator clips simulate vessel stenosis. After a timeframe of 5min in probe was followed by intravenous administration in all rats. ICG-boli were detected with a high-speed infrared camera (150fps). In a lack of an established evaluation software for high-speed recordings we visualised the ICG flow using a two-step procedure: Firstly, a deep fully convolutional network (FCN; U-Net) segmented the foreground pixel. The U-Net was trained based on manually labelled input images. Secondly, the flow was quantified by calculating temporal changes in brightness over time using pixel differences within the segmented foreground masks resulting in high contrast heat-maps.

Results:
All rats were catheterized and prepared successfully without any complications. Applications via intravenous and intra-arterial route demonstrated ICG fluorescence pattern. After intra-arterial injection, pulse-synchronous peaks were recorded and a clearer and detailed vision of all abdominal vessels could be achieved. Local turbulences of the laminar flow at vessel branches are visible in the real-time video and in the postprocessing heat-map with precise boundaries in the intra-arterial measurements.

Conclusion:
Intra-arterial ICG angiography is a feasible method with potential for assessing blood flow and cerebral perfusion during surgery. By furthermore using our two step postprocessing protocol distinct improvement of resolution, granularity and presentation of laminar flow phenomena compared to the intra-venous ICG application could be shown obviously. Implementation of intra-arterial ICG combined with high-speed recording and subsequent real-time calculation could facilitate vascular neurosurgery with meaningful details.