Validation of a novel artificial intelligence (AI) machine learning algorithm for quantification of vascular pathology in preclinical models

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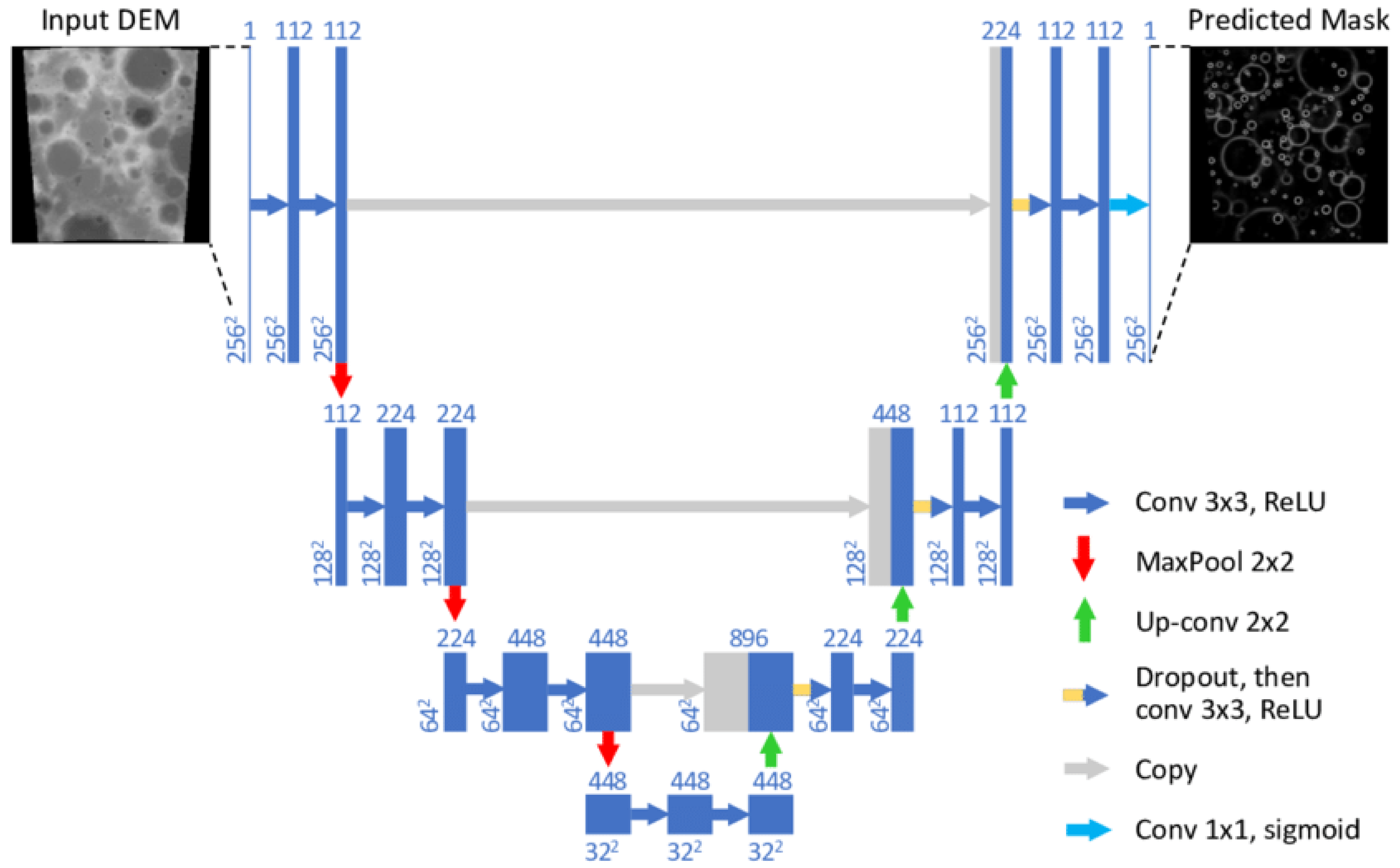
Introduction

The goal of this study was to validate a novel automated algorithm for the automated quantification of lesion size in the mouse choroidal neovascularization (CNV) model.

Methodology

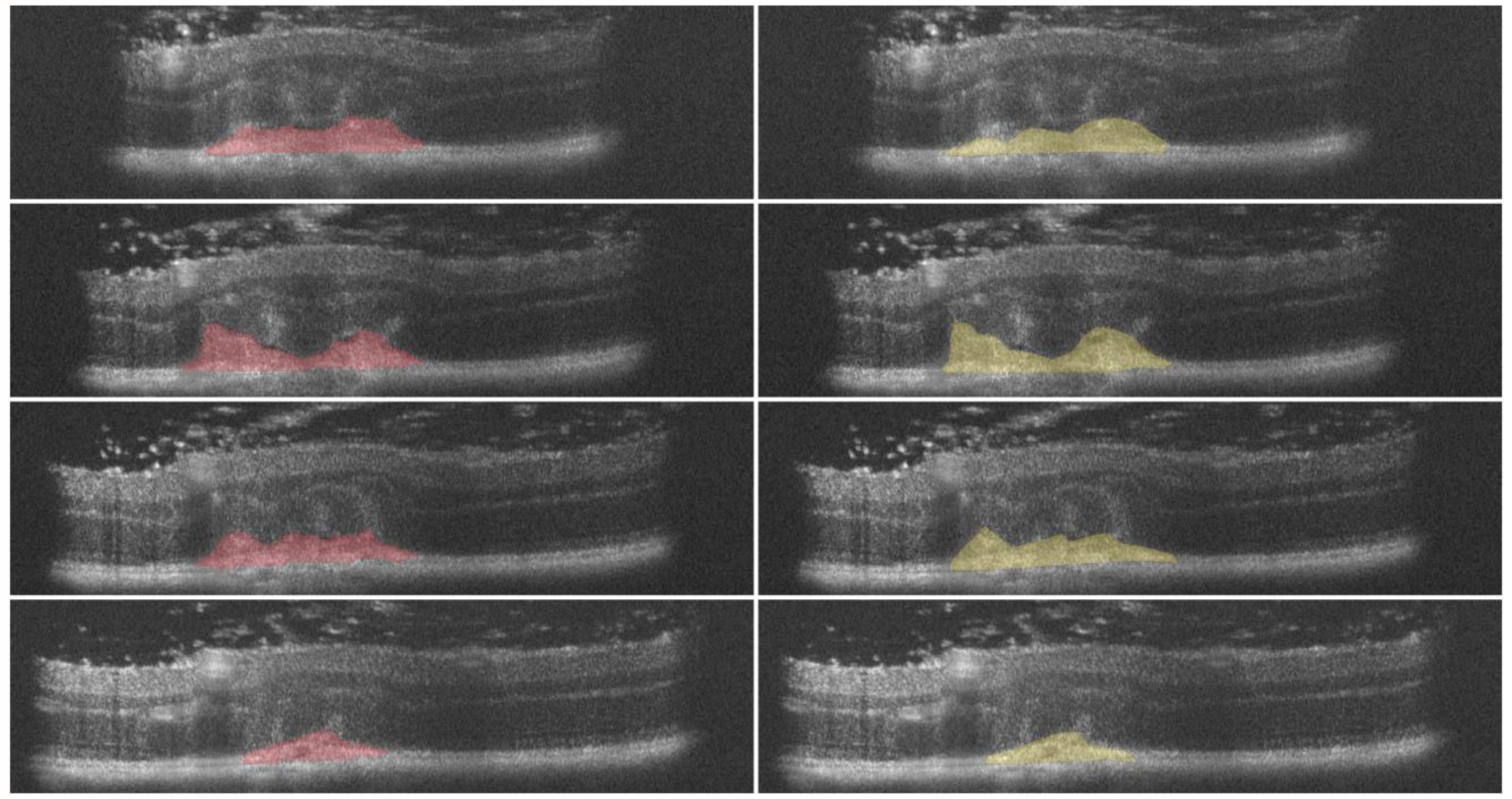
CNV was induced in male C57BL/6JRj mice using a diode laser. Progression of CNV was monitored using live *in vivo* imaging, including fluorescein angiography (FA) and spectral-domain optical coherence tomography (SD-OCT). Lesions in 858 b-scans that represent 2D slices of the 3D SD-OCT scan were annotated manually. Convolutional neural network based on U-Net architecture[1] and pretrained on Imagenet dataset was used for lesion segmentation task.



A three-dimensional (volumetric) representation of lesions was created based on segmented b-scans. Pixels were classified as either "lesion" or "non-lesion". Subsequently noise was removed and "lesion" pixels were separated into instances, i.e. assigned to the individual CNV lesion. Results were validated using the Dice coefficient, comparing automated b-scan segmentation with manual annotation of a previously unseen data, i.e. a dataset not used for model training.

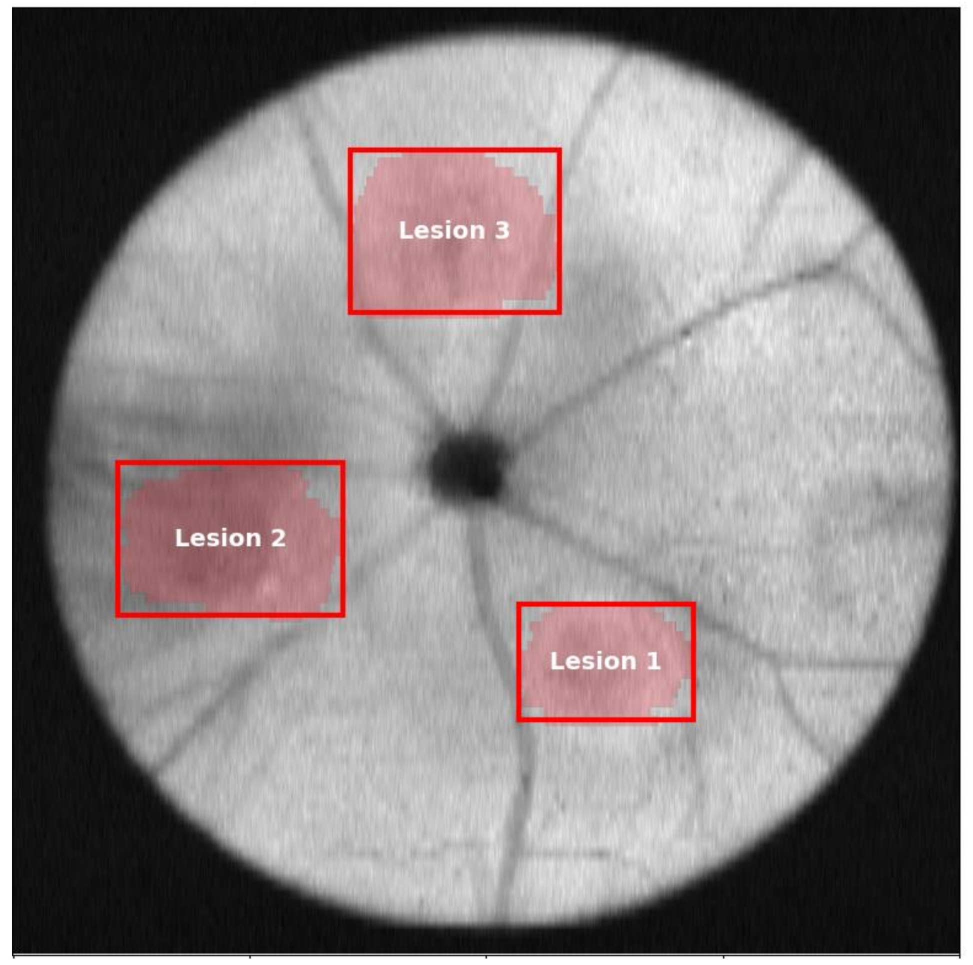
Results

Lesion annotations with the fine-tuned U-Net model:



Predicted area **Manually annotated area**

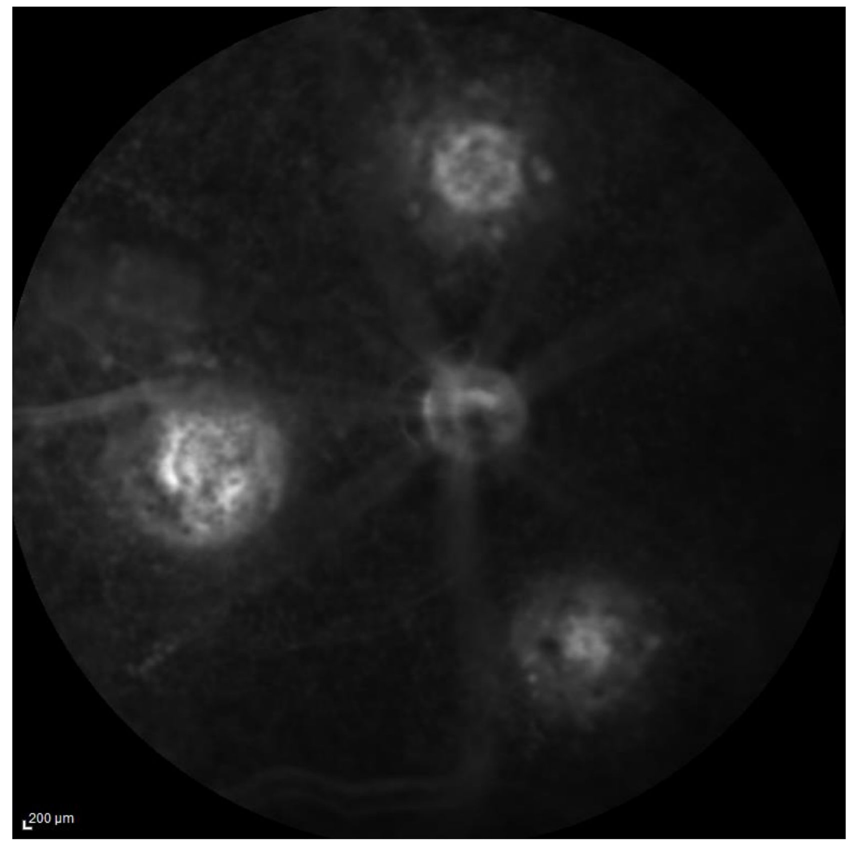
Instances of lesions from VIP view



Correlation between leakage area and lesion volume:

Follow- up day	Day 3	Day 7	Day 10	Day 14
Pearson correlation	0.09	0.65**	0.63**	0.70**
*** significant at the P < 0.001 level*				

Fluorescein angiography



- Dice coefficient comparing the predicted lesion area with the area from manually annotated data was 0.88, indicating high accuracy of predicted areas.
- Various augmentation techniques [2] were applied; however, prediction was not significantly improved.
- 3D volume of CNV lesions determined by automated lesion quantification showed a statistically significant correlation with 2D leakage areas obtained from FA images, especially at later follow-up times, further validating our results.

References

[1] Ronneberger, Olaf & Fischer, Philipp & Brox, Thomas. (2015). U-Net: Convolutional Networks for Biomedical Image Segmentation. LNCS. 9351. 234-241. 10.1007/978-3-319-24574-4_28.

[2] Buslaev, A.; Iglovikov, V.I.; Khvedchenya, E.; Parinov, A.; Druzhinin, M.; Kalinin, A.A. Albumentations: Fast and Flexible Image Augmentations. Information 2020, 11, 125. https://doi.org/10.3390/info11020125

Conclusion

- **Convolutional neural networks can provide accurate segmentation results for SD-OCT CNV data.**
- **Pre-training significantly improves detection, even when performed on images from a different domain.**
- **Future work will determine the impact of pretraining on neural network on medical data *vs*. general domain data.**

Disclosures
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