Combination of Intravital Imaging and Artificial Intelligence to Examine Mitochondrial, Nuclear and Vascular Alterations to Tubular and Peritubular Capillary Compartments During Ischemia-Reperfusion Injury

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Introduction

- Renal ischemia-reperfusion injury (IRI) is a complex disorder that reduces renal function.
- Such losses depend on injury severity and the kidney's ability to recover on its own.
- In this study we developed a framework to support the future development of an artificial Intelligence (AI) model to detect in vivo and real-time mitochondrial, nuclear, and vascular dysfunctions that lead to chronic and end-stage disorders.

Methods

Intravital two-photon microscopy was used to track changes in mitochondrial potential, nuclear structure, and peritubular capillary patency for 30 minutes of ischemia and 30 minutes after reperfusion.

Results

- Ischemia abruptly decreased TMRM fluorescence illustrated via rapid mitochondrial depolarization, accompanied by apoptosis and necrosis, and alterations in peritubular capillary patency.
- Reperfusion brought sluggish vascular flow and an inability to regain pre-injury mitochondrial activity.

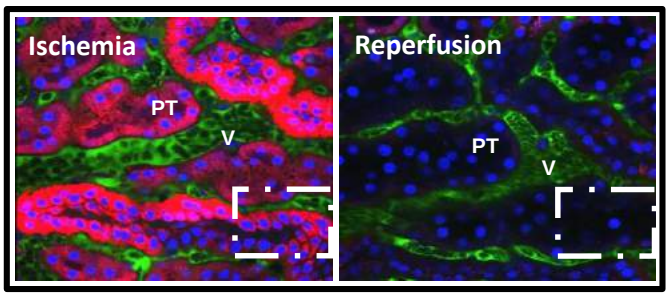

Figure 1: Time-lapse videos of 30 minutes of ischemia followed by 30 minutes of reperfusion.

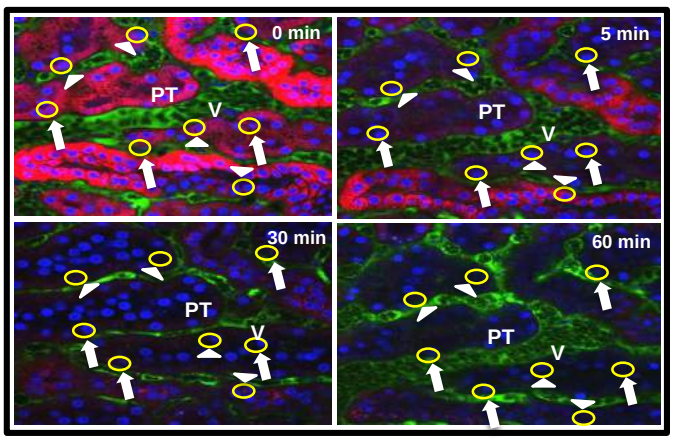

Figure 2: Intravital two-photon micrographs obtained with a X60 objective across a 60-minute period. Apoptotic nuclei highlighted by arrowheads, while necrotic nuclei indicated by arrows.

Intravital Micrographs

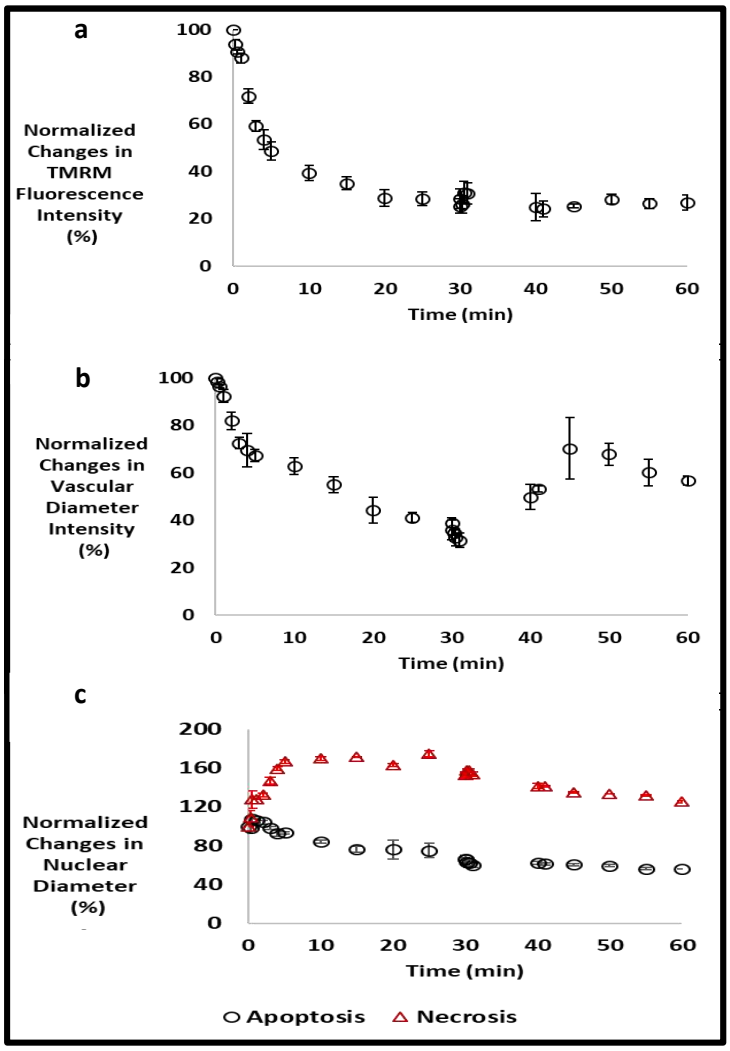

Figure 3: Time dependent changes in (a) TMRM fluorescence, (b) vascular diameter, and (c) nuclear diameter observed during IRI.

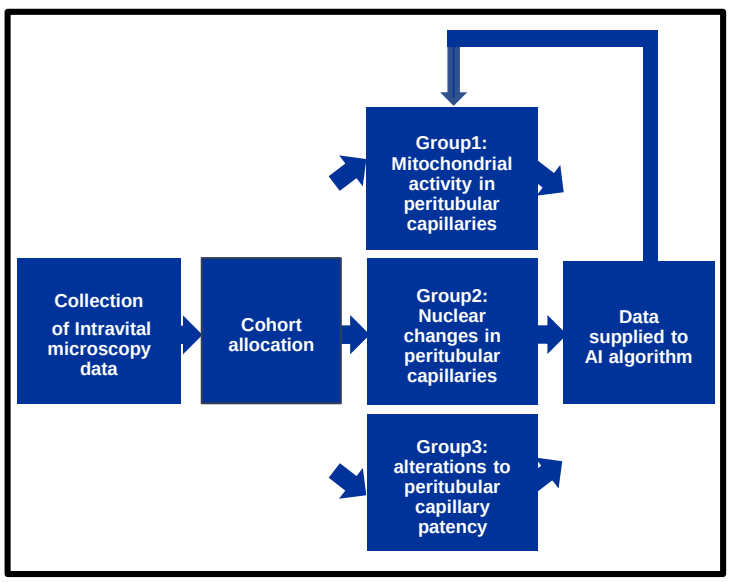

Figure 4: Flowchart of proposed AI model.

Conclusion

Mitochondrial-, nuclear- and vascular-based fluorescent intensities helped track debilitating changes induced by IRI that are known to generate irreversible renal pathologies. Such data will support the development of an AI model to examine these real-time changes.