

HIGH RESOLUTION LYMPHOVASCULAR IMAGING WITH A DUAL CAMERA NIR-SWIR MULTISPECTRAL IMAGING SYSTEM

Chris Hansen[1], Jaidip M. Jagtap PhD[1], Gayatri Sharma PhD[1], Abdul Parchur PhD[1], Amit Joshi PhD[1]

[1]Department of Biomedical Engineering, Medical College of Wisconsin, Milwaukee, WI 53226, USA

ABSTRACT

Near infrared optical fluorescence imaging is a low cost, non-ionizing, highly sensitive, and high temporal resolution imaging modality which has been used extensively in small animals. We report a dual camera system for sensitive and simultaneous video-rate imaging of near infrared and shortwave infrared fluorescent probes in rodent systems. The lymphatic system of a Sprague Dawley rat was imaged using indocyanine green and silver sulfide quantum dots. The image quality and variation between camera images pre and post processing was examined. The proposed system can be modified for use in a variety of *in vivo* imaging applications.

Keywords: infrared, optical, fluorescence, imaging, shortwave, indocyanine green, lymphatic, multispectral, quantum dots, nanoparticles

INTRODUCTION

Near infrared (NIR) optical fluorescence has been used extensively for functional and molecular imaging of small animals *in vivo* and is currently being explored for clinical use in intraoperative imaging and image guided surgeries[1]. These optical modalities are relatively low cost, non-ionizing, highly sensitive (low concentrations of contrast agents) and offer high temporal resolution, as well as allowing for high throughput. However, as tissue depth increases signal to noise ratio (SNR) and spatial resolution suffer[2]. NIR-I light (700–900 nm), and Shortwave IR (SWIR, 1100–1500nm) can travel multiple centimeters in tissue due to low tissue absorption, and autofluorescence[3]. While SWIR imaging has further advantages of reduced tissue scattering leading to higher resolution (Fig 1A), it remains limited due to paucity of SWIR probes and imaging sensors. Unlike the charge-coupled device (CCD) and complementary metal oxide semiconductor (CMOS) sensors used in visible light and NIR-I cameras, which can be made from the well-developed technology of silicon wafers, SWIR cameras must use sensors made from more exotic, less characterized semiconducting materials[4]. This barrier to cheap, reliable sensors has contributed to comparatively little development of fluorescent probes with emission at these wavelengths.

Many NIR-I fluorescent probes exist but, Indocyanine green (ICG) and methylene blue are the only two FDA approved NIR fluorescent probes for clinical use[5]. In addition to a higher quantum yield, ICG has the advantages of lower autofluorescence, higher signal to background ratio, and decreased tissue absorption at its emission spectrum peak around 810nm compared to methylene blue's peak around 700nm[6]. There are no FDA approved SWIR probes, as they are mostly low bandgap semiconductors such as quantum dots (QDs) and single-walled carbon nanotubes (SWNTs) which must be polymer coated to make them biocompatible, however, at least one small molecule organic probe has been synthesized[7, 8]. Combined administration of widely spectrally separated NIR and SWIR luminescing probes to lymphovascular and hemovascular circulation can enable simultaneous investigation of systemic function, pathology, and vascular phenotypes without cross-talk. Alternatively, two probes can be injected into the same system and the biodistribution pharmacokinetics of two distinct probes can be monitored