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A Critical Evaluation of Human Perception in Conventional Flap Monitoring Versus Spatial Frequency Domain Imaging

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INTRODUCTION: Detection of failing tissue flaps before clinically apparent changes are noticeable has the potential to improve post-operative flap management and salvage. This study demonstrates a model to quantitatively compare clinical appearance, as recorded via digital camera, with spatial frequency domain imaging (SFDI), a non-invasive imaging technique utilizing wide field patterned illumination to generate images of tissue perfusion.

METHODS: Utilizing a swine pedicle model, 8 pigs had bilateral fasciocutaneous pedicle flaps raised in the abdominal area. The flaps were skeletonized on the deep inferior epigastric vasculature. Each pig acted as its own control, blood flow in either the artery (4 pigs) or the vein (4 pigs) was carefully regulated with occlusion cuffs and monitored with ultrasound probes. Throughput was sequentially reduced by 25%, 50%, 75%, and 100% of baseline values for 30 minutes at a time and restored to normal flow for 30 minutes between each occlusion. The flap color changes recorded by a digital camera were quantified in order to predict which occlusion levels were visible to the human eye. SFDI was simultaneously used to measure the changes in physiological parameters including total hemoglobin and oxygen saturation associated with each occlusion and then contrasted with the visual data (Figure 1).
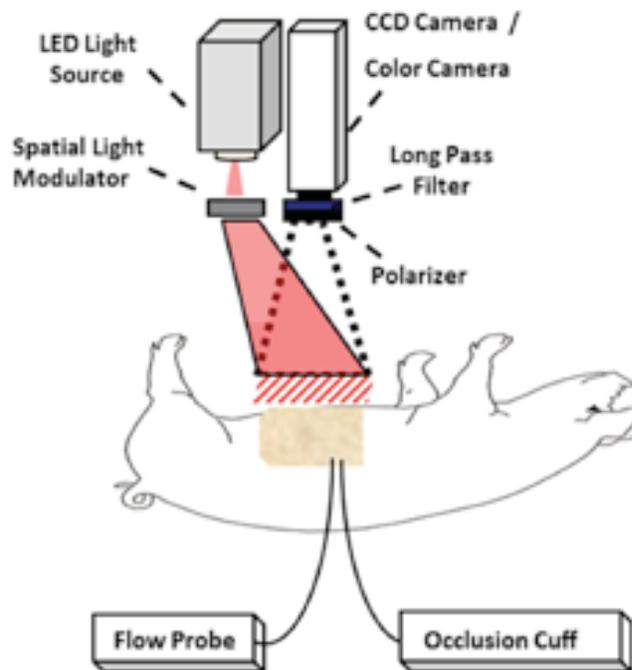

Figure 1. The experimental setup.

RESULTS: There were no statistically significant changes in color above the noticeable perception levels associated with human vision during any of the partial occlusion levels or the 100% level. Utilizing SFDI there were statistically significant changes in oxygen saturation detected at the 75% and 100% levels after 30 minutes of arterial and venous occlusion. There was significant variability between different animals with some showing identifiable oxygenation changes at lower levels of occlusion.

CONCLUSIONS: As demonstrated by the color imaging data, visual flap changes are difficult to detect even when significant occlusion has occurred. SFDI is capable of detecting changes in tissue oxygen saturation with partial blood flow occlusions to pedicle flaps before they are visible to the human eye. Utilization of SFDI may allow for improved response times and salvage of compromised flaps in comparison to conventional monitoring techniques.