Looks can be deceiving: Detection of regional differences in physiologic perfusion levels in human esophagogastrointestinal tract using Laser Speckle Contrast Imaging

Garrett Skinner [1,2], Emily Huang [3], Chris McCulloh [1], Yao Liu [1,4], Alan Harzman [2], Peter Kim [1,4]

[1] Activ Surgical, [2] University at Buffalo Jacobs School of Medicine and Biomedical Sciences, [3] The Ohio State University Wexner Medical Center, [4] Brown University Warren Alpert Medical School

Introduction

Perfusion assessment is a vital in surgeries throughout the esophagogastrointestinal (EGI) tract. Compared to white light imaging (WLI, **Fig 1A**), advanced visualization (AV) with near infrared indocyanine green (NIR ICG, **Fig 1B**) and laser speckle contrast imaging (LSCI, **Fig 1C**) further informs real time perfusion status. It is hypothesized that tissues in the EGI tract will have varied baseline perfusion quantification, and this could inform operative decision making.

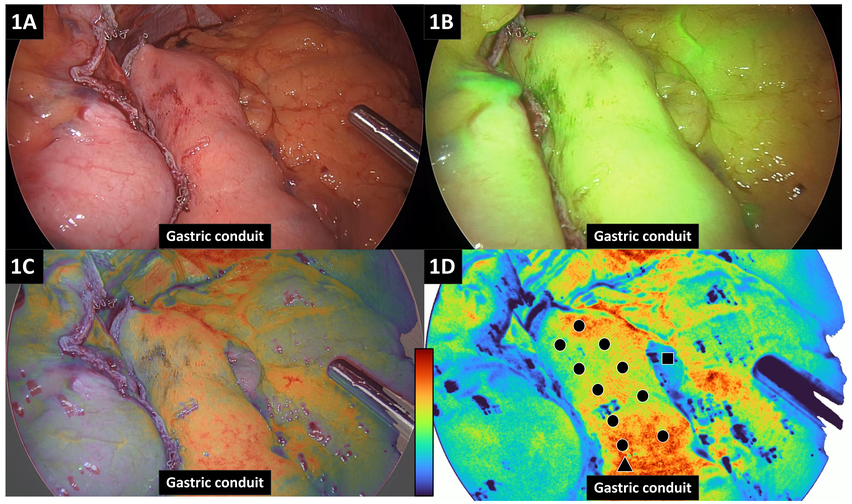


Figure 1. Perfusion assessment of gastric conduit in esophagectomy in white light imaging (1A), ICG-FA (1B), LSCI overlay (1C) and LSCI contrast mode (1D) with raw LSCI regions of interest and standard hot points.

Methodology

Relative perfusion units (RPU) are calculated by placing raw LSCI data grouped in 100px regions of interest (ROI, circles) in a scale with a standard hot reference point (Hot, triangle) and cold point (Cold, square). **(Fig 1D, Fig 2)**. Normally perfused tissues throughout the EGI tract were analyzed with RPU analysis to obtain baseline values.

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$$ROI^{RPU} = \frac{ROI^{raw} - Cold^{raw}}{Hot^{raw} - Cold^{raw}}$$

Figure 2. Equation used to calculate RPU for selected regions of interest.

RPU analysis, with baseline perfusion data as a reference, was applied to esophagectomy by quantifying the ischemic patterns of the gastric conduit during esophageal reconstruction.

Results

Baseline perfusion of tissues can be represented as RPU. Throughout the EGI tract, baseline RPU vary by tissue type. Baseline RPU values can be referenced when comparing tissue of unknown perfusion status.

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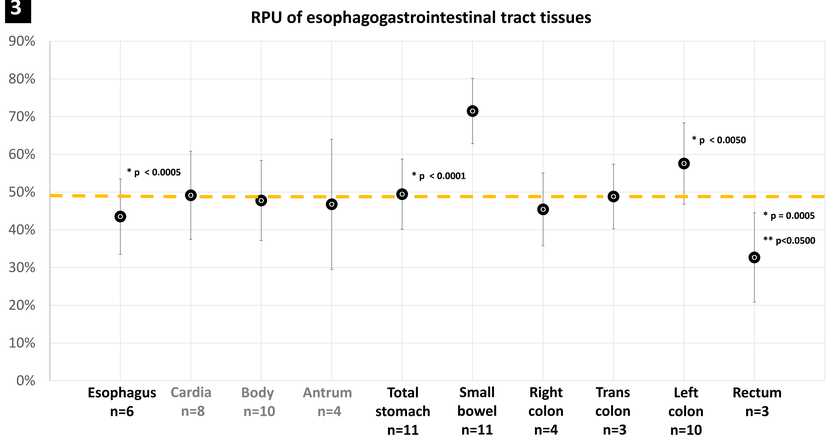


Figure 3. Baseline RPU values of tissues throughout the esophagogastrointestinal tract.

Baseline RPU value of the stomach is 49% +/- 9%. The average perfusion level of all tissues combined was 49% (yellow line). RPU of the esophagus, stomach, left colon and rectum are significantly lower than the small bowel (*) and rectum is significantly lower than left colon (**) **(Fig 3)**.

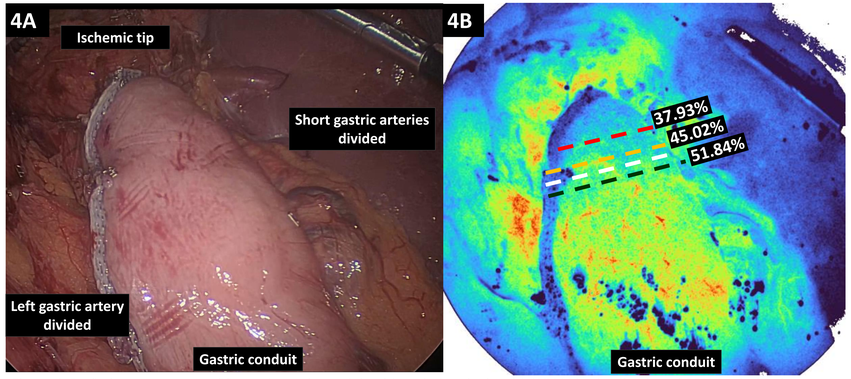


Figure 4. Perfusion assessment of formed gastric conduit with an ischemic tip with WLI (4A). Application of RPU analysis with reference to baseline RPU of stomach (4B).

LSCI can help inform the surgeon of the level of ischemia at the tip of the gastric conduit in esophagectomy when compared to WLI **(Fig 4A)**. RPU analysis can define the level of ischemia on a gastric conduit and the specific location at which conduit perfusion approaches baseline gastric perfusion (49% +/- 9%) **(Fig 4B)**.

Conclusion

LSCI allows for assessment of tissue perfusion in a laparoscopic form factor. Baseline RPU of small bowel is significantly higher than esophagus, stomach, left colon and rectum and may shed light on higher complication rates of esophagogastric and colorectal anastomoses compared to small bowel anastomoses. RPU analysis can also quantify the level of ischemia resulting from surgical dissection, as in gastric conduit creation during esophagectomy.

University at Buffalo The State University of New York

Department of Surgery
Jacobs School of Medicine and Biomedical Sciences
gs69buffalo.edu