Optical Fiber Spectroscopy Device for Noninvasively Measuring Chromophores in Biological Tissue

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Technology description

OHSU scientists developed a simple optical fiber probe spectrometer for nondestructive laparoscopic measurement of blood content and hemoglobin oxygen saturation in tissue microvasculature during surgeries.

Fiber optic spectroscopy can be implemented with a small footprint (two 1-mm-diameter optical fibers placed 3 mm apart) and can avoid the dangers of placing electrical components in the patient. The probe measures a strong steady-state light signal, as opposed to a pulse oximetry unit that must lock onto a weak pulsatile signal to extract information. The oxyhemoglobin (HbO2) and deoxyhemoglobin (Hb) molecules exhibit distinct absorption properties in the visible spectral range. The spectroscopic analysis utilizes the absorption spectra of oxy- and deoxyhemoglobin and optical diffusion theory, incorporating tissue scattering properties and blood absorption to estimate the blood volume fraction (B) and the oxygen saturation of hemoglobin [S = HbO2/(Hb +HbO2)] in the mixed arteriovenous microvasculature.

In esophagectomies performed on 22 patients, the probe measured the light transport in stomach tissue between two fibers spaced 3-mm apart (500- to 650-nm wavelength range). Measurements were made at each of five steps throughout the surgery. The resting baseline saturation was 0.51±0.15 and decreased to 0.35±0.20 with ligation. Seven patients developed anastomotic complications, and a decreased saturation at either of the last two surgical steps is predictive of complication with a sensitivity of 0.71 when the specificity equaled 0.71.

Anastomotic leaks present too late for effective preventative intervention. Anastomotic leak contributes substantially to the 5% mortality rate associated with esophagectomy, therefore any method of early detection for the scheduling of prefailure intervention would improve patient outcome. Detection of a significant decrease in normal tissue

oxygenation at theanastomosis could alert the surgeon that the conduit or anastamosis may be at risk for ischemic injury, and further diagnostic and therapeutic intervention must be scheduled.Background of the Invention

Esophagectomy is the surgical removal of a cancerous esophagus and restoration of gastrointestinal continuity with part of the stomach that is remodeled to serve as a gastric conduit tube. To mobilize the stomach tissue that will become the conduit, the tethering short gastric and left gastric arteries must be surgically ligated. The right gastroepiploic artery is the sole remaining vessel supplying the

gastric conduit, and consequently the blood supply is decreased to the very tissue that must be anastamosed to the remaining esophagus in the patient' s neck. Ischemia is known to impact the occurrence rates of the two types of complications that can result in this surgery:
1. stricture, which can be treated postsurgically, and
2. anastomotic failure/leak, which leads to sepsis, a far more dangerous complication.
In one study, postmortem examination of gastric conduits in postesophagectomy patients showed that the blood supply of the proximal 20% of the gastric conduit was through a microscopic network of capillaries and arterioles. Numerous studies indicate that schemia of the gastric conduit due to altered arterial inflow and venous drainage has been implicated in high anastomotic leak rates. Another study reported that the incidence of anastomotic leak ranges between 3.5 and 19%. Many factors influence the outcome, but adequate oxygenation at the anastamosis is critical to success.

Application area

As discussed above, the fiber optic probe technology shows promise in the monitoring of oxygenation levels during and after esophagectomy. However, the probes have multiple applications, including for use in:
Free Flap Surgeries
- Examples: Cosmetic reconstruction, traumatic reconstruction, and removal of cancer in the mouth and neck region.
- The most common serious complication of a free flap is loss of the venous outflow (e.g. a clot forms in the vein that
drains the blood from the flap).
Organ transplantation and skin grafts
Surgical resection and anastomosis
- esophageal
- colon
Neurosurgery (e.g. cerebrovascular surgery)
- neurovascular surgical procedures often require temporary cerebral arterial occlusion.
With respect to abdominal aortic aneurysms
- standard open surgery
- less invasive, endovascular aneurysm repair (EVAR)

Institution

State of Oregon

Inventors

John Hunter
Chair

SM.Surgery

Steven Jacques

Professor of the Practice

Biomedical Engineering

Daniel Gareau

联系我们

叶先生

电 话：021-65679356

手 机：13414935137

邮 箱：yeyingsheng@zf-ym.com