Colorectal surgery is one of the most common surgeries performed in Switzerland, with more than 4000 new cancers found each year. Minimally invasive colorectal resection is becoming widespread in our country and most centers offer patients laparoscopic surgery. New technologies are emerging in surgery, for example with better imaging through high definition (HD) screens, and 3D vision to overcome the loss of the third dimension in laparoscopy. In addition, enhanced reality or augmented reality is a new concept to help surgeons to better understand the surrounding environment. Near infrared (NIR) technology is one of the most promising technologies allowing the improvement of perception and maybe to assist in decreasing surgically related complications (especially anastomotic leakage). The aim of this work is to describe this new imaging modality and its possible use in operating theaters.

Technological applications and the use of biomarkers:

Anastomotic leakage is one of the major complications in colorectal surgery. Reported leak rates range between 1-3% for ileo-colic anastomosis, but can go up to 20% for a low colorectal anastomosis. It has been proven that a good perfusion of the anastomosis is necessary in order to ensure proper healing. There are many factors which can lead to an anastomotic leak. Some are patient-related, like age, gender (male), smoking habits, diabetes, nutritional status, use of steroids, site and/or size of the disease. Intraoperative technical factors could also be involved (blood loss or transfusion), number of staples, hematoma, abscess or tension at the time of the anastomosis.

There are very few factors that can be modified to prevent a leak. Microvascularisation assessment at the time of surgery is definitely one of them. Unfortunately, up to recently there was no available tool that could be converted into daily clinical practice. The ideal tool should be possible to use in laparoscopic surgery, easy to use, reproducible, accurate (false negative or positive results) and cost effective.

Enhancing reality in colorectal surgery with the near infrared (NIR) technology:

The principle of NIR technology is to emit a signal at a certain wave-length (806 nm) that is able to stimulate a biomarker, which in turn responds at a different wavelength (830nm). Indocyanine green (ICG) is a good biomarker with few side effects (allergic reaction 1/30000) and a very large safety margin (maximal dose of 0.5-2mg/kg of body weight). In laparoscopic surgery, there are two available endoscopy systems which perform near infrared imaging: the Pinpoint from Novadaq (Canada) and the D-Light from Storz (Germany). There is only one robotic application, the Firefly (Da Vinci, USA). There are currently two main applications for the use of this technology in colorectal surgery: anastomosis microvascularisation assessment and lymph node mapping.

Anastomosis microvascularisation assessment:

During the anastomosis, the division of the vessels can lead to a decrease in the microvascularisation at the level of the anastomosis; this localized hypoperfusion could induce an anastomotic leak. Intravenous angiograms during open surgery can show this mechanism, but this technique is very difficult to perform routinely in open and in laparoscopic surgery. Although there are other tools available, they have not been proven to be useful for this particular purpose. Other options include Pulse oxymetry, Polarographic Oxygen tension, Doppler Ultrasound, pH measurement, Spectrophotometry, Fluoresceine fluorescence. Near infrared technology with the use of indocyanine green can be used for laparoscopic surgery, is easy to use, reproducible, accurate and objective. Once the near infrared laparoscope has been purchase, the cost of a single procedure is low (around CHF 60.- per patient or procedure).

The assessment of the microvascularisation of an anastomosis in real-time can alter the course of surgery by potentially preventing the development of a leak. Figure 1 shows the use of a near infrared microvascularisation assessment after division of the main vessels. There is a clear cut-off level, where the bowel is not vascularized anymore. Figure 2 shows the same operation after the anastomosis has been performed with a good signal at the level of the anastomosis. Recent literature in colorectal surgery, show the potential impact of this technology could have on our daily practice. Sherwinter and colleagues published results from a series of 20 patients, who had a low anterior resection and a transanal angiogram with near infrared scope. Among the four patients who had a bad perfusion angiogram at the time of surgery, two developed an anastomotic leak. In the study of Jafari et al., which was performed with the robot and the firefly in a prospective setting, there was a significant decrease in the leak rate. In fact a decrease of 2/3 of anastomotic dehiscence in the near infrared group was demonstrated, with anastomotic leakage in 18% of the control group versus 6% in the near infrared group. This was confirmed by the latest robotic study with a change in the proximal transection area in 40% of the patients, and anastomotic leakage in 5% of those patients. Finally a prospective study of laparoscopic colorectal resection in laparoscopic surgery showed no leaks among 30 patients after low anterior(n=6), high anterior(n=18) or right hemicolecetomies(n=6). The assessment of the microvascularisation of the anastomosis is in its early stages. The practice of inspecting the situs during surgery and altering the course of the surgery to prevent a potential leak is still novel.
Focus

Conclusion and perspective:
We are entering a new era of surgery in which new tools will allow the surgeon to enhance the operating field. The assessment of the microperfusion of an anastomosis is the first step. This technology will provide new biomarkers, which will be more specific and allow the surgeon to tag organs as well as introduce new applications such as near infrared, to find the first draining lymphnode during surgery.

References:

Figure 1: Near infrared imaging after vessel division in a low anterior resection: (Left top: normal view, left middle: NIR mode, left bottom: composite view mixed) A: Before injection of indocyanine green (ICG), the arrow shows the planned level of transection

Figure 2: Near infrared imaging after side to end anastomosis in a low anterior resection: (Left top: normal view, left middle: NIR mode, left bottom: composite view mixed) B: After apparition of the signal with the main screen with the composite view, showing a clear cut-off of the signal where the clip has been positioned.