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CASE REPORT

Detection of inadequate anastomotic perfusion with handheld vital microscopy in two patients during colorectal surgery

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Abstract

Introduction Anastomotic leakage is one of the most feared complications after gastrointestinal surgery. Assessment of anastomotic viability during surgery remains challenging. Sufficient bowel tissue perfusion is a requisite for anastomotic healing. Handheld vital microscopy (HVM) is a non-invasive technique that can directly visualize the intestinal microcirculation during surgery.

Presentation of two cases Two patients underwent elective laparoscopic colorectal surgery. During surgery HVM was used to assess bowel perfusion prior to creation of a primary anastomosis. Although the bowel macroscopically appeared to be well perfused, HVM showed a severely compromised microcirculation. The colon was re-internalized and during the following minutes cyanosis of the bowel occurred which was visually determined by the surgeon. After dissection towards cranially, a new site for the primary anastomosis was chosen. The postoperative period was uncomplicated.

Discussion Sufficient bowel tissue perfusion is often mentioned as key in the pathophysiology of anastomotic leakage. HVM is a technique that could potentially aid surgeons in the assessment of microcirculatory perfusion of the bowel during surgery.

Conclusion We report two cases undergoing colorectal surgery in which HVM showed merit in detecting compromised bowel perfusion before creation of a primary anastomosis.

Keywords Intestinal microcirculation · Surgery · Anastomotic leakage · Handheld vital microscopy · Colorectal cancer

Introduction

Anastomotic leakage (AL) is a feared complication after gastrointestinal surgery. Patients with AL have higher rates of morbidity and hospital mortality [1]. Although risk factors for AL have been described, assessment of anastomotic viability during surgery remains challenging [2]. Sufficient bowel tissue perfusion is a requisite for anastomotic healing. Techniques that can aid surgeons in the assessment of bowel perfusion during surgery could potentially aid in the quest to reduce AL.

Handheld vital microscopy (HVM) is a non-invasive technique that can directly visualize intestinal microcirculation during surgery [3, 4]. A prospective observational study, with the aim of visualizing and describing the human intestinal microcirculation during abdominal surgery, was conducted by our group (clinicaltrials.gov identifier: NCT02688946). From this cohort, we report two cases in which HVM showed merit in detecting compromised bowel

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perfusion before creation of a primary anastomosis during colorectal surgery.

Case 1

A 47-year-old female without comorbidity presented at our hospital with complaints of pain in the epigastric area and weight loss. Colonoscopy revealed a tumor 25 cm proximal to the anal verge. Pathologic examination of biopsy showed a tubular adenoma with focal high grade dysplasia. Abdominal CT scan displayed a lesion in the sigmoid, no lymph nodes suspect for malignancy and no metastasis. Patient underwent elective laparoscopic sigmoidectomy. Surgery and anesthesia were performed according to standard clinical practice. Patient received thoracic epidural analgesia. The following surgical steps were performed laparoscopically. After exploration of the abdomen and identification of the ureter and gonadal vessels, the mesocolon was opened. Subsequently, the inferior mesenteric artery was ligated, using a low tie technique with preservation of the left colic artery. Hereafter, the lateral attachments of the descending colon were transected and the splenic flexure mobilized. Next the bowel was transected distal to tumor spotting, which was 25 cm from the anal verge. Hereafter, the colonic loop was externalized through a Pfannenstiel incision and subsequent extra-abdominal macroscopic assessment of bowel perfusion was performed. After visual inspection, blood flow in the proximal part of the bowel loop appeared adequate as the bowel had a vital pink color. Images of the serosal microcirculation were acquired after the surgeon had marked a planned line of transection and site for the primary anastomosis. Imaging of the serosal microcirculation was performed 20 cm proximal to the planned transection line, as displayed in Fig. 1, and showed severely compromised blood flow (Video 1). The colon was re-internalized and during the following minutes cyanosis of the bowel occurred, as visually assessed by the surgeon. As a result, the bowel was dissected further towards macroscopic well perfused area. Again, the bowel was externalized through a Pfannenstiel incision. Blood flow was assessed macroscopically by the surgeon. No further HVM recordings were performed. After insertion of the anvil in the colon loop, surgery was continued laparoscopically and a primary end side-to-end anastomosis was created using a circular stapler. The air leak test was negative. Patient was treated according to ERAS protocol after surgery and was discharged 5 day post procedure after an uncomplicated course. Pathology classified the tumor as pT1N0 sigmoid carcinoma. In follow-up of 90 days, no AL occurred.

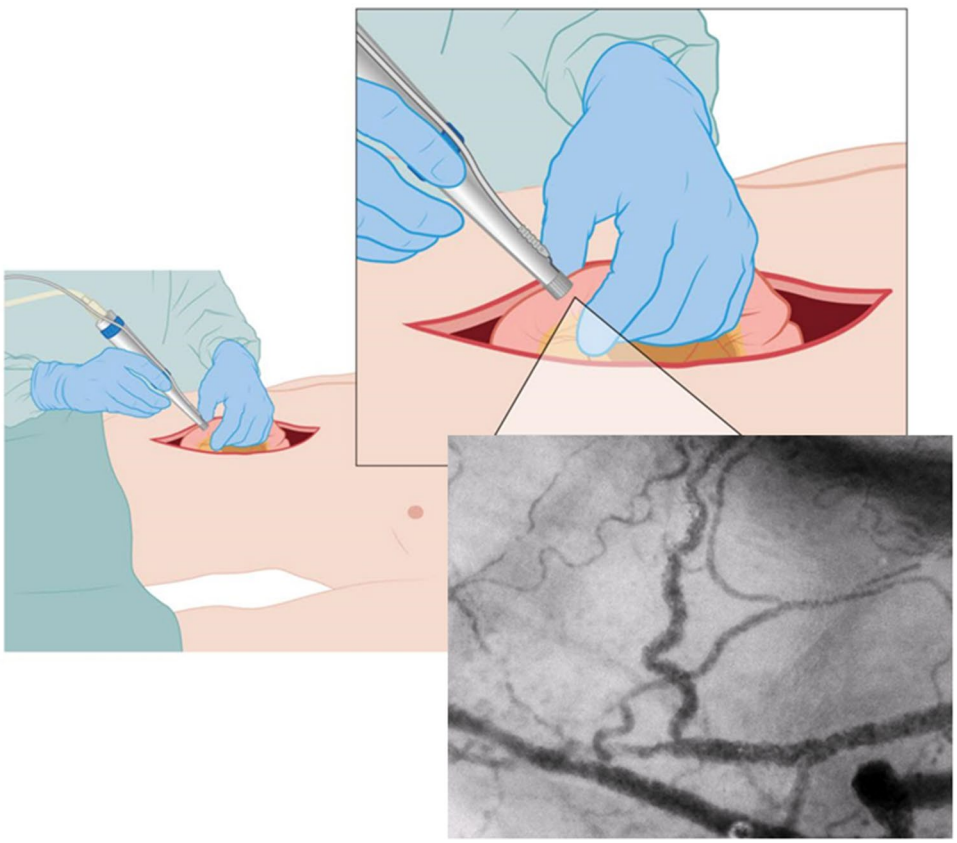

Fig. 1 Use of handheld vital microscopy during surgery. Figure 1 shows an adaptation of a previously published figure and is reprinted by permission from Springer [4]. © 2018

Case 2

A 61-year-old male with no relevant medical history was referred to our hospital with rectal blood loss. Colonoscopy identified a tumor in the sigmoid. Pathologic examination revealed an adenocarcinoma. CT-abdomen showed a lesion suspect for malignancy in the sigmoid, one enlarged lymph node and no distant metastasis. Patient underwent elective laparoscopic sigmoidectomy. Surgery was performed as described in Case 1. After transection, approximately 40 cm from the anal verge, the bowel was externalized through a Pfannenstiel incision and extra abdominal assessment of bowel perfusion was performed. The surgeon marked a planned transection line, based on macroscopic assessment. Subsequently, the microcirculation was assessed with HVM 20 cm proximal to this line and showed a severely compromised perfusion. The bowel was re-internalized, and upon visual inspection by the surgeon the bowel was cyanotic. After dissection toward well perfused area the bowel was externalized and assessment of macroscopic perfusion was performed. Hereafter, HVM images were acquired 20 cm proximal to the new planned transection line and at the planned anastomosis (Video 2). This time HVM confirmed adequate blood flow. The anvil of a 31 mm circular stapler was inserted in the colonic stump and the colon loop re-internalized into the abdomen. After pneumoperitoneum was established, a primary side-to-end anastomosis was created. An air leak test was performed, which was negative. The first 4 days following surgery were uncomplicated and the patient was discharged. Pathologic examination of biopsy classified a T4N2 malignancy. In a follow-up period of 90 days, no AL occurred.

Methods

The patients gave written informed consent to participate in a cohort study (clintrials.gov (identifier: NCT02688946), performed at the St. Antonius Hospital in Nieuwegein, the Netherlands for which approval was obtained from local and institutional ethics committees. The serosal microcirculation was visualized with Sidestream dark field imaging in case 1 and with Cytocam-IDF imaging (Braedius Medical, Huizen, The Netherlands) in case 2. An image acquisition stabilizer was used [5]. Images were acquired by a trained researcher and according to international consensus, as recommended three unique HVM images were acquired per measurement [6]. To calculate microcirculatory parameters, videos were analyzed offline using AVA 3.2 software (MicroVision Medical, Amsterdam, the Netherlands.) The microvascular flow index (MFI), percentage of perfused vessels (PPV), the heterogeneity index (HI), total vessel density (TVD), perfused vessel density (PVD) were calculated. The MFI of an image is determined by assessing the predominant type of flow in each quadrant, ranging from 0 = no flow to 3 = continuous flow. A MFI of 3 is considered normal. The PPV is the percentage of length of vessels which shows a continuous flow (range 0–100%). The MFI and PPV are considered as markers of perfusion. The TVD is the total length of vessels per surface and is measured in mm/mm^2. The PVD is reflects the length of perfused vessels per surface. The TVD and PVD reveal information on diffusion distance. To determine the heterogeneity of flow at a certain bowel site the HI was calculated as follows, (highest MFI − lowest MFI)/average MFI at that site [6]. The occurrence of AL was extracted from patients' medical records.

Results

A total of 9 images were acquired in two patients. In case 1 three images were acquired of the descending colon 20 cm proximal to the planned transection line. The heart rate during recording was 67 beats/min and blood pressure was 95/48 mmHg (mean arterial pressure of 64 mm Hg). While, the surgeon visually assessed the bowel to be adequately perfused, HVM revealed that no blood flow was present in the serosal microcirculation as the MFI and PPV were both 0. The TVD was 8.51 mm/mm^2.

In Case 2, while the bowel macroscopically appeared to be well perfused HVM showed a MFI of 0. After a second resection, the bowel was externalized again. Six images were then acquired at two parts of the bowel. Mean arterial blood pressure during imaging was 67 mm Hg. Microcirculatory parameters are presented in Table 1. The bowel, as visualized with HVM, was well perfused 20 cm proximal to the planned transection line (MFI 2.88, PPV 96%). Microcirculatory perfusion was also present at the planned site of anastomosis with a MFI of 2.50 and PPV of 79%.

Discussion

We present two cases with insufficient intra-operative serosal blood flow at the site of the planned anastomosis, as visualized with HVM, while at the same time perfusion of the colon was assessed as adequate upon visual inspection. After re-internalization of the bowel inadequate blood flow was indeed confirmed. In both cases the microscopic findings appeared to be the harbinger of clinically relevant

Table 1 Microcirculatory parameters for acquired Handheld vital microscopy images in case 2 as calculated by off-line analysis

Imaging location	MFI	PPV	TVD (mm/mm^2)	PVD (mm/mm^2)	HI
Descending colon after first resection*	0.00	NA	NA	NA	NA
Descending colon after second resection^	2.88	0.96	10.59	10.20	0.09
Site of anastomosis^	2.50	0.79	9.12	7.34	0.40

MFI microcirculatory flow index, *PPV* proportion of perfused vessels, *TVD* total vessel density, *PVD* perfused vessel density, *HI* heterogeneity index

*Colon visually assessed to be well perfused by surgeon; however, no blood flow was seen with Handheld vital microscopy

^Colon visually assessed to be well perfused by surgeon in addition Handheld vital microscopy also showed perfusion

NA not available

insufficient bowel perfusion with subsequent need for re-intervention.

Intra-operative prediction of anastomotic integrity is challenging [2]. Therefore, technology aiding surgeons in the assessment of bowel perfusion may prove valuable in lowering AL rates. A promising technique is the use of intravenous indocyanine green (ICG) fluorescence angiography. Assessment of perfusion with this technique resulted in a change of site for planned anastomosis in 7.4% of the cases and a low incidence of AL. Although this device has mainly been studied in cohort studies [7]. With HVM it is possible to directly visualize the microcirculation and assess the presence of red blood cell flow and, therefore, assess the number of vessels perfused and the quality of flow. This makes it possible to assess perfusion, diffusion distances and heterogeneity of flow. In addition to distinguishing between flow and no flow, HVM is also able to detect a gradual decline in microperfusion [8]. However, microcirculation parameters, as determined with HVM, have not yet been coupled to AL. To examine this a larger cohort study is needed. The presented cases are the first two patients in which we found intestinal perfusion, visualized with HVM, to be absent at the planned site for a primary anastomosis. This lead to reassessment of the transection level by the surgeon. We did previously find a partially compromised serosal microcirculation at the planned anastomosis during colorectal surgery [8, 9]. However, in these patients no AL occurred. Suggesting that not a gradual decline predicts AL, but maybe the distinction between flow or no flow is of greater importance. We also found that mucosal perfusion in these patients was preserved [9], suggesting, that the serosal microcirculation in more sensitive to a surgical hit than the mucosa.

Although, practical difficulties in acquiring stable image have largely been overcome with the use of an IAS with an average imaging time per organ site of 3 min, still limitations of HVM remain [5]. Firstly, direct access to the bowel is necessary, making applicability limited to open procedures or surgery, where the bowel is externalized as in the cases described. In addition, in laparoscopic procedures as performed in the cases presented, it is not possible to image the distal end of the anastomosis with HVM as there is no direct access to this part of the bowel. While perfusion in this part of the anastomosis is also of importance for anastomotic viability. To assess perfusion of the anal margin, mucosal imaging of the rectal pouch would have to be performed, which is feasible [10]. However, this would only be applicable for an anastomosis close to the anal margin. Additionally, an absence of blood flow visualized by HVM, as we report here, has never directly been correlated to AL. Finally, in contrast to the MFI, which can quickly be scored, an extensive analysis is required for the calculation of the PPV and vessel density. However, recently an automated quantification of the microcirculatory parameters has been validated for the sublingual microcirculation [11]. This could potentially result in quick use of all microcirculatory parameters during surgery.

In conclusion, two cases are presented, where HVM showed merit in aiding the surgeon by detecting the absence of adequate bowel perfusion before creation of a primary anastomosis. The ability to directly visualize intestinal microcirculation may prove of value to surgeons when assessing adequate bowel perfusion and anastomotic viability.

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Author contributions Acquisition and analysis of data: AT, AB, AS, DB. All authors participated in data interpretation and manuscript preparation.

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Compliance with ethical standards

Conflict of interest C.I. and his team developed SDF imaging and AVA software for analysis of microcirculation images used in this paper. These products are commercialized by MicroVision Medi-

cal (MVM) under a license from the Amsterdam University Medical Center. Braedius Medical, a company owned by a relative of C.I., has developed and designed a handheld microscope called CytoCam-IDF imaging used in this study. C.I. has no financial relationship with Braedius Medical of any sort, that is, never owned shares, or received consultancy or speaker fees from Braedius Medical. Active Medical BV, of which C.I. is a shareholder, runs an internet site called microcirculationacademy.org which offers educational courses and services related to clinical microcirculation. MicroTools software automatic analysis of microcirculation images is being developed with support from Active Medical BV. The other authors have no conflict of interest to declare.

Ethical approval This study complied with ethical requirements and was approved by the medical ethical committee. Informed consent was obtained from all individual participants. Trial registry number: ClinicalTrials.gov identifier NCT02688946.

Informed consent All study participants gave written informed consent to participate in the study, as described in the methods section.

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