

Alterations in intestinal serosal microcirculation precipitated by the Pringle manoeuvre

Lucinda Shen,^{1,2} Zühre Uz,^{1,3} Can Ince,^{1,2} Thomas van Gulik⁴

¹Department of Translational Physiology, Amsterdam UMC, Amsterdam, The Netherlands

²Department of Intensive Care, Erasmus MC, Rotterdam, The Netherlands

³Department of Experimental Surgery, Amsterdam UMC, Amsterdam, The Netherlands

⁴Department of Surgery, Academic Medical Center, Amsterdam, The Netherlands

Correspondence to

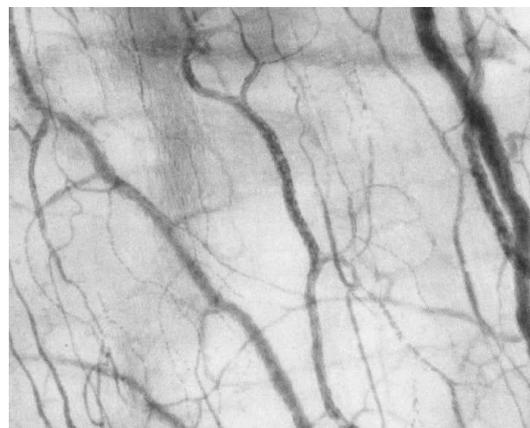
Professor Thomas van Gulik, t.m.vangulik@amc.nl

Accepted 7 December 2018

DESCRIPTION

The Pringle manoeuvre can be applied during liver resection to reduce blood loss. During this procedure, inflow of blood into the liver is occluded through clamping of both the portal vein and hepatic artery in the hepatoduodenal ligament. This induces portal congestion in the splanchnic bed and causes collateral blood flow. Experimental and clinical studies have shown an association between the application of the Pringle manoeuvre and intestinal dysfunction.^{1,2} Herein, we present a case report showing intraoperative intestinal serosal microcirculatory alterations resulting from the Pringle manoeuvre.

A 51-year-old man with a history of chronic hepatitis B presented with hepatocellular carcinoma and was admitted to our department for elective extended right hepatectomy. During surgery, the patient received 1000 mL of colloids (Tetraspan 6%) to correct for blood loss, in addition to general fluid therapy. Systemic parameters such as heart rate, blood pressure and mean



Video 1 Clip of incident dark field imaging of the intestinal serosal microcirculation at the T0. A dense capillary networks can be seen on the serosal surface of the jejunum. Continuous flow of red blood cells is observed in nearly all vessels.

arterial pressure remained at an acceptable standard throughout surgery and there were no intraoperative complications.

Intestinal serosal microcirculatory monitoring (IntMiMo) was carried out using incident dark field (IDF) imaging (CytoCam, Braedius Medical, Huizen, The Netherlands). The CytoCam is a handheld video-microscope that emits light at 548 nm. This is absorbed by haemoglobin yielding

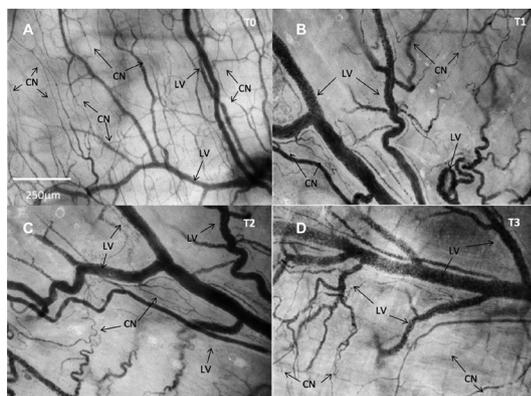
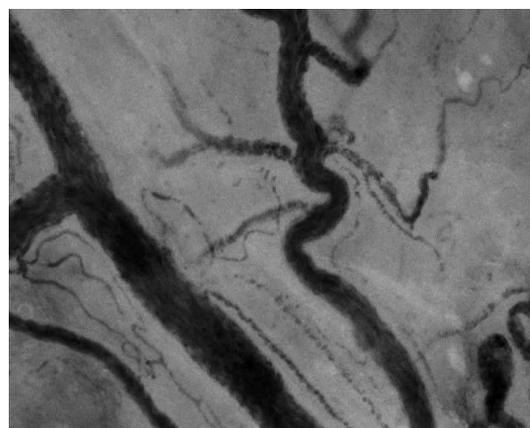


Figure 1 Screenshots of incident dark field imaging of the intestinal microcirculation at four different timepoints. The arrow heads indicate capillary networks (CN) and large vessels (LV). (A) Image acquired immediately following skin incision. Microcirculatory parameters: total vessel density (TVD) 33.75 mm/mm², perfused vessel density (PVD) 33.69 mm/mm², portion of perfused vessel (PPV) 99.81% and microvascular mean flow index (MFI) 3.0. (B) At the end of the Pringle, after 20 min of occlusion. Microcirculatory parameters: TVD 17.5 mm/mm², PVD 14.4 mm/mm², PPV 80.73% and MFI 2.25. (C) Immediately following release of the Pringle manoeuvre. Microcirculatory parameters: TVD 19.42 mm/mm², PVD 17.3 mm/mm², PPV 89.05% and MFI 2.5. (D) At the end of surgery, before skin closure. Microcirculatory parameters: TVD 13.67 mm/mm², PVD 11.19 mm/mm², PPV 81.35% and MFI 2.67.

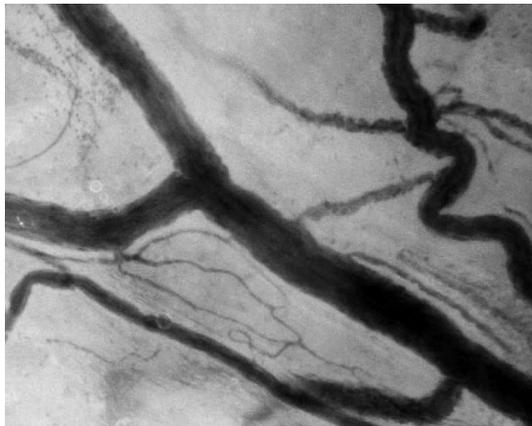


Video 2 Clip of incident dark field imaging of the intestinal serosal microcirculation at T1. The dense capillary network (CN) seen at T0 have dissipated and areas of malperfusion become visible. Blood flow in the CNs is sluggish and shows an intermittent pattern. Large vessels are dilated and showed increase in blood flow when compared with T0, such that individual red blood cells are no longer identifiable.



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To cite: Shen L, Uz Z, Ince C, et al. *BMJ Case Rep* 2019;**12**:e228111. doi:10.1136/bcr-2018-228111



Video 3 Clip of incident dark field imaging of the intestinal serosal microcirculation at T2 restoration of blood flow is observed in the capillary networks. In the large vessel, the blood flow has further increased when compared with that of T1, such that the red blood cells have adopted a stripe formation.



Video 4 Clip of incident dark field imaging of the intestinal serosal microcirculation at T3 Restoration of capillary networks is observed while larger vessels remain dilated. A greyish colour inside the vessels suggests dilution of red blood cells caused by the administration of colloids.

visibility to red blood cells (RBCs).³ The CytoCam was placed on the serosal surface of the jejunum 50 cm distally from the ligament of Treitz and IntMiMo was carried out at four different timepoints: immediately following skin incision (T0), at the end of the Pringle manoeuvre (after 20 min of occlusion) (T1), immediately after release of the Pringle manoeuvre (T2) and at the end of the operation before skin closure (T3). Analysis of IntMiMo was carried out offline using the software Automated Vascular Analysis V.3.0 (Microvision Medical, Amsterdam, The Netherlands).

The results showed a drop in microcirculatory density (total vessel density and perfused vessel density) and perfusion parameters (proportion of perfused vessels and microvascular mean flow index), between the baseline (T0) and the end of surgery (T3) (see legends of [figure 1](#) and [videos 1–4](#)). Alterations of the intestinal serosal microcirculation can also be assessed visually. The dense capillary networks seen at baseline (T0) dissipated following the occlusion and reperfusion (T1, T2, T3), revealing areas of malperfusion. The temporary acute rise in portal venous pressure during the Pringle manoeuvre may have further contributed to these alterations.² Following the administration of colloids, large plasma gaps and low RBC density became visible in the serosal microcirculation.

This report shows for the first time, intestinal serosal microcirculatory alterations in perfusion. Together with previous studies demonstrating intestinal epithelial damage and endotoxaemia subsequent to the Pringle manoeuvre,² the visualisation of the intestinal microcirculation can further aid in the understanding of the pathophysiological changes in the intestines following portal occlusion and allows monitoring of the patient's intestinal perfusion status during liver resection.

Patient was discharged after 16 days in hospital. On outpatient examination at follow-up, no further complications were found incurring that the observed intestinal microcirculatory alterations had resolved following surgery.

Learning points

- ▶ Intraoperative application of the Pringle manoeuvre causes intestinal microcirculatory alterations.
- ▶ Intestinal serosal microcirculatory monitoring allows additional checks on the patient's intestinal perfusion status during liver surgery.

Contributors LS was involved in the data collection of the microcirculatory images, the analysis of data using Automated Vascular Analysis and drafting of the final manuscript. ZU was also involved in the data collection, the interpretation of the collected data and drafting of the manuscript. CI gave critical intellectual insight and aided in the drafting and approval of the final manuscript. TvG was involved in the data collection and the design of the case report. He also gave critical feedback on the interpretation of data. He was also involved in the drafting and the approval of the final manuscript.

Funding The authors have not declared a specific grant for this research from any funding agency in the public, commercial or not-for-profit sectors.

Competing interests None declared.

Patient consent Obtained.

Provenance and peer review Not commissioned; externally peer reviewed.

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