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ΣΥΝΕΧΙΖΟΜΕΝΗ ΙΑΤΡΙΚΗ ΕΚΠΑΙΔΕΥΣΗ

Surgery Quiz – Case 45

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ΑΡΧΕΙΑ ΕΛΛΗΝΙΚΗΣ ΙΑΤΡΙΚΗΣ 2023, 40(5):713–715

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A 82-year-old male patient with a history of chronic atrial fibrillation and mechanical mitral valve replacement undertreated by coumarin anticoagulants presented to the emergency department with severe, poorly localized abdominal pain associated with clinical signs of peritonitis. No history of chronic postprandial abdominal pain was present. Crystalloid fluids resuscitation, nasogastric decompression and broad-spectrum antibiotics initiated. Laboratory tests revealed leukocytosis, elevated serum l-lactate and D-dimer levels. Prompt computed tomography angiography (CTA) performed which revealed an atherosclerotic aorta, no vascular calcifications at superior mesenteric artery (SMA) origin, the presence of thrombus in SMA 3–10 cm distal to its origin without enhancement of peripheral SMA branches, ileum and right colon wall thickening with reduction of enhancement and no free intraperitoneal fluid or air, suggestive of acute mesenteric arterial embolism.

Emergency laparotomy performed which revealed: (a) normal viable bowel extending 60 cm from ligament of Treitz; (b) a continual 80 cm bowel loop with threatened viability or critical ischemia based on surgical inspection (color, peristalsis, edema and mesenteric hemorrhage); (c) a non-viable bowel extending 140 cm from ligament of Treitz to the hepatic flexure. Resection of non-viable bowel (extensive enterectomy plus D1 right colectomy) along with retrograde SMA embolectomy performed. As after reperfusion the viability of the 80 cm threatened bowel remained questionable, fluorescence angiography with indocyanine green (ICG) performed. The ICG 25 mg vial diluted with 10 mL normal saline (2.5 mg/mL) and 3 mL (7.5 mg) administrated via a peripheral line followed by 10 mL normal saline flush.

Upon intravenous ICG injection, video documentation conducted using the 4K-NIR/ICG IMAGE1 S™ Rubina™ camera which revealed multifocal perfused patchy areas surrounded by sparsely non-perfused patchy areas, as shown in figure 1. Based on ICG angiography, the 80 cm bowel with questionable viability considered to have lesions of reversible ischemia and wasn't resected. However, construction of a jejunotransverse anastomosis considered unsafe and a transient end enterostomy performed.

What we could have done intraoperatively for better bowel viability assessment using ICG fluorescence angiography?

Comments

Acute mesenteric ischemia is a life threatening disease with high mortality. Intraoperative evaluation of bowel vitality is the most critical point of surgical treatment. However, clinical judgement including color, peristalsis, edema and mesenteric hemorrhage have low sensitivity and specificity. Therefore, objective tools to evaluate intestinal perfusion are necessary to set correctly the resection margins and to preserve bowel that has the potential to recover. ICG is a near-infrared fluorophore with an emission fluorescent intensity peak of 832 nm in whole blood. It is used primarily in the elective surgical setting for visual and quantitative evaluation of tissue perfusion in various fields. ICG utilization in the emergent setting, particularly in acute mesenteric ischemia, has not been well investigated to date, although experimental animal models, isolated cases and cohort studies show promising results.

Visual or qualitative ICG fluorescence bowel angiography reveals homogeneous perfusion pattern of the normal viable bowel and total perfusion defect pattern with no visible fluorescence signal of the non-viable bowel. However, visual ICG evaluation of bowel viability is difficult in areas with threatened viability or critical ischemia due to the variable degrees of fluorescent signals depending on the period of ischemia. In these areas with questionable viability, visual-only ICG fluorescence angiography can definitely answer the question of the presence or absence of perfusion; however, perfusion pattern differs substantially from the homogeneous perfusion pattern of the normal viable bowel and long-term viability remains questionable.

In grey areas with intermediate perfusion, quantitative ICG fluorescence angiography can supplementary be performed based on suitable quantification software programs at a predetermined time schedule such as: (a) at baseline, e.g. after entering the abdominal cavity during surgical inspection; (b) after reperfusion; (c) at endline, e.g. after surgical decision or before abdominal closure. At each time point, ICG fluorescence angiography should be performed with absolute dynamic analysis of fluorescent time-intensity curves (fig. 2). For example, a significant increase of mean fluorescent intensity

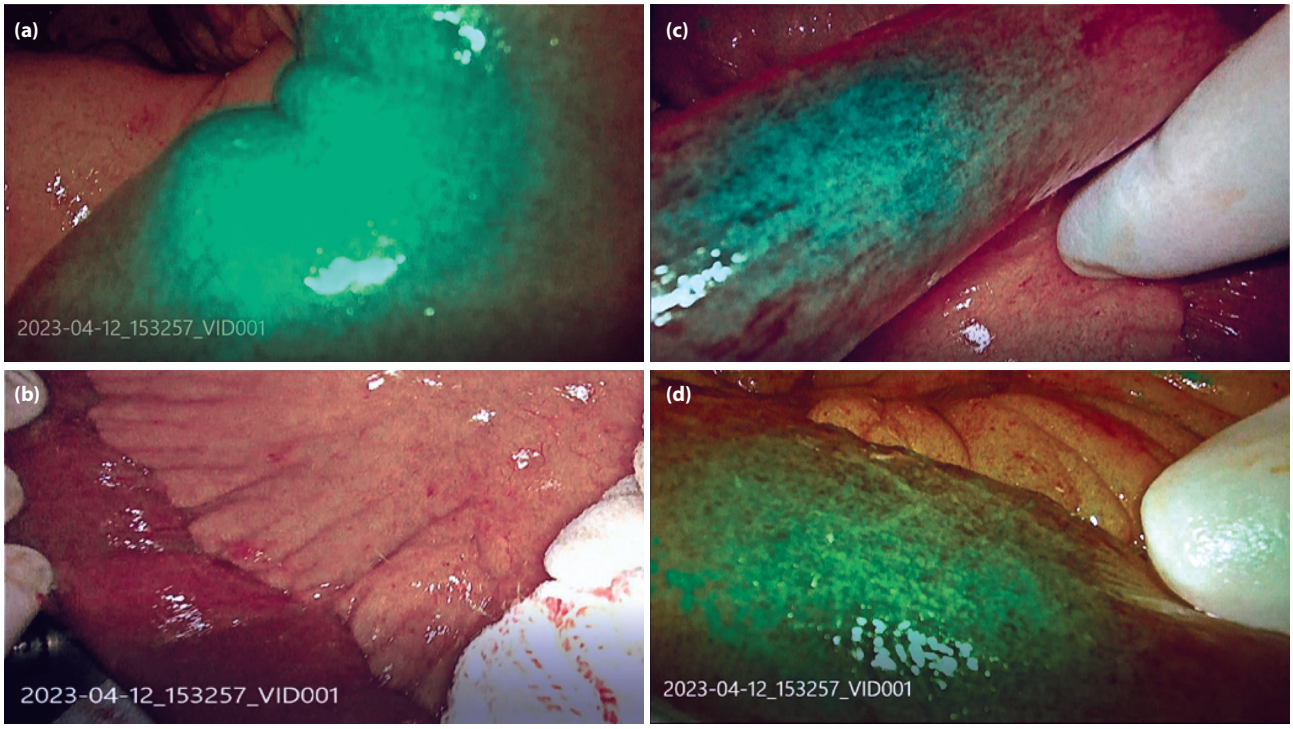

Figure 1. Photo documentation of **(a)** the normal viable bowel under fluorescence angiography with indocyanine green (ICG) with overlay mode showing the typical homogeneous perfusion pattern; **(b)** the bowel segment with questionable viability under standard white light showing discoloration, edema and mesenteric hemorrhage; **(c)** and **(d)** the bowel segment with questionable viability under ICG fluorescence with overlay mode at reperfusion phase 60 sec upon intravenous ICG injection showing multifocal perfused patchy areas surrounded by sparsely non-perfused patchy areas.

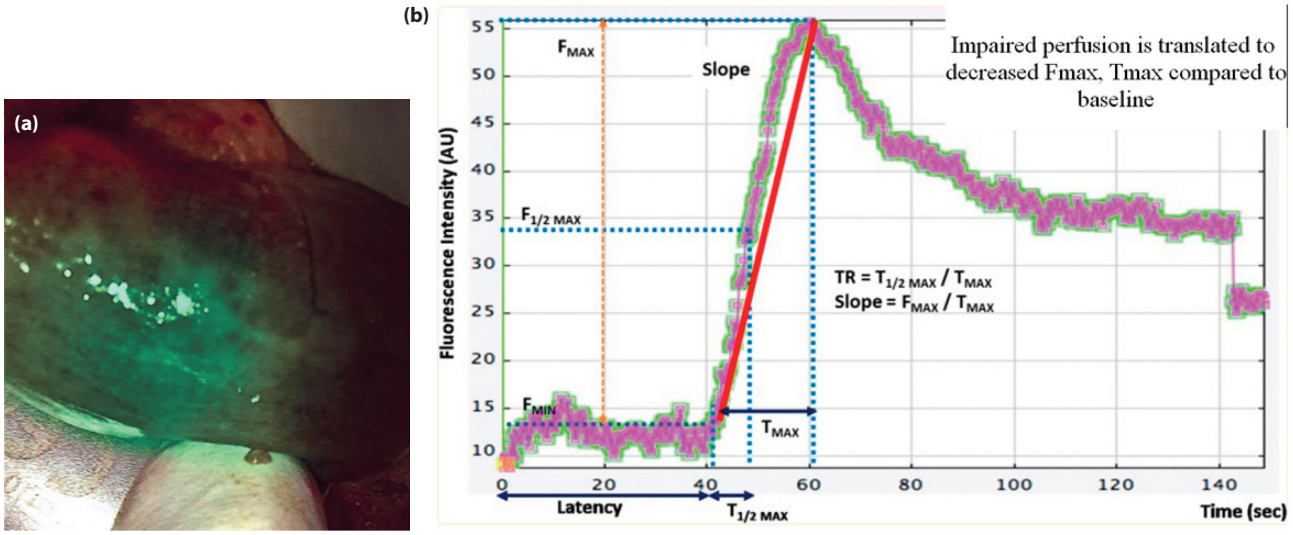

Figure 2. (a) Qualitative fluorescence angiography with indocyanine green (ICG) after reperfusion showing impaired perfusion of the bowel segment with questionable viability. In grey areas with impaired perfusion a shift from quality assessment to quantification is useful; **(b)** Schematic quantitative ICG angiography with absolute dynamic analysis of fluorescent time-intensity curve. Fluorescence intensity factors: fluorescence intensity at baseline (F_{MIN}), maximum fluorescence intensity (F_{MAX}), fluorescence difference (ΔF) between F_{MAX} and F_{MIN}, fluorescence slope (slope=$\Delta F/\Delta T=F_{MAX}/T_{MAX}$). Perfusion time factors: Time from first fluorescence increase to maximum (T_{MAX}), time from first fluorescence increase to half of maximum ($T_{1/2MAX}$), time ratio (TR=$T_{1/2MAX}/T_{MAX}$). Impaired perfusion is translated to lower F_{MAX} and T_{MAX} compared to baseline.

value 60 sec after ICG injection at reperfusion phase compared to baseline should be an important adjunct to surgical inspection for final surgical decision guidance. However, reliable quantitative analysis for predicting bowel perfusion is still not sufficient, and until now there have been many limitations in clinically applying the quantitative analysis of ICG fluorescence in the surgical field.

In our patient's case, qualitative ICG fluorescence angiography at reperfusion phase 60 sec after ICG injection revealed multifocal fluorescence perfused patchy areas surrounded by sparsely non-perfused patchy areas at the bowel segment with questionable viability. Qualitative ICG fluorescence angiography definitely answered the question of the presence perfusion. However, perfusion pattern differed substantially from the perfusion pattern of normal viable bowel and long-term viability remained questionable. In our patient's case, quantitative ICG fluorescence angiography could have been supplementary performed. Although surgical strategy wouldn't probably had changed, observation of a significant increase of mean fluorescent intensity value 60 sec after ICG injection at reperfusion phase compared to baseline would had been an important adjunct to our final decision.

In our patient's case, visual ICG angiography changed our surgical strategy; non-resection decided as perfusion was present and an end transient enterostomy performed instead of an anastomosis as long-term viability remained questionable. Postoperative period was uneventful. The patient submitted to our surgical unit hemodynamically stable. Nutritional support including parenteral, enteral, oral nutrition and coumarin anticoagulation with target international normalized ratio (INR) of 3.5 initiated within 72 hours. After performing endoscopic evaluation of the remaining bowel with normal macroscopic mucosal appearance, early bowel continuity restoration performed on postoperative day 22 with uneventful recovery.

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Diagnosis: *Switch from qualitative to quantitative fluorescence angiography with indocyanine green (ICG) at a predetermined time schedule based on a suitable quantification software program*