Diagnostic Green

CASE REPORT

Hepatic Segmentation using Positive Fluorescent Staining via Intra-hepatic Artery Indocyanine Green Injection

Yu-Yin Liu[1], MD, Michele Diana[2, 3, 4], MD, PhD

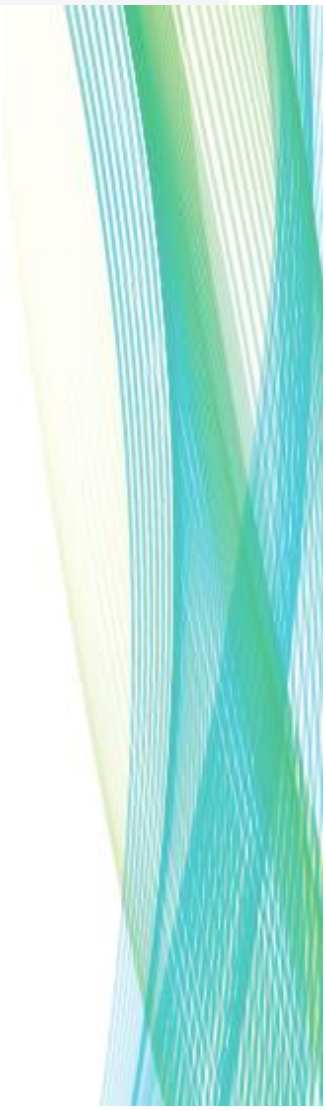
1 Department of general Surgery, Kaohsiung Chang Gung Memorial Hospital and Chang Gung University College of Medicine, Kaohsiung, Taiwan.
2 Department of General, Digestive and Endocrine Surgery, University Hospital of Strasbourg, France.
3 IRCAD, Research Institute against Digestive Cancer, Strasbourg, France. ICube Laboratory, Photonics
4 Instrumentation for Health, Strasbourg, France

Disclosures: Michele Diana is member of the Advisory Board of Diagnostic Green. Yu-Yin Liu has no conflicts of interest or financial ties to disclose.

Summary

An expanding number of hepatic resections are performed laparoscopically. However, the identification of the tumor location and the precise resection line are challenging in the minimally invasive setting. The hepatic artery supplies the hepatocellular carcinoma (HCC) and angiography can precisely localize the tumor position and the territory of the liver parenchyma. However, the angiographic information is displayed to the surgeon outside of the operative field and it may be difficult to exploit it as an intraoperative navigation tool. Near-infrared fluorescence (NIRF) optical imaging with indocyanine green (ICG) is increasingly used in several surgical procedures, as a real-time technology to guide surgical decision-making.[1,2,3,4] The intraoperative combination of angiography with NIRF imaging can transfer the angiography information directly to the operative field and provide real-time liver segmentation by means of positive staining.

To overcome the difficulties related to positive staining during laparoscopic surgery, our group first reported a selective intra-arterial ICG injection technique for fluorescent positive staining in the experimental model.[5] Here, we report a successful case of minimally invasive segmental hepatectomy guided by means of NIRF positive staining via a selective intra-arterial ICG administration.



Patient Background

A 67-year-old man (BMI of 23.8) with a past medical history of hepatitis B virus (HBV), presented with a 2cm liver tumor at segments 6/7 on the regular sonography follow-up. The alpha-fetoprotein (AFP) level was 2.5ng/mL. Computed tomography (CT) confirmed the presence of a 3cm hypervascular tumor at the boundaries of liver segments S6/7.

The case was discussed in the multidisciplinary tumor board and the patient was scheduled for a laparoscopic hepatectomy. The study protocol, approved the Ethical Committee of the Chang Gung Memorial Hospital, Kaohsiung in Taiwan and registered with ClinicalTrials.gov (NCT04266548) was presented to the patient who signed the informed consent.

Procedure

The procedure consisted of two steps, as follows:

Step I: *Endovascular procedure*
Under local anesthesia, a 4 French angiography sheath (Terumo Corporation, Japan) was inserted under aseptic conditions into the right femoral artery, following the Seldinger technique. A 4 French Cobra-2 catheter (Terumo Corporation, Japan) was positioned at the origin of the celiac trunk. A selective celiac trunk digital subtraction angiography (DSA) was performed, after administration of a contrast medium (Omnipaque, GE Healthcare, United Kingdom) at a rate of 4mL/sec and a total of 28mL. A 2.7 French micro-catheter (PROGREAT™, Terumo Corporation, Japan) was used to superselectively catheterize the hepatic segmental arteries, which perfuse the target segment including the HCC over S6/7 (Fig 1).

The correct position of the catheter (defined as the position in which the catheter was placed or proximal to the artery feeding the anatomical segment of the HCC) was confirmed by performing a DSA and an angio-CT with selective micro-catheter injections (Fig 2). The micro-catheter was then flushed with saline and left in place. After this procedure, the patient was transferred to the operating room, with the catheter in place.

Fig 1. S6/7 HCC tumor stain on angiography

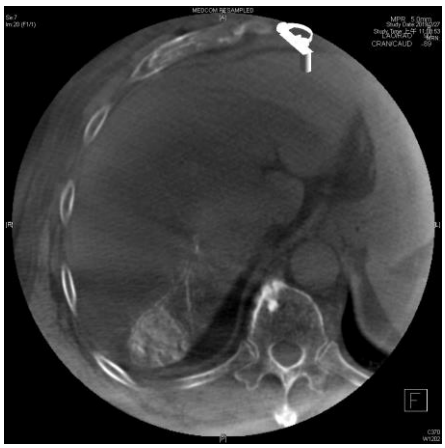


Fig 2. S6/7 HCC tumor CT angiogram

Procedure

Step II: *NIR-guided laparoscopic hepatectomy*
A 12mmHg pneumoperitoneum was established through the introduction of a Veress needle in the umbilicus. Five trocars were introduced under laparoscopic vision. The liver was mobilized and intraoperative ultrasound (IOUS) was used to localize the HCC over S6/7. The resection line with a 2cm free margin from the tumor was defined in conventional white light imaging based on the clinical evaluation and on intraoperative ultrasonography (IOUS).

The laparoscopic camera (PINPOINT PC9000 endoscopic fluorescence imaging camera, Stryker, United States) was switched to NIR mode and a bolus of 5mL of ICG at a concentration of 0.125mg/mL was injected via the catheter placed in the hepatic artery. The demarcation line of the corresponding liver segment could be clearly visualized based on NIRF imaging. The region of the tumor located in liver segments S6/7 turned fluorescent and matched the IOUS-guided resection plan (Fig 3), confirming the planned resection line. A laparoscopic hepatectomy was subsequently performed following the IOUS resection line by using the Pringle maneuver under vascular control. The micro-catheter and the femoral artery catheter were removed at the end of the surgical procedure.

The specimen presented a 30mm X 25mm X 24mm HCC. The minimal fluorescent margin was 1.5cm from the HCC (Fig 4). The patient was discharged 7 days after the operation without any surgical or angiography-related complications.

Conclusion

Near-infrared fluorescence angiography using intra-arterial ICG injection provides a real-time image-guided intraoperative demarcation of targeted liver segments. This method could help to define the resection line during laparoscopic liver surgery for HCC.

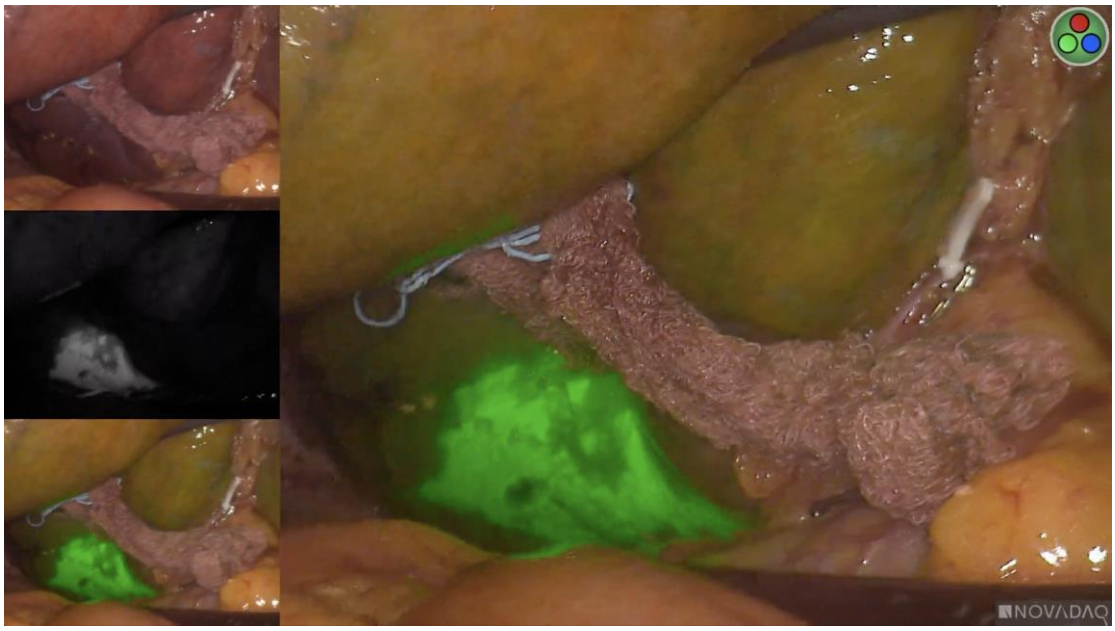


Fig 3. PINPOINT fluorescence image after ICG injection via superselective intrahepatic artery supplying the HCC. The enhanced liver area was covered with the IOUS-guided resection line.

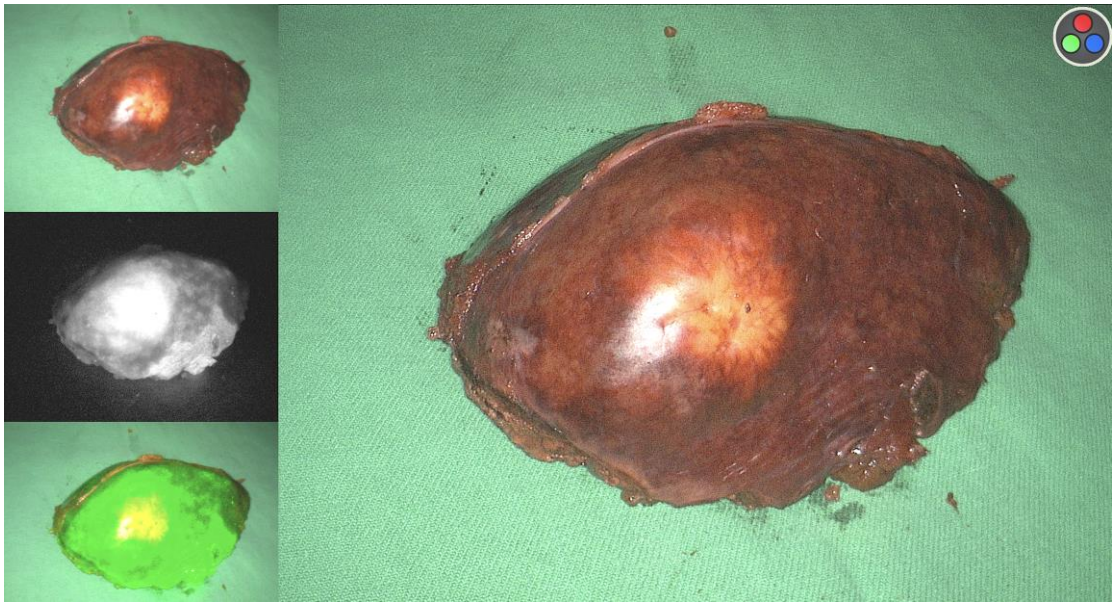


Fig 4. Specimen under white light and fluorescence image.

References

1. van Manen L, Handgraaf HJM, Diana M, Dijkstra J, Ishizawa T, Vahrmeijer AL, et al. A practical guide for the use of indocyanine green and methylene blue in fluorescence-guided abdominal surgery. J Surg Oncol. 2018;118(2):283-300.

2. Mascagni P, Longo F, Barberio M, Seeliger B, Agnus V, Saccomandi P, et al. New intraoperative imaging technologies: Innovating the surgeon's eye toward surgical precision. J Surg Oncol. 2018;118(2):265-82.

3. Baiocchi GL, Diana M, Boni L. Indocyanine green-based fluorescence imaging in visceral and hepatobiliary and pancreatic surgery: State of the art and future directions. World J Gastroenterol. 2018;24(27):2921-30.

4. Diana M. Enabling precision digestive surgery with fluorescence imaging. Transl Gastroenterol Hepatol. 2017;2:97.

5. Diana M, Liu Y-Y, Pop R, Kong S-H, Legnèr A, Beaujeux R, et al. Superselective intra-arterial hepatic injection of indocyanine green (ICG) for fluorescence image-guided segmental positive staining: experimental proof of the concept. Surg Endosc. 2017;31(3):1451-60.