



A novel suction–coagulation probe dedicated for robot-assisted hepatectomy: Early clinical series



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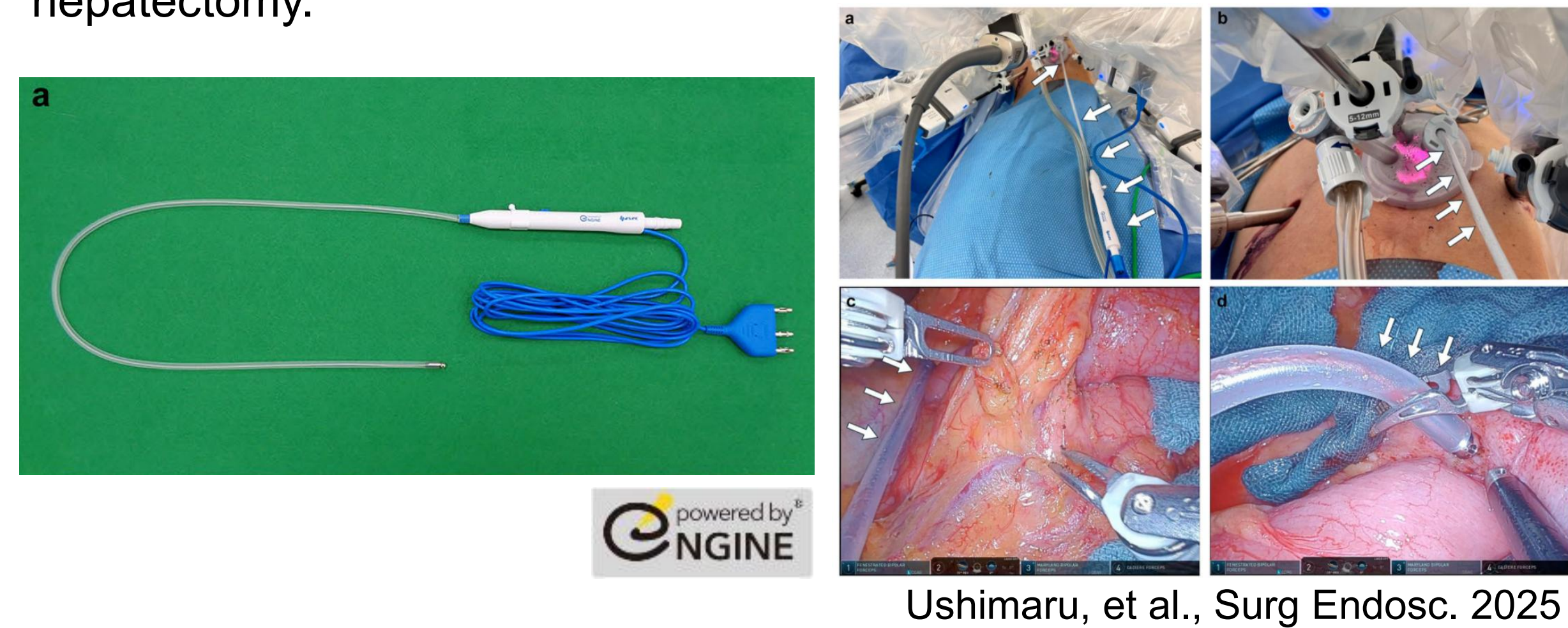
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Background

- Robot-assisted hepatectomy requires frequent suction and hemostasis during parenchymal transection. Conventional suction–coagulation probes (SBCs) enable simultaneous suction and coagulation but are limited by their rigid structure in robotic settings.
- To address this issue, we developed a novel flexible suction–coagulation probe (flex-SBC) that improves maneuverability while maintaining simultaneous suction and coagulation.
- Although its feasibility has been confirmed in robot-assisted gastrectomy, its utility in robot-assisted hepatectomy has not been investigated. Therefore, we evaluated the usefulness of the flex-SBC in robot-assisted hepatectomy.



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Patients and Methods

Study Design and Participants

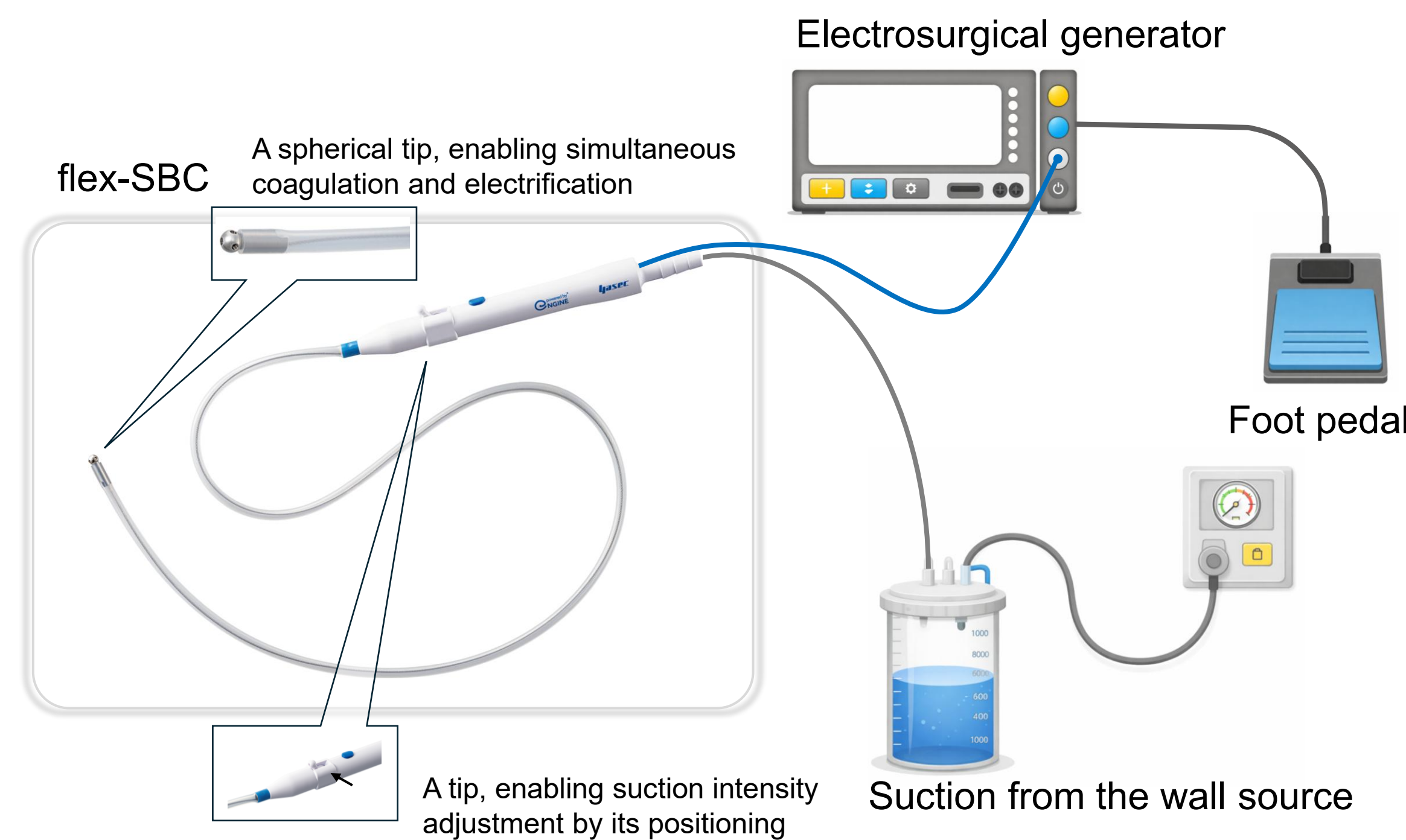
- This prospective study enrolled 12 consecutive patients undergoing robot-assisted hepatectomy for hepatocellular carcinoma (HCC), intrahepatic cholangiocarcinoma (ICC), or liver metastases at The University of Osaka Hospital.
- Robot-assisted hepatectomy was performed using either the da Vinci Xi surgical system (Intuitive Surgical, Sunnyvale, CA, USA) or the hinotori Surgical Robot System (Medicaroid Corporation, Kobe, Japan).
- The study was approved by the Institutional Review Board (No. 15145-4), and written informed consent was obtained from all participants.

Clinical Evaluation and Outcomes

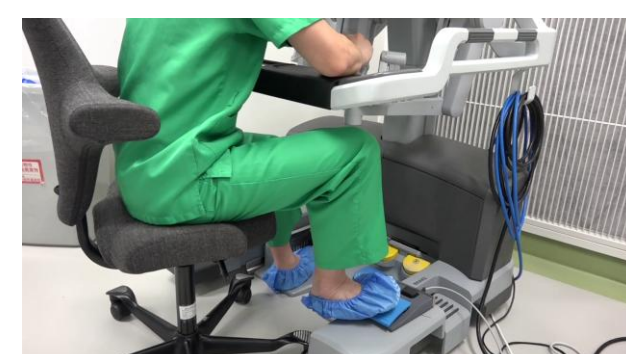
- Operative time, estimated blood loss, and postoperative complications (Clavien–Dindo classification ≥ grade II) were recorded as surgical outcomes.
- Immediately post-surgery, console surgeons evaluated the device across seven domains (e.g., maneuverability, suction/coagulation efficiency, and overall satisfaction) using a 3-point Likert scale (satisfactory, average, or unsatisfactory).

Flex-SBC Device and Setup

- The flex-SBC is a commercially available, Class II medical device in Japan (No. 226AFBZX00158000), designed as a 5-mm single-use flexible suction–ball coagulation probe.
- As a stand-alone instrument, it is not electronically integrated into the robotic system; instead, it is directly grasped and manipulated by the console surgeon using robotic forceps.
- For extracorporeal setup, the proximal end of the flex-SBC is connected to a standard electrosurgical generator via a monopolar output port and to a wall suction system via a conventional suction tube.



- The device is compatible with any standard electrosurgical generator equipped with a monopolar output, including commonly used systems such as the ERBE VIO series (ERBE Elektromedizin GmbH, Tübingen, Germany) and the Valleylab FT10 (Medtronic, Minneapolis, MN, USA).
- Coagulation: Activated by the console surgeon using a foot pedal pedal connected to the electrosurgical generator in very-low-voltage mode
- Suction: Continuously available and controlled by the console surgeon through the tip positioning, with intensity adjustments made by the bedside assistants as directed.
- A video showing intraoperative handling of the flex-SBC.



Results

Patient Demographics and Surgical Outcomes

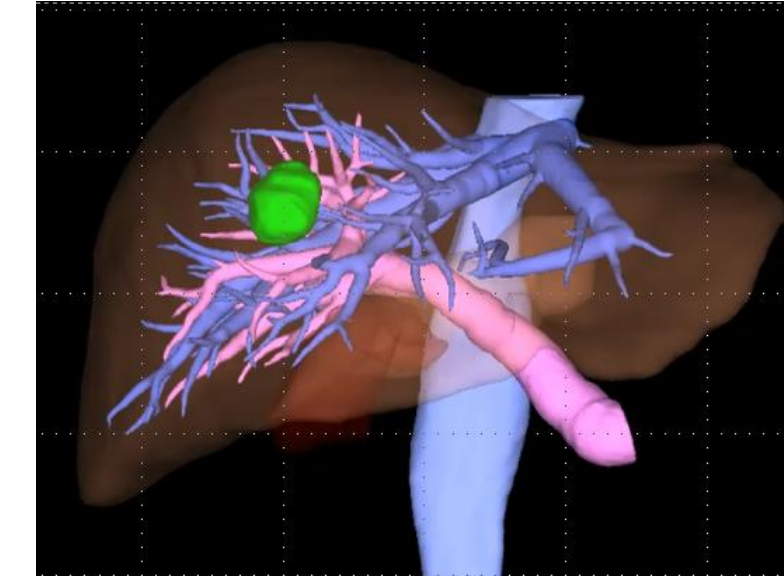
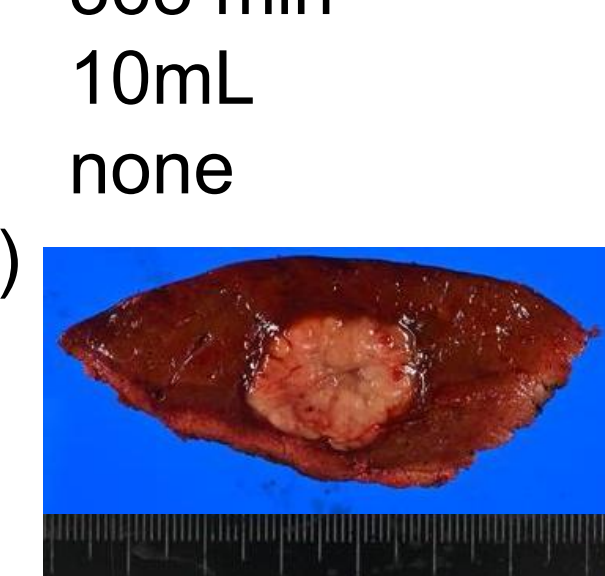
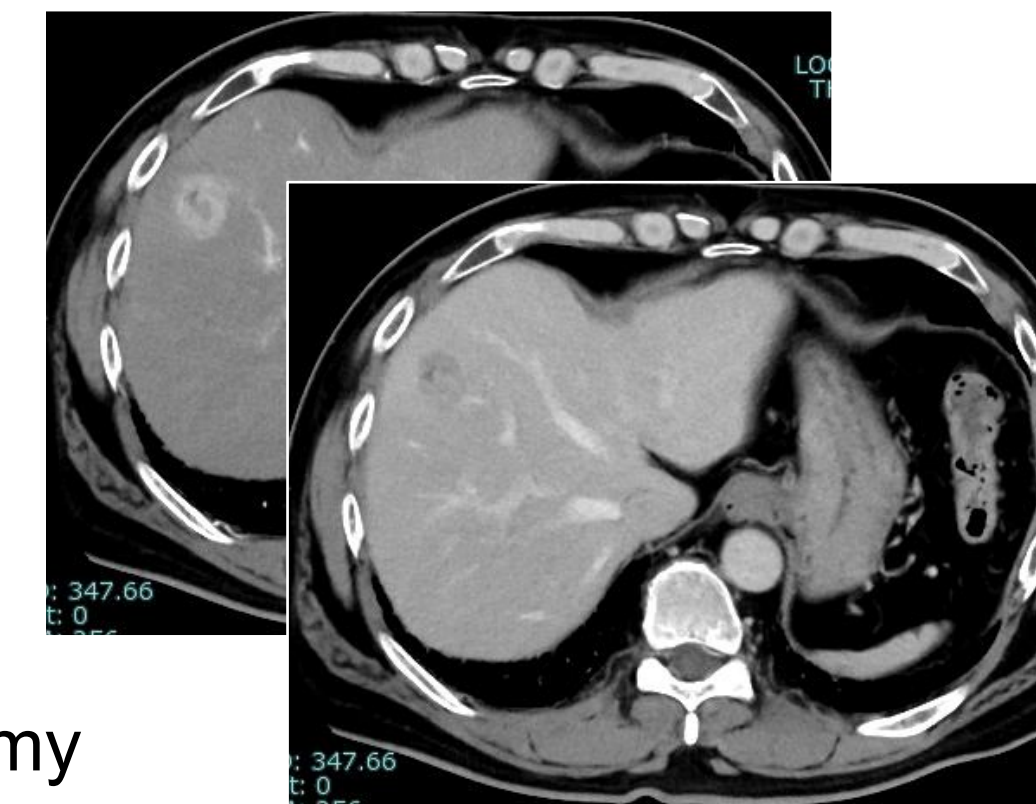
No.	Age (years)	Sex	Disease	No. of tumors	Tumor diameter (mm)	Child-Pugh classification	Non-cancerous liver tissue	Surgical procedure	Operative time (min)	Estimated blood loss (mL)	Postoperative complications	Device-related adverse events
1	84	Male	HCC	1	30	A	NL	S7 segmentectomy	409	320	None	None
2	79	Male	HCC	1	15	B	CH	S7 segmentectomy	461	260	None	None
3	87	Male	HCC	1	50	A	CH	Extended S8 segmentectomy	386	270	None	None
4	56	Female	ICC	1	15	A	NL	Left hepatectomy	312	20	None	None
5	76	Male	Liver metastasis	2	12, 20	A	NL	S2, S7 partial hepatectomy	518	210	None	None
6	66	Male	HCC	1	15	A	NL	S1 partial hepatectomy	256	50	None	None
7	66	Male	HCC	1	25	A	NL	S8 segmentectomy	363	10	None	None
8	69	Male	HCC	1	18	A	NL	S2/3 partial hepatectomy	295	0	None	None
9	67	Male	Liver metastasis	1	20	A	NL	Left hepatectomy, S7 partial hepatectomy	543	0	None	None
10	72	Male	Liver metastasis	3	8, 5, 45	A	NL	S4, S5, S6/7 partial hepatectomy	678	170	None	None
11	80	Male	HCC	1	80	B	CH	S2 segmentectomy	421	250	None	None
12	29	Male	HCC	1	20	A	NL	S2 partial hepatectomy	301	0	None	None

CH, chronic hepatitis; Flex-SBC, flexible suction-coagulation probe; HCC, hepatocellular carcinoma; ICC, intrahepatic cholangiocarcinoma; NL, normal liver.

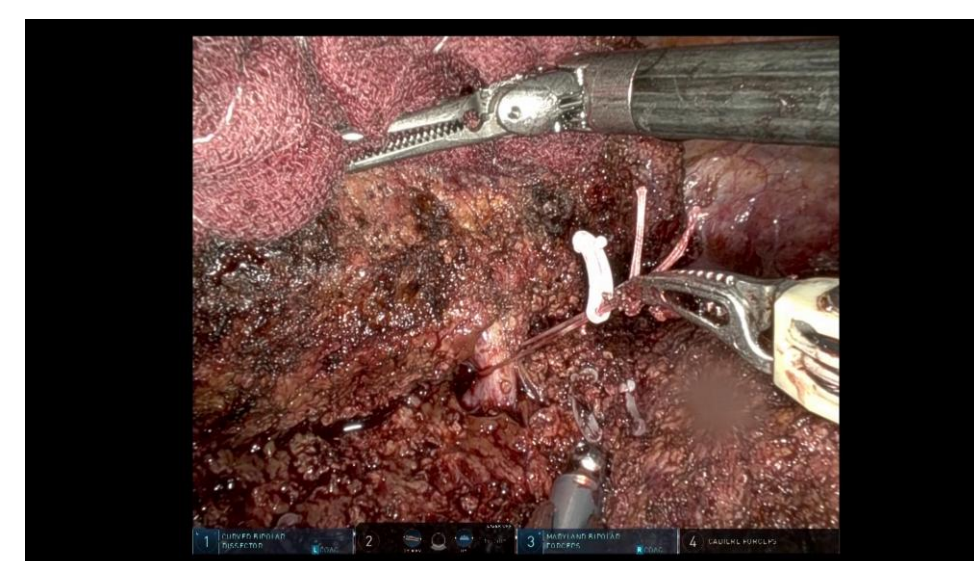
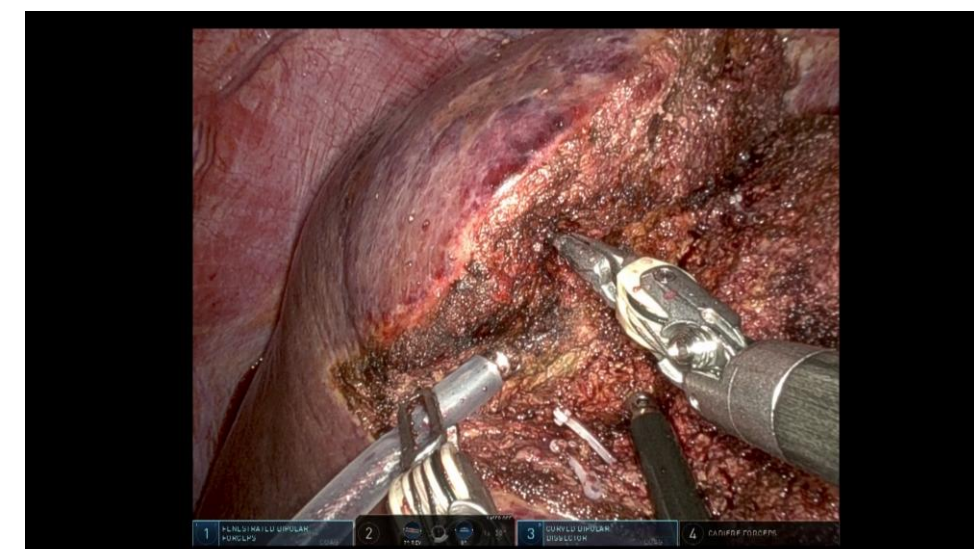
Case Presentation

- 66 years, male
- HCC (S8, solitary, 25mm)
- HBs Ag (+)
- Child-Pugh A, Liver damage A
- Platelet $26.7 \times 10^4/\mu\text{L}$, ICG-R₁₅ 10%

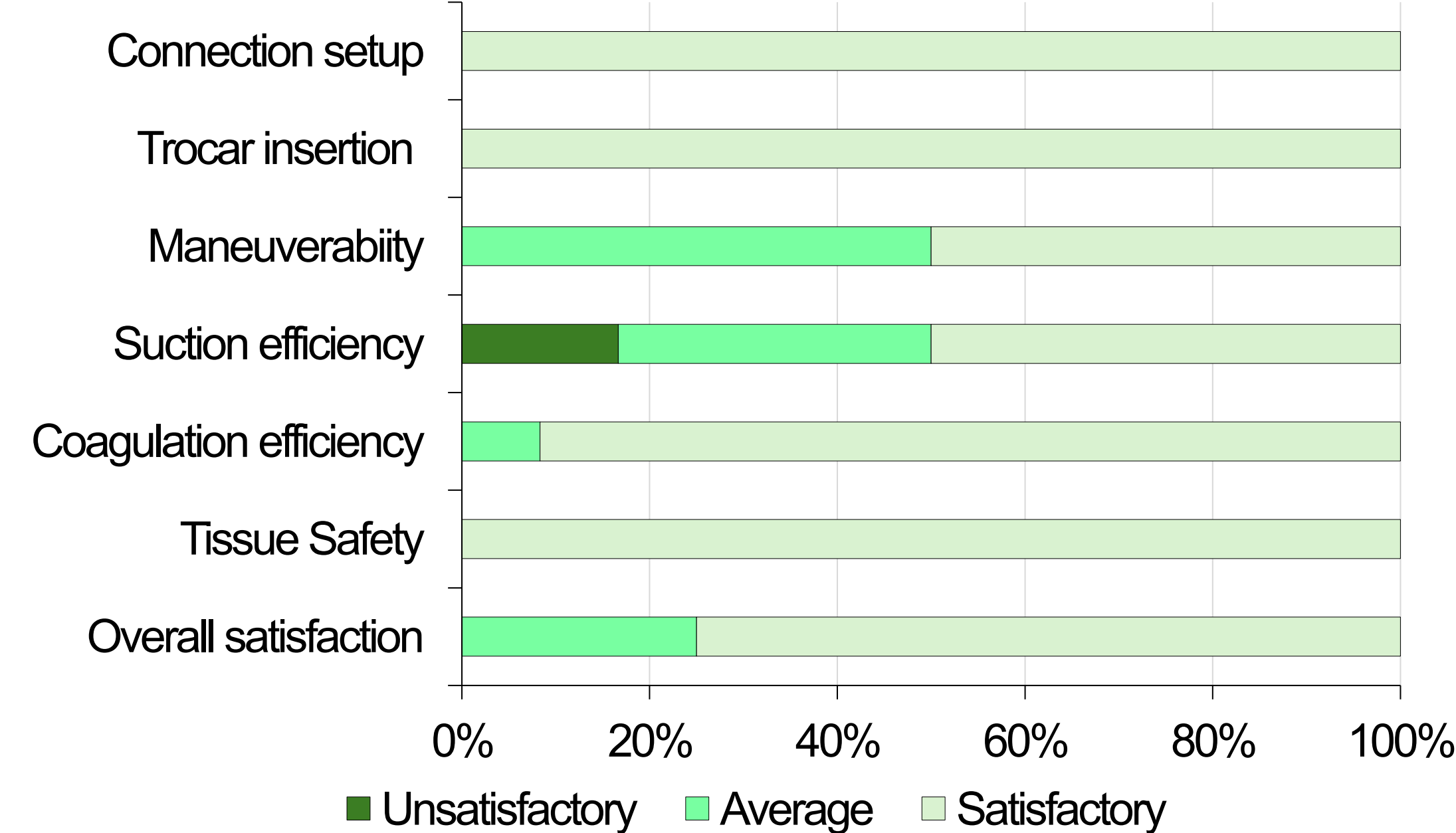
- Surgical procedure Robot-assisted S8 segmentectomy
- Operative time 363 min
- Estimated blood loss 10mL
- Postoperative complication none
- Histology HCC, margin (-)



- Intraoperative videos



Surgeon Questionnaire Results



- Among 12 successful robot-assisted hepatectomies with no conversions or complications, the median blood loss was 110 mL and the flex-SBC demonstrated versatile utility in both active coagulation and passive tissue retraction.
- While suction efficiency was rated "unsatisfactory" in 16.7% of chronic hepatitis cases, overall surgeon satisfaction was 100% "satisfactory" or "average," confirming the device's clinical feasibility.

Conclusion

Based on the surgical outcomes and surgeons' feedback, flex-SBC was considered a practical option in robot-assisted hepatectomy, maintaining hemostatic performance and providing ergonomic advantages. The unsatisfactory rating in suction suggests a potential for future improvement.