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Clinical Technology

Pioneering case: Robot-assisted remote radical distal gastrectomy for gastric cancer based on 5G communication technology

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ABSTRACT

Background: The aim of this study is to describe technical considerations and short-term outcomes of the first officially published robot-assisted remote radical distal gastrectomy for gastric cancer with 5G technology.
Methods: A 51-year-old gastric cancer patient with clinical stage T2N0M0 underwent 5G-enabled robot-assisted remote radical distal gastrectomy on September 11, 2023 at the Third Department of Surgery, the Fourth Hospital of Hebei Medical University.
Results: The surgery procedure was successfully performed with an average total intraoperative delay of 225 ms, average round-trip delay of 30 ms and no packet loss rate. The operative time was 140 min and intraoperative blood loss was 20 ml. The patient was discharged on postoperative day 6 without any postoperative complications.
Conclusion: This case has preliminarily verified the feasibility and safety of 5G-enabled robot-assisted remote radical distal gastrectomy for patients with gastric cancer. The initial study fills in the gaps in related fields and lays a solid foundation for subsequent research. To verify its superior operative outcomes, further clinical trials are needed.

1. Introduction

Remote surgery is pivotal in addressing the global disparity in medical resources, a particularly acute issue in nations such as China. It provides superior medical services to isolated regions, thereby enhancing healthcare standards.[1] The 'Lindberg operation' in 2001 was a significant milestone in remote surgery,[2] although initial progress was impeded by limitations in network technology. The advent of fifth-generation (5G) wireless communication, characterized by its high speed, low latency, and large capacity, has substantially advanced remote surgery.[3]

Robotic-assisted gastrectomy, first used in 2002, is now prevalent in treating gastric cancer. Compared to conventional open and laparoscopic surgeries, it facilitates quicker postoperative recovery, less inflammation, and fewer complications.[4,5] The fusion of robotic surgery systems with 5G technology is increasingly being adopted in urology and orthopedics, showcasing its efficacy.[6–8] Nonetheless, its application in gastric surgery is still emerging, primarily focusing on animal and cadaveric studies.[9,10]

This study presents a case of a gastric cancer patient undergoing remote radical distal gastrectomy using the Toumai robotic surgical system and 5G technology at the Fourth Hospital of Hebei Medical University on September 11, 2023. A comprehensive search conducted by the Hebei Province Institute of Scientific and Technical Information

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yielded no relevant reports. This is the inaugural instance of such technology being applied to a gastric cancer patient in a clinical environment, signifying a notable progression in the use of remote surgery for gastric cancer treatment.

2. Methods

2.1. Case presentation

The patient, a 51-year-old female, presented to our hospital with a one-year history of intermittent melena and occasional symptoms of acid reflux. After coming to our hospital, the abdominal enhanced computed tomography (CT) scan revealed localized thickening in the gastric angle, indicating a clinical stage of T2N0M0 (Fig. 1a). Gastroscopy identified a 2-cm ulcerated lesion at the gastric angle (Fig. 1b). Histopathological examination confirmed adenocarcinoma upon biopsy analysis. Other preoperative examinations yielded unremarkable results. The physical examination was negative. Systematical evaluation was performed on the patient's physical status before surgery. The patient has a body-mass index (BMI) of 20.8 kg/m^2, with an Eastern Cooperative Oncology Group score of 1 and an American Society of Anesthesiologists score of 2, which indicated that the patient could tolerate the operation.

2.2. Robot equipment and network preparation

The domestically produced Tuomai four-arm laparoscopic robotic surgery system (Shanghai MicroPort Medical Robot Co., Ltd., MT-1000, China) was utilized. The patient surgery platform and the imaging platform were located at the main campus of the Fourth Hospital of Hebei Medical University (the slave unit), while the surgeon console was situated at the branch campus (the master unit). Both the imaging platform and the surgeon console were equipped with remote communication workstations to facilitate remote communication. Connection between the robotic surgeon console and the patient surgery platform was established via a public 5G wireless network (China Mobile) and 5G customer premise equipment (CPE) (Fig. 2). Network latency and packet loss were monitored in real-time using the User Datagram Protocol (UDP), recording the total network delay, average round-trip delay and packet loss rate. As a contingency for ensuring surgical safety, wired network transmission technology was available as an alternative network connection in case of 5G wireless network failure.

2.3. Surgical techniques

The 5G remote distal radical gastrectomy was performed by Professor Qun Zhao with over 400 cases experience of robotic surgery. Before the

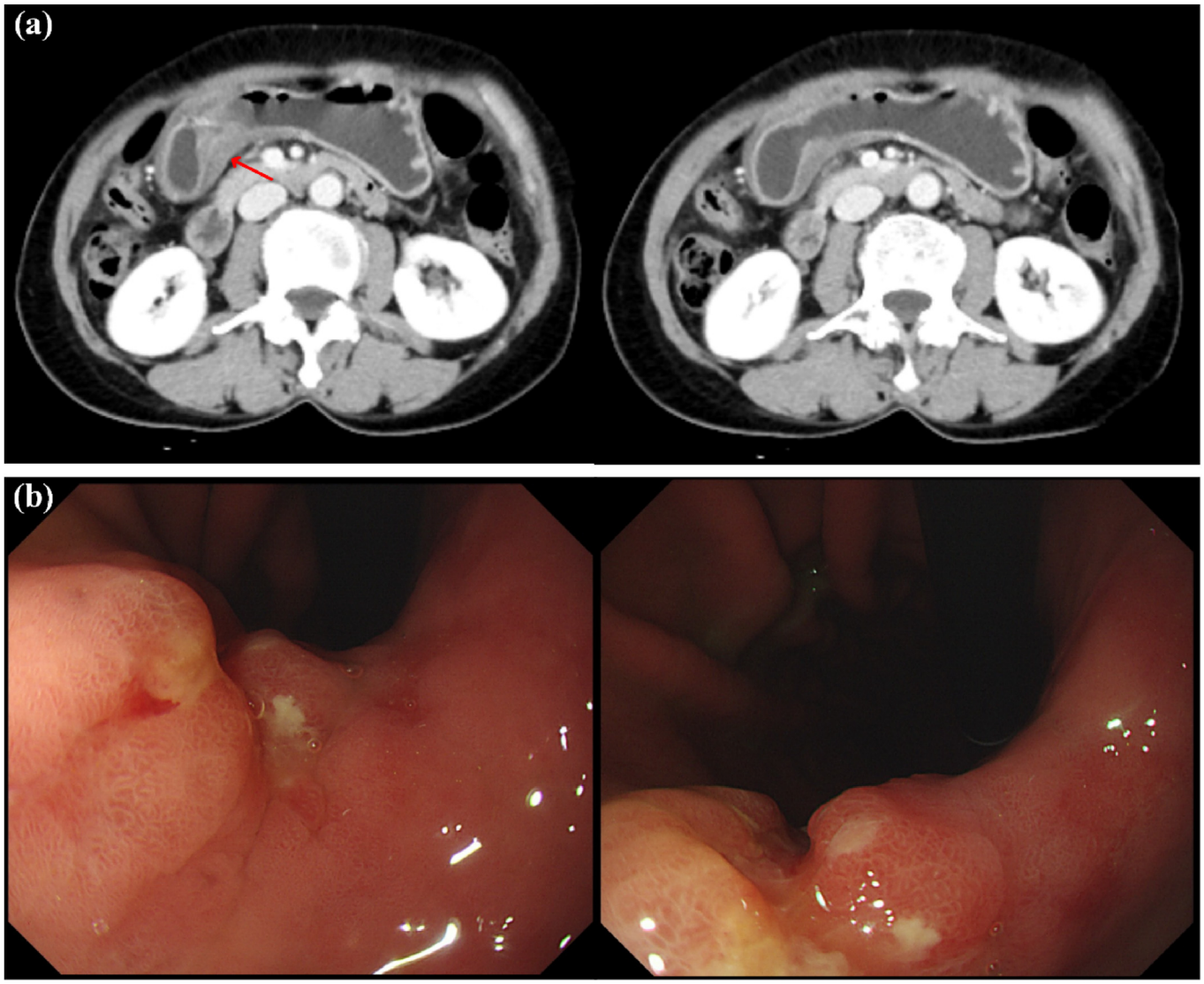

Fig. 1. Preoperative examination. (a) The enhanced computed tomography (CT) images. (b) The gastroscopy images.

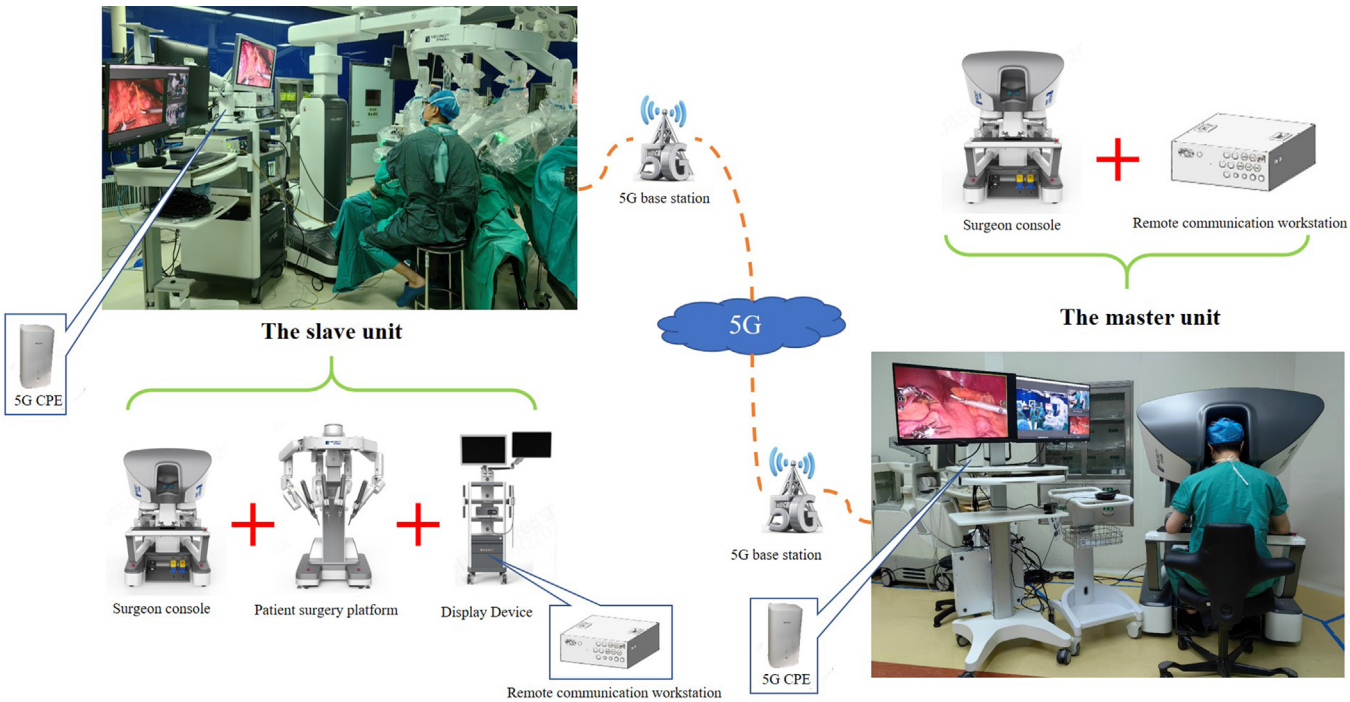

Fig. 2. Network configuration and remote surgery platform.

surgery, we ensured optimal network conditions and precise calibration of the robotic system. The patient received general anesthesia and was positioned supine in a lithotomy posture, with the head and left side elevated by 15° each. We adopted a 'smile-shaped' five-port Trocar layout for the procedure, as illustrated in Fig. 3. The surgical steps followed a modular sequence developed by our center, aiming to reduce stomach manipulation and unnecessary movements of the mechanical arm and camera. This approach improved procedural flow.

The surgical steps, detailed in Fig. 4, were as follows: (I) Dissociation of the lesser omentum and liver suspension using a pouch pin. (II) Ligation and division of the right gastric vessel, with dissection of No.5 and No.12a lymph nodes. (III) Dissociation of the lesser curvature of the stomach and dissection of No.1 and No.3 lymph nodes. (IV) Ligation and division of the right gastric omental vessel and the inferior pylorus artery, followed by dissection of No.6a lymph nodes. (V) Division of the duodenal bulb using a linear stapler inserted through the assistant trocar. (VI) Dissection of No.7, No.8a, No.9, and No.11p lymph nodes in the upper pancreatic area, with ligation and division of the coronary vein and left gastric artery. (VII) Ligation and division of the left gastric omental vessel and dissection of No.4sb lymph nodes. (VIII) Resection of the stomach by transecting from the greater to the lesser curvature using two linear staplers. (IX) Location of the jejunum 20 cm from the Treitz ligament and incision of the intestinal wall opposite to the mesangial margin. Side-to-side anastomosis of the small intestine with the remnant stomach's greater curvature was performed using a linear stapler (Billroth II anastomosis). 3-0 barb line suture was used to close the common stab and reinforce gastric closure margin. (X) Incisions in the proximal and distal jejunum 20 cm below the gastrojejunostomy, followed by a side-to-side jejunojejunostomy using a linear stapler. Closure of the common stab was achieved with 3-0 barb line sutures (Braun's anastomosis). Finally, a drainage tube was placed adjacent to the Billroth II anastomosis through the R1 incision in the upper right quadrant.

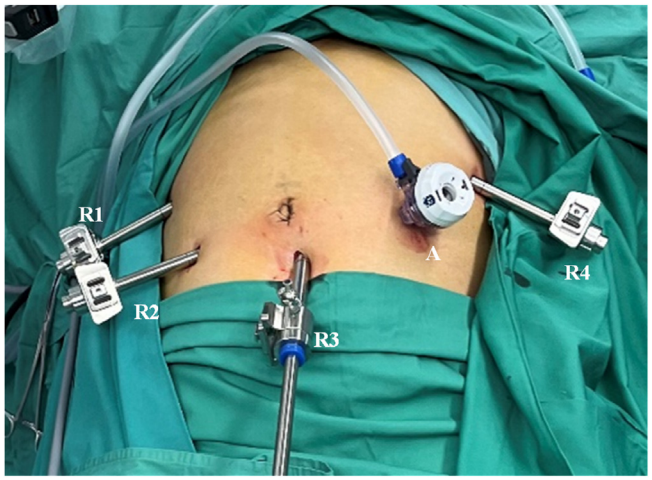

Fig. 3. Trocar layout (the Toumai Surgical System).

2.4. Perioperative outcomes

The results were as follows. Successful performance of the 5G remote robotic surgery with an average total intraoperative delay of 225 ms, average round-trip delay of 30 ms and no packet loss rate. The operative time was 140 min and intraoperative blood loss was 20 ml. The patient began oral water intake on postoperative day 2 and transitioned to a liquid diet on day 3. The right infrahepatic drainage tube was removed on postoperative day 5, and the patient was discharged on postoperative day 6 without any postoperative complications. Postoperative pathology showed adenocarcinoma invasion the superficial muscular layer, and a total of 46 lymph nodes were detected with one lymph node metastasis in No. 3. The four incisions each measured 1 cm, and one incision measured 4 cm, as showed in Fig. 5. As of January 2024, the patient is currently undergoing adjuvant chemotherapy.

3. Disscussion

The integration of 5G technology in remote surgery, particularly in the domain of gastric cancer treatment, marks a significant leap forward. This technological advancement addresses critical challenges in medical

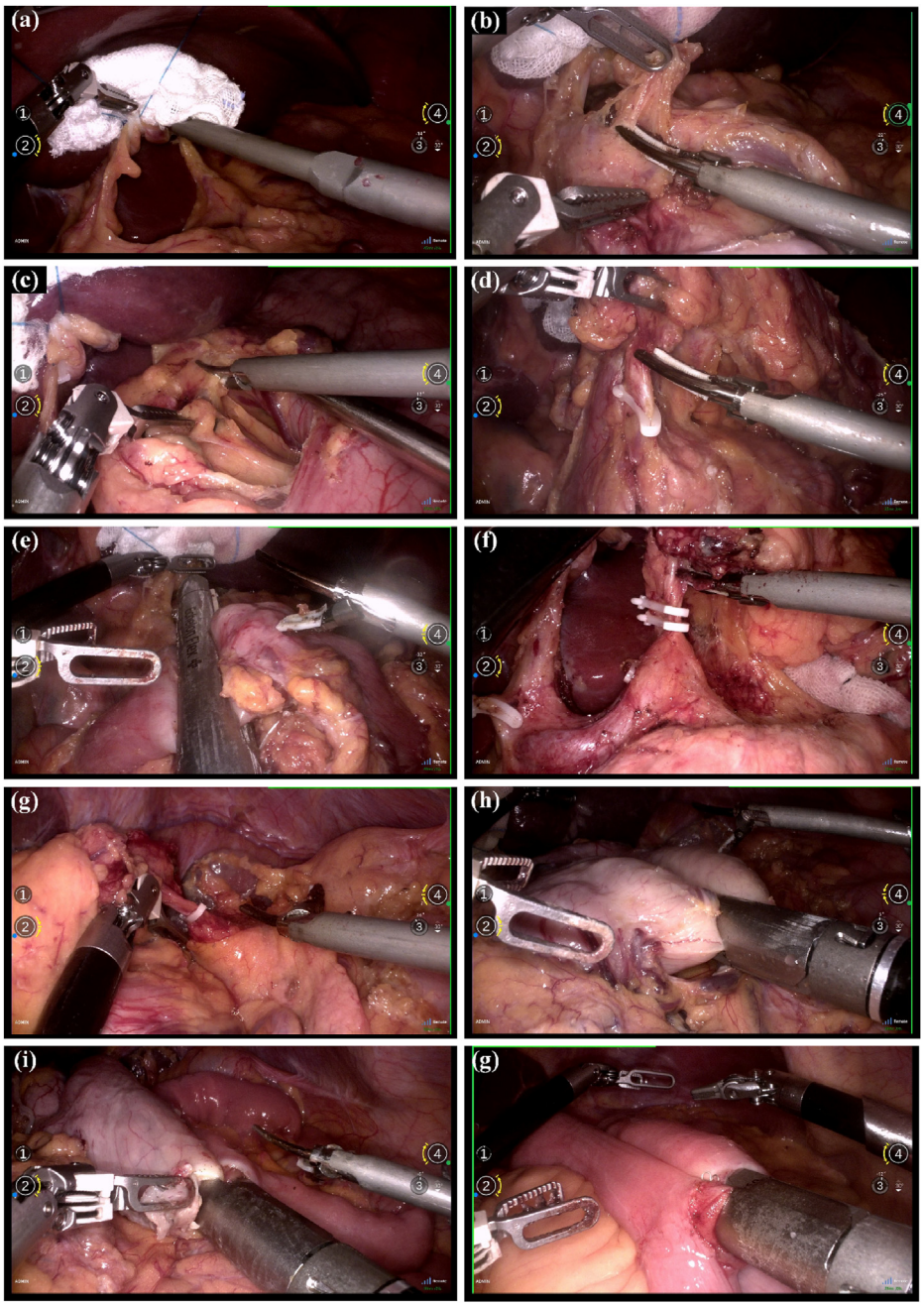

Fig. 4. The surgical procedure steps. (a) Suspension of the liver. (b) Dissociation of RGV &A and dissection of No.5, No.12a Lymph node. (c) Dissection of No.1, No.3 Lymph node. (e) Division of REGV &A and dissection of No.6 Lymph node. (f) Dissection of the duodenum. (g) Dissection of No.7, 8a, 9,11p Lymph node and division of LGA. (h) Dissection of No.4sb Lymph node. (i) Dissection of the stomach. (g) Billroth II anastomosis. (k)Braun's anastomosis.

resource distribution, especially in regions with limited access to specialized healthcare. This is particularly prevalent in China, where gastric cancer incidence and mortality rates are high, and there is an imbalance in diagnosis and treatment resources, especially in remote and underserved areas.[11–13]

In this case, our data have demonstrated the safety and feasibility of 5G-enabled robot-assisted remote radical distal gastrectomy. The remarkably low intraoperative delays and absence of packet loss are indicative of the reliability and efficiency of 5G networks in real-time, high-stakes medical procedures. The surgical outcomes of this procedure, including operation time, intraoperative blood loss, postoperative recovery, complications, and number of lymph nodes harvested, are comparable to those of common robot-assisted distal radical gastrectomy. Additionally, the operation showcased the potential of the Toumai robot system, augmented with communication technology, to facilitate remote surgical operations. This has implications for enhancing medical resource utilization, enabling physicians to perform surgeries remotely and reducing the need for travel. The success of these procedures also hinges on the expertise of the surgical team.

In addition to the network quality and the stability of the robotic surgical system, the surgeon's experience and surgical procedure optimization are critical in ensuring patient safety during remote surgery. The surgeon in this study, with over 400 cases of robotic surgery experience, possesses the skills required to effectively handle emergency situations during operations. Despite network delays, the surgeon could adeptly complete the necessary procedures. Moreover, the surgical procedure was conducted in a modular sequence, reducing the frequency of stomach manipulation, mechanical arm and camera movements, thereby

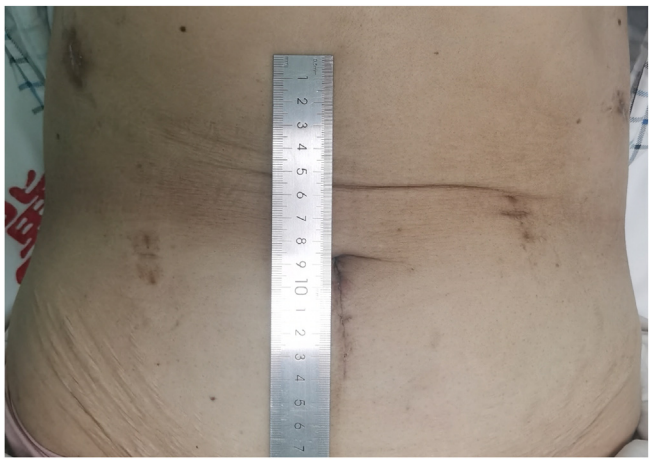

Fig. 5. The postoperative incision.

improving the procedural flow.

This is the initial clinical experience of 5G remote robot-assisted radical gastrectomy for patient with gastric cancer. This case has preliminarily verified the feasibility and safety of this technology and lays a solid foundation for subsequent research. Nonetheless, this study had several limitations. The current procedure was conducted solely by one expert surgeon on a single case, raising questions regarding its generalizability. Additionally, due to the short follow-up time, long-term survival analysis was not feasible. Further clinical trials are necessary to validate the efficacy and safety of this approach. A comparative study on a larger scale is ongoing.

Ethical statement

The study was approved by the Fourth Hospital of Hebei Medical University ethics committee, and informed consent was obtained from the patient.

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CRediT authorship contribution statement

Honghai Guo: Writing – original draft, Formal analysis, Data curation. **Yuan Tian:** Writing – original draft, Project administration. **Jia Shi:** Writing – review & editing. **Peigang Yang:** Formal analysis, Data curation. **Jiaxuan Yang:** Formal analysis, Data curation. **Pingan Ding:** Formal analysis, Data curation. **Xuefeng Zhao:** Supervision, Data curation. **Zhidong Zhang:** Supervision, Data curation. **Qun Zhao:** Writing – review & editing, Supervision, Project administration, Investigation, Funding acquisition, Data curation.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper. Jia Shi is an editor for Intelligent Surgery and was not involved in the editorial review or the decision to publish this article.

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