Safety and Reliability of a Robot-assisted Laparoscopic Telesurgery System: Expanding Indications in Urological Surgery

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With the rapid development of surgical robotics and communication technology in recent years, new telesurgery opportunities have emerged that overcome the spatial limitations of surgeons and may contribute to development of the metaverse [1,2]. However, the safety and reliability of these telesurgery systems remain unclear. The current study was

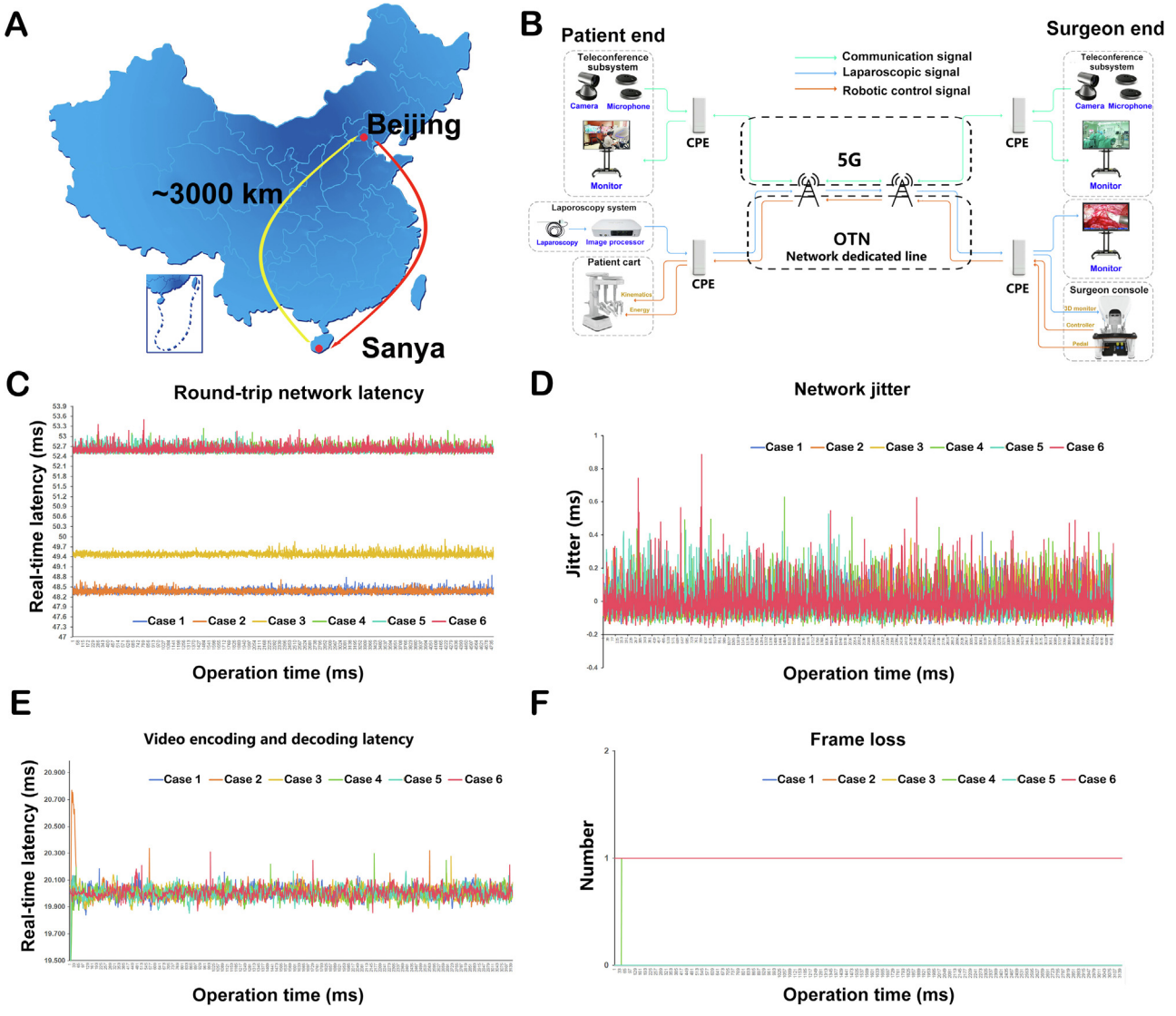

Fig. 1 – (A) Location of the two hospitals in Beijing and Sanya. The one-way communication distance is approximately 3000 km. (B) Schematic of the telesurgery system. A complete surgical robotic system consisting of a console and a robot arm system was installed in each hospital. The telecommunication system for the robotic set-up used a level AAA optical transport network (OTN) dedicated line with bandwidth of 60 Mbps, characterized by low latency and high reliability and security. The teleconference system used the 5G wireless network for communication between the first surgeon and the assistant and for real-time imaging of the operating room and the first surgeon. (C)The real-time round-trip network latency was between 48.37 and 52.20 ms. (D) Network jitter was <1 ms. (E) The latency for video encoding and decoding was stable at ~20 ms. (F) Frame loss was not observed or was less than one frame. CPE = customer premises equipment.

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conducted after a series of animal experiments. The study protocol was registered at ChiCTR.org (ChiCTR2300074761) and approved by the institutional ethics committee. Patients signed informed consent forms that contained information regarding the potential risks of telesurgery.

We conducted telesurgery between two hospitals located in Beijing and Sanya, with a round-trip communication distance exceeding 6000 km. The telesurgery system consisted of a surgical robotic system, a teleconference system, and a telecommunications system, which used a main optical transport network dedicated line along with a backup one. A complete MP1000 surgical robotic system (Shenzhen Edge Medical Company, Shenzen, China) was installed at each hospital (Fig. 1A, B). If the telesurgery system breaks down, the local surgeon can control the robot via the local surgeon console, taking into consideration the ethics and safety involved.

Organs of the urological system are distributed throughout various regions of the posterior abdominal cavity, with diverse and complex anatomical structures and adjacent organs. Therefore, exploring the application of telesurgery for different organs is of practical significance. For this study, we recruited six patients diagnosed with a retrocaval ureter, renal cancer, prostate cancer, and adrenal tumor. All telesurgery operations were successfully performed by two surgeons without a need for conversion to local robot control. In our experience, the intracavity operation time and postoperative follow-up data, including Quality of Recovery 15 (QoR15) scores [3], were similar to those for local operations. Except for patient 1, all patients were discharged as normal from our hospitals. No Clavien-Dindo complications higher than grade II were observed at 2-wk follow-up (Supplementary Table 1).

Latency is a critical factor affecting the applicability of telesurgery systems [4]. Our previous animal research revealed that total latency of 320 ms had no obvious significant influence (manuscript under review). In this study, the real-time round-trip network latency ranged from 48.37 to 52.20 ms, with jitter of <1 ms (Fig. 1C, D). The latency for video encoding and decoding remained stable at ~20 ms (Fig. 1E). Total latency, consisting of round-trip network latency, video encoding/decoding latency, and robot master-slave latency, was between 168.37 and 172.20 ms. Frame loss was not observed or was one frame among all six operations (Figure 1F). Results for the NASA Task Load Index [5] and the scale used to test subjective feelings regarding the telesurgery system showed that the telesurgery operation had no obvious impact on task load or the subjective feelings of the surgeons (Supplementary Fig. 1). Overall, our results demonstrate the reliability of the telesurgery system.

In conclusion, six urological telesurgeries involving four urological organs and five different operation types were successfully performed, highlighting the safety, reliability, and utility of telesurgery.

Conflicts of interest: The authors have nothing to disclose.

Ethics statement: Informed written consent was obtained from the patients.

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Peer Review Summary

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References

[1] Li J, Yang X, Chu G, et al. Application of improved robot-assisted laparoscopic telesurgery with 5G technology in urology. Eur Urol 2023;83:41–4.
[2] Checcucci E, Cacciamani GE, Amparore D, et al. The metaverse in urology: ready for prime time. The ESUT, ERUS, EULIS, and ESU perspective. Eur Urol Open Sci 2022;46:96–8.
[3] Temple-Oberle C, Yakaback S, Webb C, et al. Effect of smartphone app postoperative home monitoring after oncologic surgery on quality of recovery: a randomized clinical trial. JAMA Surg 2023;158:693–9.
[4] Xu S, Perez M, Yang K, et al. Determination of the latency effects on surgical performance and the acceptable latency levels in telesurgery using the dV-Trainer® simulator. Surg Endosc 2014;28:2569–76.
[5] Law KE, Lowndes BR, Kelley SR, et al. NASA-Task Load Index differentiates surgical approach: opportunities for improvement in colon and rectal surgery. Ann Surg 2020;271:906–12.

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