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Research Letter

Improved robot-assisted laparoscopic telesurgery: feasibility of network converged communication

G. Chu[1,#], X. Yang[1,#], L. Luo[1], W. Feng[2], W. Jiao[1], X. Zhang[3], Y. Wang[1], Z. Yang[1], B. Wang[4], J. Li[5,*] and H. Niu[1,*]

[1]Department of Urology, Affiliated Hospital of Qingdao University, Qingdao, China
[2]Department of Anaesthesiology, Affiliated Hospital of Qingdao University, Qingdao, China
[3]Department of Education and Training, Affiliated Hospital of Qingdao University, Qingdao, China
[4]Shandong Weigao Surgical Robot Company, Weihai, China
[5]Key Laboratory for Mechanism Theory and Equipment Design of Ministry of Education, Tianjin University, Tianjin, China

*Correspondence to: Department of Urology, Affiliated Hospital of Qingdao University, Qingdao, China (e-mail: niuht0532@126.com); Key Laboratory for Mechanism Theory and Equipment Design of Ministry of Education, Tianjin University, Tianjin, China (e-mail: mjli@tju.edu.cn)
#Contributed equally to this work.

Dear Editor,

Telesurgery comprises use of the combination of surgical robots and advanced communications technology. It refers to a surgical operation performed on a patient from a long distance and transmitted at high speed through a network. Medical information, such as imaging, audio, and video data, is digitized and transmitted via cable or wireless telecommunications networks. Since Marescaux and colleagues[1] performed the first clinical telesurgery, further development and popularization of telesurgery has been slow and difficult. The rapid development of network communication technologies, such as the emerging fifth-generation (5G) wireless networks, has led to new opportunities opening up for telesurgery[2]. The authors' team has successfully completed the first 5G delivery robot-assisted laparoscopic telesurgery for bladder cancer in the world[3]. The requirements of telesurgery for a signal base station and line laying are, however, extremely high, making it difficult to deliver this technology to remote and less developed areas. To truly promote telesurgery to benefit both poor and remote areas, the key is the solution of the network.

Based on this situation, the internet and Micro Hand® surgical robot[4] (WEGO Group, Weihai, China) were used in May 2021 to perform three remote laparoscopic procedures in experimental animals across 300 and 700 km. Operations were performed once from Qingdao, China, to Weihai, China; and twice from Shanghai, China, to Qingdao, China. These studies were approved by the Research Ethics Committee of the Affiliated Hospital of Qingdao University. The experiments were conducted under the guidelines set by the National Institutes of Health, and all animals were treated humanely after the experiments had been completed.

Heterogeneous multilink network converged transmission technology was used innovatively in these operations, to improve network communication and update the network architecture. This makes the data in the network transport layer divide into different transmission in the network; the algorithm is realized in the operating system kernel, which leads to the application layer having lower latency, higher stability, and efficiency, and automatic completion of dynamic congestion control and bandwidth allocation. Through the unilateral acceleration and path-sensing capability of the terminal and cloud, the robot motion data are given high priority, which could support the application of telesurgery robots across the public network. The specific signal transmission process is shown in *Fig. 1a*.

All the experimental telesurgeries were carried out successfully. The experimental animals maintained stable vital signs throughout the operation, and the operations went smoothly. Important tissue structures were clearly dissected (*Fig. 1b,c*). There were no intraoperative complications and no operations had to be converted to another technique or method. The network communication transmission remained stable throughout the operation. The packet loss rate of data packet transmission was 0 per cent, the average round-trip signal transmission delay was less than 60 ms, and the average total delay was less than 250 ms in all three telesurgeries. The surgeons and assistants at both ends also determined subjectively that the master-slave controllers had good consistency, with a smooth and flexible operation being performed without pauses (*Fig. 1d,e*). Xu and colleagues[5] proposed previously that a delay of less than 300 ms in telesurgery is applicable, indicating the safety and feasibility of this novel network technology for telesurgery .

Based on these findings, it can be concluded that the converged transmission-assisted network communication architecture used could meet the requirements of telesurgery, and effectively guarantee the security and immediacy of communication. This can potentially allow application of telesurgery and telemedicine at a higher level.

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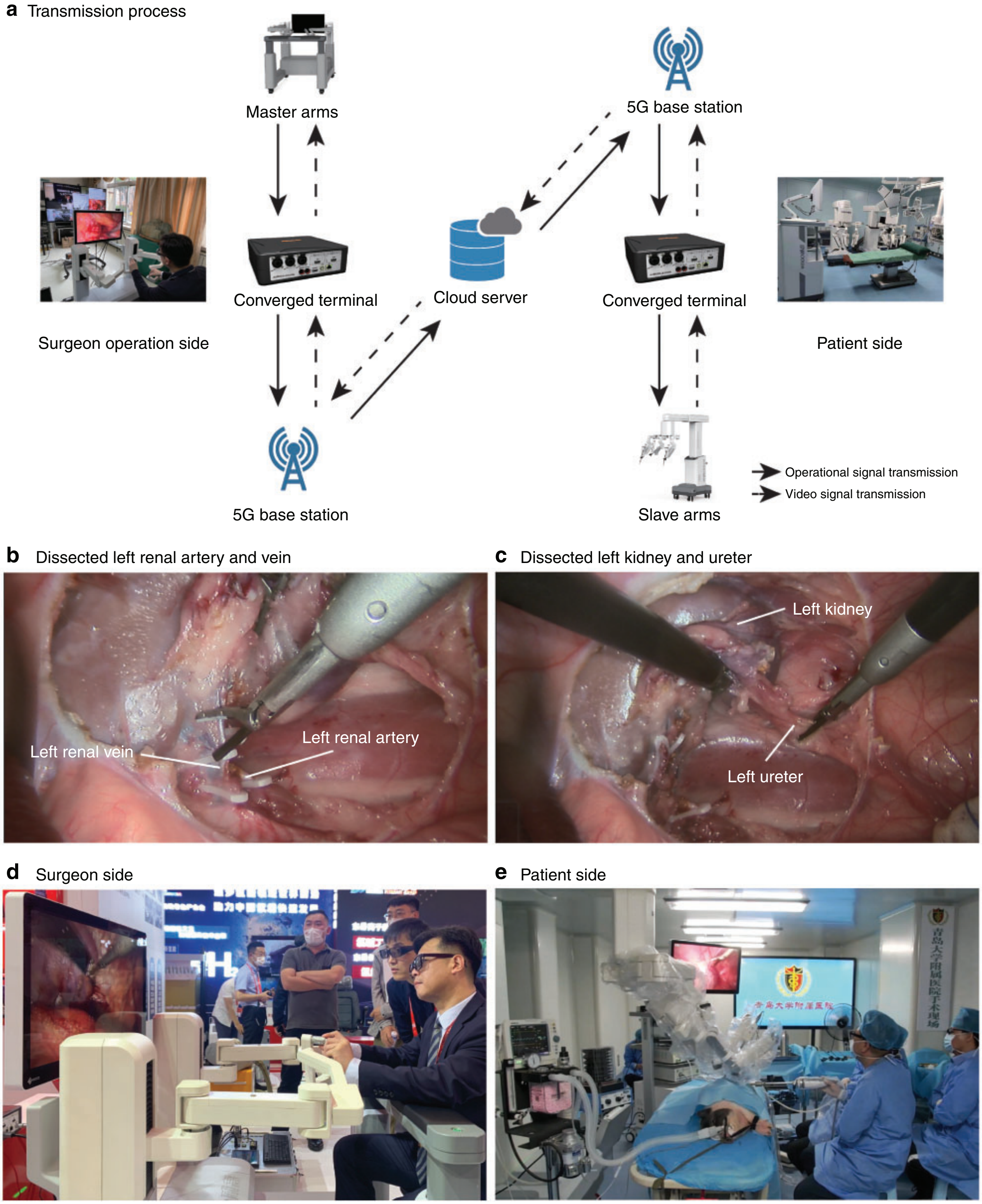

Fig. 1 Signal transmission and telesurgery procedures

a Transmission process for surgical operation signals and video signals between surgical operation and patient sides. These two sides are connected by the wireless network, and the network converged communication system is used to realize the converged transmission of multiple lines. **b** Dissected left renal artery and left renal vein during operation, **c** dissected left kidney and left ureter during operation, **d** surgeon side, and **e** patient side.

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References

1. Marescaux J, Leroy J, Rubino F, Smith M, Vix M, Simone M *et al.* Transcontinental robot-assisted remote telesurgery: feasibility and potential applications. *Ann Surg* 2002;**235**:487–492.
2. Lacy AM, Bravo R, Otero-Piñeiro AM, Pena R, De Lacy FB, Menchaca R *et al.* 5G-assisted telementored surgery. *Br J Surg* 2019;**106**:1576–1579.
3. Zheng J, Wang Y, Zhang J, Guo W, Yang X, Luo L *et al.* 5G ultra-remote robot-assisted laparoscopic surgery in China. *Surg Endosc* 2020;**34**:5172–5180.
4. Yao Y, Liu Y, Li Z, Yi B, Wang G, Zhu S. Chinese surgical robot micro hand S: a consecutive case series in general surgery. *Int J Surg* 2020;**75**:55–59.
5. Xu S, Perez M, Yang K, Perrenot C, Felblinger J, Hubert J. Determination of the latency effects on surgical performance and the acceptable latency levels in telesurgery using the dV-Trainer® simulator. *Surg Endosc* 2014;**28**:2569–2576.