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EDITORIAL

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The changing surgical scene: From the days of Billroth to the upcoming future of artificial intelligence and telerobotic surgery

Since the first successful gastric cancer surgery performed by Billroth 140 years ago, gastric cancer surgery has undergone major changes.[1] In the last 30 years, in particular, the main operative modality has shifted from open surgery to minimally invasive surgery; and now, robotic surgery is on the rise. Robotic surgery, with its multi-joint function, overcomes the disadvantages of motion limitation in laparoscopic surgery, prevents camera shake, and enables surgical precision with magnified stereoscopic effect. However, at this time, the superiority of robotic surgery over laparoscopic surgery is not fully clear in terms of short-term or long-term surgical outcomes. Practitioners anxiously await the findings of future randomized controlled trials.

In this issue of the *Annals of Gastroenterological Surgery*, Terashima has reviewed the history of challenges in gastric cancer surgery from the era of Billroth to the present, including advances in open gastric cancer surgery, laparoscopic surgery, and the introduction of robotic surgery.[1] In addition, he imagines the future surgical landscape, including the introduction of artificial intelligence (AI) and new technologies involving surgical robots.

It should be noted that robotic-assisted surgery is a kind of remote surgery that happens right in the operating room. In other words, the surgeon operates the robotic arm remotely from a cockpit at a distance from the patient. For this reason, from its inception, robotic surgery has been developed with the goal of realizing remote surgery. The basic concept is the "digitization of surgery," and remote surgery is theoretically possible by converting the surgeon's visual information and hand movements into digitized video and coordinate signals for transmission.

Telesurgery has been studied extensively since the 1970s. In 2001, the world's first remote laparoscopic cholecystectomy was performed between New York, the United States, and Strasbourg, France (Lindbergh procedure),[2] followed by 22 clinical telesurgeries in Canada,[3] all of which were reported to be successful. Thus, the feasibility of telesurgery has been proven, but many issues have been identified, such as the high cost of dedicated communication lines, the security and redundancy of communication, the delays associated with the compression and decompression of transmission signals, and the delays associated with remote communication.

The rapid development of information and communication technology and high-speed communication networks in recent years has created a communication environment in which remote surgery can be realized by overcoming the problems of transmission delay, communication security, and the high cost of communication. At the same time, information processing technology for compressing and decompressing robot signals and video signals has also made progress, so issues such as transmission delay, transmission jitter, and signal packet loss associated with information processing have been improved. Many previous studies on telesurgery reported that common general surgeries can be performed if the transmission delay is <200 ms and that the delay has little effect if it is <100 ms.[4,5] It is assumed that the current level of information processing and communication technology meets these standards.

In addition, competition to develop new surgical robots has begun both in Japan and overseas as patents related to earlier surgical robots expire. The development of surgical robots for advanced telesurgery is also underway. Thus, technological innovation is creating the prerequisites for the social implementation of telesurgery.

So why is telesurgery getting renewed attention today? In Japan, there is a shortage of surgeons in rural areas due to the uneven regional distribution of physicians between large cities and rural areas and a decrease in the number of applicants for surgical residencies. Telesurgery is expected to be an incentive to get young surgeons to work in rural areas, as they can continue to receive surgical education and support from supervisors at core facilities while engaging in community medicine in rural areas.

As the population in Japan is rapidly aging, the need for minimally invasive surgery, including robot-assisted surgery, is increasing. However, it is difficult to receive all the latest medical treatments in rural areas where medical resources are scarce. The availability of telesurgery is expected to increase the options for patients to receive a variety of specialized treatments at local medical institutions and reduce the risks and financial burden associated with long-distance travel. Therefore, the government has revised the online medical treatment guidelines and improved the legal environment to enable remote surgery.

Telesurgery can be divided into three stages: tele-mentoring, in which only instructions are given remotely; telesurgical support, in which actual surgical operations are performed remotely; and full telesurgery, in which all surgical operations are performed remotely in environments where there is no doctor, such as in space or the deep sea. At this time, Japan has legally approved remote surgical (telesurgical) support, in which surgery is performed remotely on the premise that there is a surgeon on site.

Currently, the Japan Surgical Association, together with related academic societies, two domestic robotics companies, information processing companies, telecommunications carriers, and related ministries, has launched a project to promote telesurgery and is conducting research on technical and non-technical issues. Eventually, guidelines will be formulated for the social implementation of telesurgery.

In February 2021, a series of telesurgery experiments were conducted between Hirosaki University Hospital and an affiliated hospital, 150 km away, using a domestic surgical robot currently under development. Utilizing a commercial network line with secure communication, the network transmission delay was 4 ms, the delay associated with encoding/decoding was 60 ms, and the total delay experienced by the surgeon was less than 100 ms. Most of the remote surgeons completed their tasks with almost no perceived delay.

Remote surgery is highly compatible with a variety of digital technologies. As Terashima mentions, AI and augmented reality technologies will be introduced in the near future, and it is expected that higher-quality surgical operations will be realized. If this happens, gastric cancer surgery will enter a new stage.

In addition, precise teleoperation and low-latency transmission know-how can be used as fundamental technologies, not only in medicine but also in various industries. It will also be possible to contribute to international medical welfare by exporting remote surgery systems to countries with limited medical resources. In this way, the realization of remote surgery has the potential to have a significant ripple effect on society as a whole due to the diverse scalability of the technology.

DISCLOSURE

Conflicts of Interest: Authors declare no conflicts of interest for this article.

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REFERENCES

1. Terashima M. The 140 years' journey of gastric cancer surgery: from the two hands of Billroth to the multiple hands of the robot. Ann Gastroenterol Surg. 2021;5(3):1–8.
2. Marescaux J, Leroy J, Gagner M, Rubino F, Mutter D, Vix M, , , et al. Transatlantic robot-assisted telesurgery. Nature. 2001;413(6854):379–80.
3. Anvari M. Remote telepresence surgery: the Canadian experience. Surg Endosc. 2007;21(4):537–41.
4. 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(R) simulator. Surg Endosc. 2014;28(9):2569–76.
5. Kim T, Zimmerman PM, Wade MJ, Weiss CA 3rd. The effect of delayed visual feedback on telerobotic surgery. Surg Endosc. 2005;19(5):683–6.