

Robot-assisted Surgery

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What is robot-assisted surgery?

Do you know what robot-assisted surgery is? In recent years, we have seen surgical robots being implemented in various types of surgery to address medical conditions not only abdominal diseases but also heart, lung, urinary, gynecological diseases, etc. Here, I am going to write mainly about abdominal surgery. While it used to be the case that when performing an abdominal surgery, laparotomy (incision of the abdominal wall) was a necessary part of the procedure, laparoscopy (endoscopic surgery) would continue to increase since 20 to 30 years ago in Japan. In the past 10 years or so, laparoscopes have been widely used to perform rather difficult operations not only on the stomach, the intestines, and the rest of the digestive tract but also on the liver, the gallbladder, and the pancreas. In the past several years, even this style of laparoscopy has gradually been replaced by robot-assisted surgery, due to the advancement of surgical systems.

Surgical robots were first developed in the U.S. in 2000. As the safety of robot-assisted surgery was subsequently verified, the number of operations performed employing the technology grew over time in the U.S. as well as in Europe. Albeit belatedly, Japan had its first approval of robot-assisted surgery in 2012, for total prostatectomy (removal of the entire prostate gland). The scope of approval on the use of surgical robots would later expand to include general surgeries targeting gastric cancer and rectal cancer as well as surgeries on the esophagus and the pancreas, all with insurance coverage. At our Hospital, 80 to 90% of all surgeries performed today to treat gastric and rectal cancers are done with robotic assistance.

Surgical robots

Now let's shift our focus to what surgical robots specifically are. Upon hearing the term, some of you might conjure up the image of fully-automated robots that are powered by AI for all cognitive tasks and can autonomously complete the entire surgery, without any human instruction, in a manner akin to those robotic vacuum cleaners whose use has become common in regular households, or to the rapidly-evolving self-driving technology applied to automobiles. But that is not the case. With surgical robots, the doctors are always in control, so the robots do not operate automatically at all. In this sense, they are more similar to those

gigantic robots that appear in any of the live-action superhero team franchises, or the robotic arms of spacecraft used in astronauts' extravehicular activities. In a typical robot-assisted surgery, several holes with a diameter of 1 cm are initially created in the abdomen, so that a video camera and mechanical arms connected to the robot system can be inserted through those holes to perform the surgery. Aside from those robotic arms that go into the patient, there is this operation seat called the console, where the doctor sits and operates the robotic arms. These near-futuristic robotic arms can be operated quite intuitively, almost like the doctor is moving his/her own hands. In addition, the live image feed that is displayed at the console is fairly high-resolution, magnifiable, and 3D processed, allowing the doctor to execute precise moves, on the order of millimeters.

In conventional laparotomic and laparoscopic surgeries, the doctor must directly hold and use the scalpels, forceps, and other surgical instruments, which entails the risk of the doctor's constant, natural hand tremors moving the tips of those instruments, often causing his/her intended moves to be slightly off by small margins. Also, in the case of laparotomy, the doctor's eyesight is always a major factor, while with laparoscopy, the image usually appears in 2D, so it had the disadvantage of lack of perspective. If you imagine yourself playing a crane game at an amusement arcade, standing still in front of the machine, you can easily imagine how difficult it might be to get a sense of proper depth in performing such a surgery. So if one views surgical robots in that light, they could be thought of as ideal surgical instruments that are free of the disadvantages of the conventional surgical techniques in terms of susceptibility to human hand tremors and the lack of perspective in 2D imaging. In addition, as each of the scars that get created in robot-assisted surgery is quite small, it can heal back to a far more aesthetically better condition than the conventional laparotomy would allow for, which leaves large incision wounds.

Furthermore, in the case of laparoscopy that also requires a similar dermal incision, it involves the use of forceps, which are long, straight, rigid shafts with scissors and tweezers attached at the end, analogous to the shape of grabber arms. Meanwhile, as robotic arms have multiple functional joints, they are capable of executing rather acrobatic maneuvers, when the doctor's sight of the target organ is blocked by another organ, etc., it can still extend the robotic arm past and around the blocking organ by bending the arm's joints to operate on the target organ, although with conventional laparoscopy the blocking organ had to be temporarily pushed aside to reach the target. This technological advancement has made it possible to execute surgical procedures requiring more complex operational steps than laparoscopy would allow.

Disadvantages of robot-assisted surgery

So far I've covered the many advantages of robot-assisted surgery. On the other hand, there might be a few disadvantages associated with the surgical technology. First of all, the waiting

time before the surgery can be performed needs to be slightly longer. Because the surgical instruments used in laparotomy and laparoscopy are relatively inexpensive, virtually all hospitals carry them in large numbers. Meanwhile, as surgical robots are quite expensive systems, each costing several hundreds of millions of yen, even our Hospital, which is considered a large hospital, only has been able to afford one unit of such a system. Even university hospitals have up to two units of these on average.

Therefore, when a hospital intends to schedule robot-assisted surgeries, the only unit of the surgical robot system that it has must be shared among its different departments in general surgery, thoracic surgery, urology, obstetrics, and gynecology to treat their patients, one by one. Under such circumstances, it is likely that the surgical robot system to remain fully booked for many months ahead.

Secondly, robot-assisted surgery is still less effective than laparotomy in executing irregular surgical operations and procedures. It also has the drawback of requiring slightly more operating time than laparotomy. To illustrate, let's use chopsticks as an example. Imagine yourself eating a grilled fish, alternatingly using a pair of regular-length chopsticks and a pair of long, cooking and serving chopsticks, while trying to separate its meat from the bones with precision. It might not be difficult to imagine that the longer chopsticks would be more difficult to use and take more time. Therefore, it is still the case that many surgeries that involve extremely difficult procedures or irregular operational maneuvers such as adhesiotomy (surgical procedure to divide or separate an adhesion) are not suited for either laparoscopy or robot-assisted surgery. So there are still many cases where laparotomy is the most suitable choice of surgical method, entailing direct human-hand operations.

Thirdly, although this might not quite qualify as a disadvantage, robot-assisted surgery is not optimal for surgeries that involve the removal of large tumors or organs. I previously mentioned how robot-assisted surgery would initially entail creating several holes in the abdomen, measuring about 1 cm each in diameter. It would eventually require the incision wound in the navel area to be expanded to roughly 4 cm, through which to remove the lesioned specimen. While most of the human organs are elastic enough to be removed through this incision, any tumor measuring over 5cm in diameter or any internal organ that is hard to change its form, like the liver, requiring major incision and removal, would eventually necessitate a significantly larger dermal incision. If this is the case, it might be better to plan and conduct a laparotomy from the start, involving a large dermal incision, as that would allow for swifter surgical execution as previously explained.

Outlook on robot-assisted surgery

The prices of surgical robot systems mostly remained quite expensive in the past because there had only been a single foreign-based company that was the exclusive developer and marketer of those systems. But in recent years, several other companies, including Japan-based manufacturers, started developing and marketing their proprietary surgical robot

systems. As such, the prices of those systems have been becoming progressively inexpensive, according to my sources, due to the principle of market competition. This leads me to believe that in no distant future each hospital will likely carry multiple units of surgical robot systems. The advancement of their functions has also been astonishing. Some of the systems available today allow for the independent operation of several different robot arms after they have been inserted into the abdominal cavity through holes created in the navel area, each measuring about 3 cm in diameter. Thirty years ago, these surgeries required dermal incisions of around 20 cm, but fast forward to today, the incisions can be as small as just 3cm.

Such advancement of surgical instruments reduces pain and improves aesthetic outcomes for the patients and improves other aspects of their post-surgery QOL, while improving the cure rates of their cancers and other diseases. Who knows, one day we might eventually have AI robots automatically performing surgeries, and have surgical robots the size of little bugs cure cancer after swallowing them or jamming them into the body through the naval, much like science fiction films.

If such time as I've just described should arrive, I'll be out of a job as a surgeon wandering down and out on the street. So in this sense, my feelings are quite mixed and ambivalent, unsure of whether I want to welcome any AI-powered, fully-automated surgical robots coming to market anytime soon.

