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Voice-Controlled Robotic Arm in Laparoscopic Surgery

Ivo Baæa, Christian Schultz, Leszek Grzybowski, Volker Götzen
Klinik für Allgemein- und Unfallchirurgie, Zentralkrankenhaus Bremen-Ost, Bremen, Germany

Aim. To report on our experience with a voice-directed robotic arm for scope management in different procedures for ”solo-surgery” and in complex laparoscopic operations.
Methods. A chip card with orders for the robotic arm is individually manufactured for every user. A surgeon gives order through a microphone and the optic field is thus under direct command of the surgeon.
Results. We analyzed 200 cases of laparoscopic procedures (gallbladder, stomach, colon, and hernia repair) done with the robotic arm. In each procedure the robotic arm worked precisely; voice understanding was exact and functioned flawlessly. A hundred ”solo-surgery” operations were performed by a single surgeon. Another 96 complex videoscopic procedures were performed by a surgeon and one assistant. In comparison to other surgical procedures, operative time was not prolonged, and the number of used ports remained unchanged.
Conclusion. Using the robotic arm in some procedures abolishes the need for assistance. Further benefit accrued by the use of robotic assistance includes greater stability of view, less inadvertent smearing of the lens, and the absence of fatigue. The robotic arm can be used successfully in every operating theater by all surgeons using laparoscopy.

Key words: cholecystectomy; colon resection; fundoplication; gastric banding; gastric resection; laparoscopic surgery; robotic

Over the last decade, operating theaters became highly equipped technical centers with computers, robots, micro system technologies, and tele-transmission installations (1), adding new qualities to surgical skills (2-9). Some of these developments are still experimental (9), whereas others are already in practical use, like the Robodoc in prosthetic hip replacement (11-13). One of the more recent developments is the use of a voice-controlled robotic arm in laparoscopic surgery for handling of the optic system (2,14-17). In this report we present operating possibilities and our experiences with the new device.

Operating Instructions and Handling

Since 1996, we have used a voice-controlled robotic arm for guiding the camera and the optic system in laparoscopic operations. We use the AESOP 2000 (Automatic Endoscopic System for Optical Positioning; Computer Motion, Goleta, CA, USA).

The technical equipment consists of a trolley with a computer, serving as a transport vehicle for the actual robotic arm. The robotic arm itself consists of a fixed vertical and a moveable horizontal part, weighing 17 kg. With an integrated lifter this weight can easily be handled. The trolley is moved in place and the arm is attached to an ordinary operating table after positioning the patient. The exact place of the arm at the table depends on the operation to be carried out and should be standardized. As a rule, the arm is fixed to the top of the operating table for surgeries on the lower abdomen (Fig. 1) and at the bottom of the table for upper abdominal operations. At the end, final adjustments are made and freedom of movement is checked by special markings on the horizontal part of the arm. The installation takes about five minutes. The camera and the robot arm are usually wrapped in a plastic cover supplied by the company. The optics is fixed to it with a sterilized magnetic device consisting of two parts, one for the arm, and one for the optics (Fig. 2). Disconnecting is easy and simple. For unimpeded movement of the optics it is advised to use a 10/12 single-use trocar.

Steering of the optic is then done by voice commands. For this purpose every surgeon has to train the computer in recognizing his or her voice. After this procedure an individual chip card is created for every surgeon which has to be put into the computer before operation. Insert surgeon's personal voice card (PVC) into the AESOP 2000 controler. Prior to use, each surgeon must create a PVC. With this card the surgeon can control the movements and position of the robotic arm by 23 short orders which are transformed through a microphone worn on the head (Fig. 3). First, the system has to be activated by the order ”AESOP”, then with orders like ”in”, ”out”, ”left”, and ”right”, the optic is moved in the position the surgeon needs. All orders are confirmed by the computer through a loudspeaker.

Normal conversation in the theater is still possible since the activation lasts only a few seconds and the computer reacts only to single orders. Further possibilities exist for positioning the optics: a hand and a foot control device. It is advisable to use one of them in the beginning in a case of difficulties.

Figure 1. Set-up matrix determines the location for the robotic arm on the table.

Figure 2. Attaching the endoscope to the positioning arm by connecting the collar holder to the endoscope collar.

Figure 3. Working with a robotic arm during a gastric surgery.

Figure 4. Working with a robotic arm in laparoscopic cholecystectomy as a solo-surgery. Commands are confirmed by the computer through a loudspeaker.

Table 1. Procedure, time, and number of trocars and assistants in operation done with the help of a robotic arm

The optics is held very stable by the system but corrections can still be made by hand. If angled optics is used, rotating movements are not possible by the robot, and have to be done manually.

Results and Experiences

Our experiences show that the voice-controlled robotic arm is safe and easy to handle. We also observed that there is a learning curve (18). Nevertheless, preparation and operating times do not differ from the ones where the camera is controlled by an assistant. The acceptance by the theater staff was gained very quickly and can be encouraged when the positioning of the robotic arm at the operating table is taken over by the operating surgeon. Considering the great number of laparoscopic procedures in our clinic, the robot is not taken as a competitor by the younger members of the surgical team, but is seen as a useful aid in times of staff reduction and has often made planning of the operation program much more flexible and efficient.

Laparoscopic surgery has the well known handicaps of missing tactile sense, impaired movement of instruments and two-dimensional sight. Another one is camera guidance which is usually not under a direct control of the surgeon. This can be overcome by possibilities offered by the voice-controlled robotic arm. Especially in long and difficult procedures, it helps in keeping up the concentration on the hand of the surgeon as well as of the assistant, and it also reduces false contacts of the tip of the optic with intraabdominal tissue resulting in impaired sight. Therefore we use the robotic arm in colorectal and gastric operations and are able to carry out these procedures with only one assistant. Minor operations, such as cholecystectomies, appendectomies, and hernia repairs were performed as ”solo-surgery” (Table 1).

Solo-Surgery

Laparoscopic Cholecystectomy

The surgeon stands on the left side of the patient while the robotic arm is fixed on the right at the bottom half of the table (Fig. 4). We use a 10/12 mm trocar for the optics infraumbilically and two 5 mm or one 10/12 mm and one 5 mm trocar for the instruments. The trocars are placed epigastrically and in the right middle abdomen. In this setting the surgeon has free access to the trocars.

Laparoscopic cholecystectomy is well suited for solo-surgery because no complex manipulations with the optic system are necessary. Only at the end of the operation, when the gallbladder is retracted, is the optics moved by hand. Average operation time is the same as in conventional laparoscopic operations.

Laparoscopic Inguinal Hernia Repair

We prefer transabdominal preperitoneal approach, and the robotic arm proved to be of great help. In cases of one-sided hernias there is no problem in positioning the robotic arm, but even in bilateral hernias the robotic arm can be used if placed with precision. One of the features of the robot, especially useful in hernia surgery, is the ability to save certain camera positions in the computer. With short orders, these positions can be recalled and the lateral and medial part of the inguinal region can be easily seen. We analyzed 37 one-sided and 17 bilateral hernias using this technique (Table 1).

Colorectal and Gastric Operations

After a short phase of training in cholecystectomies and hernia repairs, we used it in more complex procedures in laparoscopic colorectal and gastric surgery (Fig. 3). We particularly appreciate constantly stable picture in these long operations. We perform colorectal operations with a surgeon and an assistant. In cases of left colonic, sigmoid, and rectal disease, the surgeon is positioned on the right side of the patient and the robotic arm is fixed at the upper part of the table on the opposite side. The assistant stands on the right of the surgeon in the beginning and later performs transanal staple anastomosis.

In laparoscopic Nissen operations stable picture again was of great help. There was a tendency of shorter operating times compared with non-robotic procedures (Table 1).

Discussion

In our experience, the use of a voice-controlled robotic arm in laparoscopic surgery shows clear advantages. Only with the robotic arm can a stable picture be guaranteed throughout the whole operation. The surgeon has the opportunity of a direct and quick alteration of the picture. The frequency of pollution of the optics is markedly reduced. Solo-surgery offers the possibility of performing more procedures in times of reduced personal capacity. In the near future it will also be possible to extend exchange with other locations via telepresence, and even remote control of the optics will be easy to administer (19,20). With the implementation of further techniques, such as three-dimensional pictures and ultrasound dissectors (21,22), even more demanding intraabdominal operations will be possible with less risk for the patient and with all the advantages of minimal invasive surgery.

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Correspondence to:
Ivo Baæa
Zentralkrankenhaus Bremen-Ost
Züricher Str. 40
D-28325 Bremen, Germany
bacaicd@t-online.de
