Robot-assisted laparoscopy for infertility treatment: current views

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To determine the interest of using robotic laparoscopic surgery in the management of female infertility, we reviewed our own activity and searched the Medline database for publications on robotic technology in infertility surgery, with the use of the following search words: robotic laparoscopy, tubal anastomosis, myomectomy, deep infiltrating endometriosis, and adnexal surgery. Robot-assisted laparoscopic surgery has seen rapid progression over the past few years. It has been mostly used for myomectomy, proximal tubal reanastomosis, and deep endometriosis surgery. Despite its increased range of indications, no randomized control studies are available. The place of robotic surgery in the management of infertility remains undetermined. (Fertil Steril® 2014;101:621–6. ©2014 by American Society for Reproductive Medicine.)

Key Words: Robotic laparoscopy, tubal anastomosis, myomectomy, deep infiltrating endometriosis, adnexal surgery

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Laparoscopy is the criterion standard in fertility surgery. It reduces both risk of adhesion and blood loss and improves surgical outcome (less pain, shortened hospital stay, and early return to normal active life) with reduced scars compared with laparotomy. According to Muhlstein et al. (1), laparoscopy is the preferred technique for simple procedures, such as fimbrioplasty, cystectomy, pelvic investigations, and ovarian drilling. In more complex surgery, such as myomectomy, proximal tubal reanastomosis, and deep endometriosis, laparoscopy has not been fully accepted, owing to its technical limitations and lengths of the learning curve and operating time. Telerobotics technologies that have been developed over the past decade are likely to offer a new paradigm in minimally invasive surgery.

The first telerobot, called Zeus, was developed in 1995 by combining two operating arms and the Automated Endoscopic System for Optimal Positioning (AESOP) with a voice-activated camera controlled by the surgeon who also controls via a console the two robotic arms (2). The da Vinci robot was developed in 1998 by Intuitive Surgical on the same concept as Zeus, adding a three-dimensional (3D) stereoscopic vision and the possibility for the two arms to provide rotation of the instruments with seven degrees of freedom. Since then, many improvements of the system have been achieved: a supplementary operating arm in addition to that holding the camera, a new high-definition (HD) visualization, and an expanded range of surgical instruments. Currently, Intuitive Surgical has a monopoly of the market in the field.

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ROBOT-ASSISTED LAPAROSCOPY: OVERVIEW

Interest in Robotic Surgery

This technologic advance offers numerous advantages over conventional laparoscopy (Table 1). The surgeon's gesture gains accuracy owing to the robot's ability to filter and reduce physiologic tremor and to transform surgeon's hand movements into more precise micromovements of the jointed-wrist instruments; these operate with seven degrees of freedom and 360° pronosupination amplitude. The improved 3D HD visualization provided by the camera directly controlled by the operator allows accessing deep areas. Sutures gain quality as a result of both continuity and stability of the hand movements, making gesture intuitive. The advantages offered by the robotic technique may be highly valuable in the management of infertility with the assimilation of microsurgery principles into fertility-promoting procedures. It should translate into major benefits, such as the reduction of postoperative adhesions (3).

Standard Surgical Procedure

The da Vinci S or SI HD four-arm system is commonly used for any type of

TABLE 1

Interest in robotic assistance in laparoscopy.

Conventional laparoscopy	Laparoscopy with robotic assistance
2D visualization	3D visualization
	Magnification of the operating field
Physiologic tremor	Tremor filtration
Instability of the image	Stability of the image
Fixed axis of the instruments	Micro-motion of the instruments
	360° amplitude, 7° freedom
Discomfort for the surgeon	Ergonomics, comfortable handling of the console
Poor quality of the dissection	Facilitated dissection
Hard access for some areas	Improved accessibility
Difficult intracorporeal stitching	Easy suturing
Long learning curve	Short learning curve

Carbonnel. Robotic laparoscopy for infertility. Fertil Steril 2014.

FIGURE 1

Robot-assisted laparoscopy procedure.

Carbonnel. Robotic laparoscopy for infertility. Fertil Steril 2014.

gynecologic surgery. After induction of general anesthesia the patient is put in a dorsal gynecologic position. A uterine-positioning system is used to mobilize the uterus with an intrauterine cannula. Three to four standard quarter-inch incisions are made (depending on the technical difficulty of the procedure) and ports are inserted for the robot's camera and instrument arms. An operating assistant remains beside the patient and is provided with a supplementary 12-mm trocar. Then the robot is docked: The robotic column fitted with four arms (three holding a wide range of surgical instruments—monopolar scissors, bipolar surgical clamps, etc.—and the fourth holding the 3D cameras) is positioned directly over the patient during surgery. The robotic arms are controlled by a computer that replicates exactly the movements of the surgeon who is sitting at the console, operating while looking into a stereoscopic monitor that shows HD 3D views of the surgical field. The surgeon manipulates the four robotic arms by maneuvering two master controls that ensure fingertip precision of the movements. The surgeon also controls a foot switch that provides additional options, such as the ability to switch between two different energy sources (Fig. 1)

Limitations of Robotic Surgery

The main reason for the limited use of robotic surgery is the cost of the device and related expenditures. The cost of the robot is ~1.6 million U.S. dollars, the system necessitates annual maintenance contracts and requires instruments that cost ~$2,000 each, with a limited range of ten uses.

Laparoscopic and robotic procedures are combined into one current procedural technology (CPT) code, with no opportunity for higher reimbursement for the more expensive technology. In addition, longer operative times translate into significantly higher costs for the operating room and anesthesia. Another limitation is the absence of haptic or tactile feedback. Such lack may be dangerous when manipulating fragile tissues and when tactile sensation is important for the realization of the surgical gesture. It may also be responsible for suture rupture when knot tying is performed with the use of small-caliber thread. The setup time, usually considered to be a limit for the use of a robot, rapidly decreases with the operator's experience as shown by Braumann et al. (4) to be reduced from 25.0 minutes to 10.4 minutes after only ten interventions.

MYOMECTOMY

Overview of the Procedure before Robotic Surgery

Uterine fibroid disease affects 20%–30% of women of childbearing age and 70% of those >49 years of age (5). Fibroids are responsible for hypofertility, especially when they cause cavity distortion (6). In the case of fibroid disease, the sole treatment currently efficient to allow future pregnancy is surgical resection. With increased maternal age and the development of oocyte donation, the surgical management of fertility is needed more than ever. The criterion standard for abdominal myomectomy remains to be defined.

Laparotomy. Despite the advantages of laparotomy, such as the technical comfort of the procedure and the high quality of suture it provides, compared with laparoscopy laparotomy induces "heavier" postoperative outcomes and a major risk of adhesion likely to jeopardize future spontaneous pregnancy (7). Laparoscopy reduces this risk and offers advantages such as better cosmetic results and postoperative recovery (8), but the quality of suture remains uncertain (9).

Laparoscopy. Owing to its related technical difficulties, laparoscopy is still infrequently used and is considered to be hardly feasible. In fact, some sutures may be difficult, and the fixed position of the trocars limits access to some areas of myoma location, such as in case of anterior myomas, very posterior ones, or those located in the broad ligament. Myomas >8 cm, too many fibroids, and the necessity for clamping and enucleation constitute further limitations to laparoscopy (10, 11). Although hard to evaluate, the rate of uterine rupture appears to be ~1% for both techniques (12, 13).

The Surgical Procedure

Robot-assisted laparoscopic myomectomy is performed with the use of the monopolar scissors and the dipolar grasping device, sometimes with the use of the fourth arm of the robot