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CLINICAL ARTICLE

Decreasing strain on the surgeon in gynecologic minimally invasive surgery by using semi-active robotics

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Objective: To assess the advantages of a surgeon-controlled robotic endoscope holder in gynecologic minimally invasive solo-surgery as compared with conventional assistance with a second surgeon. Methods: One hundred gynecologic laparoscopies were consecutively allocated to surgery with either a robot as the surgical assistant or a conventional assistant surgeon. Total operation time, image stability, and frequency of corrective maneuvers of the camera, in addition to the surgeon’s satisfaction regarding the ergonomics of the intervention, were recorded. All interventions were performed by the same surgeon. All laparoscopic surgery was classified as either easy or advanced surgery. Results: The image stability score was significantly higher (10 vs 7; P<0.001) and fewer corrective maneuvers of the robotic endoscope were necessary (1 vs 5; P<0.001) with the robotic laparoscope holder; in addition, the surgeon recorded a significantly higher satisfaction score for the ergonomics of the semi-active robot (10 vs 7; P<0.001). Conclusion: The robot does not prolong total operation time and increases the surgeon’s comfort by improving image stability and laparoscope handling. It could provide major benefit, especially in complex gynecologic laparoscopic surgery. © 2010 Published by Elsevier Ireland Ltd. on behalf of International Federation of Gynecology and Obstetrics.

1. Introduction

Mental effort and stress are recognized problems in video-endoscopic surgery because the “visual and physical interface has been shown to increase the physical workload of the surgeon” [1]. Surgeon morbidity has been described as being directly related to the discomfort of minimal access surgery, and image stability is one of the main preliminary factors in decreasing the surgeon’s stress and fatigue [2]. In contrast to open surgery, in endoscopic surgery the vision is hand-controlled by an assisting surgeon with variable skills.

The idea of using camera-holding devices to improve the surgeon’s control of the endoscope and to enable them to direct the view in solo-surgery is not new [3,4]. There are multimodal robotic systems, such as the “da Vinci surgical system” (Intuitive Surgical, Sunnyvale, US), which provide both camera-holding arms and instrument-holding arms. In this system, the surgeon performs the operation from a distance using a console and manipulates the robot that holds all the necessary devices [5,6]. Despite the robotic assistance offered by the da Vinci surgical system, an assistant at the bedside is required to exchange instruments and for suction-irrigation. This method is efficient but time-consuming and expensive, and it can cause great strain on the surgeon if complications arise and immediate intraoperative corrections are needed.

In an “era of lacking hands in operating rooms” [7], there is a trend to maintain quality of intervention by using fully mechanotronic assistance. One way to increase mechanotronic assistance is to use a robotic endoscope holder. A description of available devices was provided by Jaspers et al. [8]. The classification of endoscope holders is based on a static or a dynamic mode of activation. Static systems require the surgeon to put down an instrument to make any change in the position of the endoscope, whereas dynamic holders are motorized and the positioning of the endoscope is achieved—through remote controls such as a foot pedal, voice, helmet, or hand control, or joystick—without interruption of surgery [3].

The aim of the present study was to evaluate a robotic laparoscope holder to see whether the robot could increase the comfort of minimal access surgery. For this assessment, image stability, frequency of correction of the scope, time loss through correction of the scope, general intervention time, and satisfaction of the surgeon were compared between laparoscopies using robotic assistance and those using conventional assistance through a second surgeon.

2. Materials and methods

This was a prospective cohort study of consecutive patients. One hundred laparoscopic interventions were evaluated between June 1, 2010, and December 31, 2010.

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The square of height in meters) of more than 35 were excluded. Fifty patients were consecutively assigned to the group undergoing conventional laparoscopy, and the following fifty were assigned to the group undergoing laparoscopy with robotic assistance. All interventions were performed by the same surgeon (GT), who was trained for robot-assisted solo-surgery in 10 preliminary instructive operations. The surgeon assisting in the conventional laparoscopy group was experienced and the same in all interventions.

The semi-active system used was the LapMan (Medsys, Gemboux, Belgium) (Fig. 1) — a dynamic endoscope holder controlled by a joystick (LapStick; Medsys, Gemboux, Belgium) (Fig. 2) connected to the handle of an instrument. Use of this system enables the number of hands to be reduced from 5 (surgeon, assisting surgeon, and scrubbed nurse) to 4: 2 for instruments and scope control (surgeon) and 2 at the operating table (scrubbed nurse). One person can be omitted.

The LapMan is based on the electromechanical control of brakes that regulate the displacement of a series of articulated arms constructed to cover the 3 dimensions of space (in–out zoom, up–down movement, and left–right movement). This low-bulk mobile assistant comprises a rolling base on motorized wheels and a sterilizable autoclavable shaft, which is connected to the scope through an easy-release system. The LapMan displaces the shaft in the 3 dimensions, translating the displacement of the laparoscope connected to it. A laser pointer indicates the geometric center of the assistant. The manipulator measures 40 × 65 cm at the base, and extends in height from 110 to 150 cm, depending on the need.

To evaluate whether use of the robot led to equally comfortable and ergonomic minimally invasive surgery as compared with conventional assistance, the following data were recorded (Table 1): duration of intervention; time of intervention; image stability; number of corrections of the scope; time loss through corrections of the scope; and surgeon’s satisfaction regarding the ergonomics of the surgery.

Intervention time was measured from the moment of incision in the umbilical area; each intervention was logged by a nurse and time was counted simultaneously by a trained study nurse. Image stability was measured with a stopwatch. Corrections of the endoscope were estimated on an analog scale from 1 to 10 (1, very unstable vision; 10, very comfortable vision) by the main surgeon. The surgeon’s satisfaction with the ergonomics of the surgery was estimated on an analog scale from 1 to 10 (1, very unsatisfied; 10, very satisfied).

To evaluate separately the cohorts undergoing more extended (“advanced”) and shorter (“easy”) laparoscopic surgical procedures, the interventions were subdivided into 2 groups: A, interventions on
The less demanding interventions (B; adnexal surgery and endometriosis treatment) were performed more slowly with the robotic device (medians, 50 minutes vs 45 minutes). These differences in surgery time were not statistically significant ($P=0.13$ and $P=0.26$, respectively).

Image stability scored significantly higher in robot-assisted laparoscopy than in interventions with conventional assistance (10 vs 7; $P<0.001$). This stability was reflected in a significantly smaller median number of corrections of the endoscope with the robotic laparoscope holder (1 vs 5; $P<0.001$). The time lost through corrections of the laparoscope was significantly less in the robot-assisted interventions than in the conventionally assisted interventions (0 minutes vs 2 minutes; $P<0.001$). The robot-assisted surgery led to a higher satisfaction score of the surgeon (10 vs 7; $P<0.001$). There was a positive correlation between image stability and satisfaction of the surgeon ($r=0.9$, $r^2=0.87$), and a negative correlation between number of corrections of scope and satisfaction of the surgeon. There was a poor correlation between intervention time and satisfaction of the surgeon.

4. Discussion

The present study shows that a dynamic laparoscope manipulator can facilitate comfortable solo-surgery. The device provides significantly greater image stability and less prolongation of the intervention owing to camera correction as compared with conventional laparoscopy. Surgeons themselves can direct their optical field; in other words, the vision is no longer controlled by another person whose availability and skills are variable. Control of the laparoscope through a hand-controlled interface, as compared with voice control or a foot pedal, corresponds to the natural ergonomics of surgery, where eyes and hands work together. By enhancing the surgeon’s autonomy of vision, while maintaining equally effective operative quality, higher satisfaction of the surgeon can be achieved regarding...

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**Table 2**

<table>
<thead>
<tr>
<th></th>
<th>Operation time, mina</th>
<th>No. of patients</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intervention A</td>
<td>90 (45–180)</td>
<td>31</td>
</tr>
<tr>
<td>Laparoscopic supracervical hysterectomy</td>
<td>21</td>
<td>10</td>
</tr>
<tr>
<td>Myomectomy</td>
<td></td>
<td>10</td>
</tr>
<tr>
<td>Intervention B</td>
<td>46 (20–180)</td>
<td>69</td>
</tr>
<tr>
<td>Adnexal surgery</td>
<td></td>
<td>36</td>
</tr>
<tr>
<td>Diagnostic laparoscopy, endometriosis, adhesiolysis</td>
<td>33</td>
<td></td>
</tr>
</tbody>
</table>

* Values are given as median (range) unless otherwise indicated.
the ergonomics of the intervention. In addition, greater involvement of the scrubbed nurse leads to the need for fewer surgeons—a factor that will have an important economic impact where staff shortage is an obstacle to the performance of laparoscopic surgery.

There were several limitations to the present study. The surgeon’s assessments of image stability and satisfaction using a visual analog scale were subjective; however, this scale is an established tool for objectifying assessments of subjective comfort (i.e., pain) and provides intra-individual reliable results. Another limitation was that the patients’ follow-up time did not exceed the conventional time of postoperative supervision during admittance to the hospital. Furthermore, possible difficulties using the robotic endoscope can occur if there is a complication, such as bleeding or trauma, in the middle and upper abdomen while working in the true pelvis because the setup has to be rearranged for the middle and upper abdomen; rearrangement of the setup can be a safety risk because it takes approximately 2 minutes. The complication rate in the present cohort was 1%. Finally, because the study was conducted in the setting of an in-patient hospital with sufficient staff, only limited conclusions can be made regarding the management of complications in solo-surgery in a setting where no assistance is available.

The robotic laparoscope holder facilitates comfortable solo-surgery, leading to higher satisfaction of the principal surgeon. The surgeon’s vision is self-directed through a hand-controlled interface according to the ergonomics of surgery. Even more demanding laparoscopic interventions, such as surgery of the uterus, can be performed without time loss in solo-surgery. The economic implications of this study are of interest for both in-patient and out-patient clinics. Well-established solo-surgery leads to a manifest absence of assisting staff; further studies should investigate the management of complications in solo-laparoscopy.

Conflict of interest

The authors have no conflicts of interest.

References