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A prospective study comparing operative time in conventional laparoscopic and robotically assisted Thal semifundoplication in children

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Abstract

Background: It is not clear if robotically assisted surgery (providing articulating instruments, 3-dimensional vision, intuitive ergonomics) performed in pediatric patients offers the same advantages over conventional surgery as in adult patients. In the laboratory setting, robots require less time to perform certain tasks. Accordingly, we tested the hypothesis that the time required to perform a robotically assisted laparoscopic Thal semifundoplication is different compared with a conventional laparoscopic procedure in children.

Methods: The time required to perform single operative steps was prospectively recorded in 10 consecutively performed Thal semifundoplications with the use of a robot (da Vinci) and in 10 consecutively performed operations done by conventional laparoscopy.

Results: No conversion to an open operation was necessary, and there were no intraoperative complications throughout the study and no postoperative complications up to 14 months after surgery. Total operative time was similar in both groups. In the robotically assisted group, time for setup was significantly longer (20.8 ± 7.5 vs 34.6 ± 9.2 minutes, $P < .05$), but dissection of the hiatal region as the most challenging operative step was accomplished 34% faster in the robotically assisted group (30.8 ± 8.7 vs 20.2 ± 5.3 minutes, $P < .05$).

Conclusion: At the current level of technology, the robotic system is superior compared with established standard laparoscopic techniques requiring tissue preparation; however, the potential benefit in operating time is counterbalanced by the increased complexity of setting up the system.

Minimally invasive laparoscopic procedures have become widely available for a number of different operations, not only in adults but also in children. Several limitations of conventional endoscopic tools, such as limited instrument mobility or decreased ergonomics, have been partially overcome with the use of robotics [1]. Therefore, appliance of surgical robots may provide substantial clinical progress to the field of pediatric laparoscopic surgery. Robotically assisted operations are safe in adult and pediatric patients; the first surgical robot (AESOP) received Food and Drug Administration approval in 1994 [2,3]. In the laboratory

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setting, the use of robots resulted in quicker and more efficient performance of standardized laparoscopic exercises compared with the standard laparoscopic approach [4,5]. It is not clear, however, if the potential technical benefits offered by this new technique are relevant in the clinical setting, especially in pediatric surgery. To the best of our knowledge, only 1 prospective trial using robotically assisted surgery for interruption of patent ductus arteriosus in children has been published to date [6]. The authors showed that robotically assisted surgery resulted in a similar outcome compared with that of conventional thoracoscopic closure of a patent ductus arteriosus; however, a longer operative time was required in the robotically assisted group. Our group and others have previously demonstrated feasibility and safety using robots to perform Thal partial fundoplication and other operative procedures in children [2,7,8]. In the study presented here, we compare the operative time required to perform a Thal semifundoplication by standard laparoscopy with the operative time required for a robotically assisted procedure. We tested the hypothesis that the time from the first incision to closure for the robotically assisted laparoscopic Thal semifundoplication is different from the time required to perform conventional laparoscopy. We chose this standard pediatric operation to evaluate the possible application of robots in the field of pediatric surgery.

1. Material and methods

1.1. Patients

All patients had clinically relevant gastroesophageal reflux (ie, pulmonary involvement, regurgitation, or persistent heartburn). No patient had other coexisting diseases that could possibly interfere with the operation. In neither group are patients with neurologic impairment present. Further exclusion criteria were the need for a gastrostomy, recurrent reflux disease, prior operation of esophageal atresia, presence of diaphragmatic hernias, omphalocele, or gastroschisis. After a careful and unprejudiced explanation of both types of operation, children were allocated to either a conventional laparoscopic procedure or a robotically assisted operation according to parents' preferences. Data from 10 consecutive standard laparoscopies and from 10 consecutive robotically assisted laparoscopic operations for correction of gastroesophageal reflux disease by anterior hemifundoplication (Thal) in children were prospectively recorded and analyzed. Data were collected from December 2001 until October 2003.

1.2. Robotic system

For robotically assisted laparoscopic surgery, the da Vinci computer-enhanced telemanipulator system (Intuitive Surgical, Mountain View, Calif) was used. The system consists of 3 major components: a surgeon console equipped with a 3-dimensional optic system and 2 manipulator handles, a computer controller, and a triple-armed surgical robot. The surgeon operates the robot via the ergonomically designed console connected to the robot in a sitting position with elbows resting on a bench. The surgeon grasps the left and right handles mounted on the console to control the robot arms. The instruments have all degrees of freedom just like the surgeon's own wrist. The grip strength of the instruments can be adjusted. The operative field is magnified 10× with stereo vision. Two of the robot's arms are used to hold instruments and the third one controls the camera. The surgeon's movements are electronically transmitted with a tremor filter via handles to the robot's arms. These signals can be downscaled from 2:1 to 5:1. Camera and monopolar coagulation are controlled with a foot switch. A built-in pivot point on each instrumental arm eliminates the use of the patient's body for leverage, thereby minimizing tissue damage.

1.3. Groups

Surgery was always performed under general anesthesia with the patient in supine reverse Trendelenburg position as described earlier by our group [9]. All patients were fitted with a thin nasogastric tube. After disinfection of the skin and draping, 4 trocars were placed and a carbon dioxide pneumoperitoneum with an intra-abdominal pressure of 12 mm Hg was established.

1.3.1. Group 1, standard laparoscopic procedure

After insertion of a 10-mm umbilical camera trocar, under endoscopic vision, 2 additional 5-mm instrument trocars were inserted in the left and right mid abdomen and one 5-mm instrument port (for the liver retractor) at the right subcostal margin. Preparation of the hiatal region was performed using a hook for electrocautery, starting with an incision in the peritoneal cover of the distal esophagus. Afterward, gastric fundus and both crura of the diaphragm were exposed. The vagal nerve was regularly identified and not separated from the esophagus. After complete mobilization of the esophagus, retroesophageal hiatal repair was performed using 2 sutures (Ethibond^{R} 2/0, SH needle). A 28F to 35F gastric tube was inserted to demonstrate patency of the esophageal passage. The gastric fundus and esophagus were approximated with Ethibond^{R} 3-0 sutures, and semifundoplication was achieved with sutures between the lateral part of the gastric fundus and the right side of the esophagus.

1.3.2. Group 2, robotically assisted laparoscopy

After insertion of a 12-mm umbilical camera trocar, under endoscopic vision, 2 additional 8-mm special robotic instrument trocars were inserted in the left and right mid abdomen and one 5-mm instrument port (for the liver retractor) at the right subcostal margin. The robot was positioned on the left side of the patient. The sterile wrapped robotic arms were connected with the trocars. A scrub nurse