Early experience in robot-assisted laparoscopic Heller myotomy
Abstract

Introduction: Heller myotomy for achalasia is routinely performed laparoscopically. This offers patients significant benefits compared to open surgery. Surgeons, however, are limited in their manipulation and visualisation during laparoscopic interventions. Robotic telemanipulation systems were introduced with the objective to alleviate these limitations. The purpose of this study was to demonstrate the efficacy and safety of performing a Heller myotomy with the use of a robotic telemanipulation system.

Methods: Fourteen patients were operated with the da Vinci robot system. Robotic system set-up time, per- and postoperative complications, blood loss, operating time and hospital stay were recorded. Follow-up included manometry and symptom score.

Results: The robotic system set-up time was 15 minutes (10-15). Thirteen procedures (13/14; 93 %) were completed by laparoscopic surgery, one was converted for reason of inadequate exposure. One peroperative mucosal perforation was closed laparoscopically. The median blood loss was 10 ml (10-200). Median operating time was 90 minutes (75-150). Hospitalisation ranged from 2 to 8 days (median 3). No complications occurred in a 30 days postoperative period. Dysphagia was relieved in 12/14 patients (86%). Heartburn was present postoperatively in 2/14 patients (14%). Manometry showed a significant decrease in median lower oesophageal sphincter (LOS) pressure from 2.9 preoperatively to 1 kPa postoperatively (p=0.008).

Conclusion: Robot-assisted laparoscopic Heller myotomy was demonstrated to be safe and effective in reducing basal LOS pressure and dysphagia. The results of this study clearly support the feasibility of the use of this system in performing a delicate laparoscopic surgical procedure. The use of a robotic system was experienced as highly supportive in manipulation and visualisation by the surgical team involved.

Introduction

Surgical treatment of achalasia consists of a myotomy of the longitudinal and circular musculature of the lower oesophageal sphincter as described by Heller. This procedure was traditionally performed through a laparotomy. A laparoscopic approach was introduced by Shimi in 1991. This minimally invasive intervention leads to a reduction in the operative trauma which results in potential benefits for the patient such as diminished hospitalisation, reduced postoperative pain, faster convalescence and cosmetic advantages.

However, laparoscopic surgery imposes technical challenges on the surgeon. These challenges mainly concern a limitation of both visualisation and manipulation. Robot-assisted laparoscopic surgery puts the minimally invasive treatment in a new perspective by dealing with these technical challenges.

The purpose of this study was to demonstrate the efficacy and safety of the robot-assisted Heller myotomy and to document the short-term effectiveness, both by clinical and functional outcome parameters.

Patients and Methods

Fourteen patients (10 females, 4 males, median body mass index 24 (18-31), median age 39 (18-73)) were operated on an elective basis between June 2001 and April 2003. The diagnosis 'achalasia' was confirmed on the combination of symptoms and oesophageal manometry. Subjective severity and frequency of dysphagia were scored on a scale from 1 to 5 (Table 1). This was also performed for heartburn to evaluate the postoperative presence of gastro-oesophageal reflux. A water-perfused silicone catheter containing 8 sideholes and an incorporated sleeve sensor (Dentsleeve, Bel Air, Australia) was used for manometry. In all patients manometry showed an incomplete to absent lower oesophageal sphincter (LOS) relaxation and simultaneous oesophageal contractions. Gastro-oesophageal reflux disease was excluded in all cases by 24-hour pH-metry.

In all patients balloon dilatation was attempted prior to surgery. In two patients, initial treatment was with circular botulinum toxin injections. This offered no or only shortlasting patient satisfaction (<3 months). In one patient previous treatment consisted of a long thoracoscopic myotomy for the diagnosis of diffuse oesophageal spasm. After absence of symptom relief, manometry was repeated and showed a LOS-resting pressure of 3 kPa without relaxation after wet swallowing. Prior manometry did not demonstrate these findings. In retrospect, this patient most probably suffered from vigorous achalasia.

All patients were operated upon with the da Vinci robotic telemanipulation system (Intuitive Surgical, Sunnyvale, Ca, USA). Patients were positioned in a supine, reversed Trendelenburg (20-30°) position with the assisting surgeon standing between the patient's legs. A 12-mm camera trocar was introduced under direct sight in the midline, halfway between the xiphoid and umbilicus. Two 8-mm trocars
with special adapters for the robotic system were introduced in the left and right subcostal space. Additional trocars were introduced in the right flank (12 mm) and left lower abdomen (11 mm) to host a liver retractor and an assisting instrument respectively (Figure 1).

![Trocar placement for robot-assisted Heller myotomy.](image)

**Figure 1**

*Trocar placement for robot-assisted Heller myotomy.*

After introduction of a 30-degree scope, facing down, a liver retractor was introduced. The gastro-oesophageal junction was exposed and an anterior myotomy was performed. The circular and longitudinal muscle fibres of the LOS and the first two centimetres of the gastric cardia were divided using electrocautery.

Robotic system set-up time, per- and postoperative complications, blood loss, operating time (first incision-wound closure) and hospital stay were recorded. Follow-up included a quantitative symptom index score for severity and incidence of dysphagia and heartburn and a standard oesophageal manometry. Data were analysed using SPSS and are expressed as medians and range. The decrease in LOS amplitude and decrease in symptom score after the procedure were analysed with a Wilcoxon signed ranks test.
Results

The time required for preparation of the robotic equipment was 15 minutes (10-15). Thirteen procedures (13/14: 93 %) were completed by laparoscopic surgery. In one patient, the laparoscopic procedure was converted to an “open” approach due to an inadequate exposure of the distal oesophagus. One intraoperative mucosal perforation could be closed laparoscopically. The median blood loss was 10 ml (10-200). Median operating time was 90 minutes (75-150, Figure 2).

Hospital stay ranged from 2 to 8 days (median 3). No complications occurred postoperatively and during 30-days follow-up.

Follow-up ranged from 2 to 24 months (median 11). All but two patients showed a decrease by two or more points of incidence and severity of both heartburn and dysphagia (Table 1). The patient with vigorous achalasia was one of the two patients (2/14) with absence of dysphagia relief. A barium oesophagogram revealed kinking of the distal oesophagus. Re-operation included an extensive re-myotomy, gastropexy and an anterior fundoplication. The patient was symptom free since this second operation, though the two-month follow-up was short. The other patient with persisting dysphagia was operated recently (< 3 months ago). Currently, she also reports severe heartburn and was diagnosed with a reflux oesphagitis at endoscopy, which was treated with a proton pump inhibitor. One more patient reports an increase of heartburn postoperatively (total 2/14: 14 %). In this patient, pathological gastro-oesophageal reflux (16 % of total time) was diagnosed at 24-hour pH-metry, necessitating an additional Dor fundoplication. Hereafter her complaints resolved. Manometry showed a significant decrease in LOS-pressure from 2.9 to 1 kPa (p=0,008) in all.
Table 1

<table>
<thead>
<tr>
<th></th>
<th>Pre-op</th>
<th>Post-op</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Heartburn frequency</td>
<td>4 (1-5)</td>
<td>1.5 (1-4)</td>
<td>0.06</td>
</tr>
<tr>
<td>Heartburn severity</td>
<td>4 (1-5)</td>
<td>2 (1-4)</td>
<td>0.05</td>
</tr>
<tr>
<td>Dysphagia frequency</td>
<td>5 (5)</td>
<td>2.5 (1-5)</td>
<td>0.007</td>
</tr>
<tr>
<td>Dysphagia severity</td>
<td>5 (5)</td>
<td>2 (1-5)</td>
<td>0.01</td>
</tr>
<tr>
<td>LOS-pressure (kPa)</td>
<td>2.9</td>
<td>1</td>
<td>0.008</td>
</tr>
</tbody>
</table>

Discussion

Treatment of achalasia aims at symptomatic relief through lowering the LOS-pressure. Since a medical treatment offers little improvement of symptoms, this is either performed through an endoscopic or a surgical approach. Two endoscopic approaches exist: intrasphincteric injection of botulinum toxin and dilatation of the LOS. Considering the botulinum toxin treatment, initial success rates of over 80% are reported, but long-term efficacy is established in fewer than 40% of patients. This results in repeated injections. Endoscopic dilatation of the LOS offers excellent short-term results and initial relief of symptoms in up to 90% of patients, but on long-term, efficacy decreases to 70% or less.

The surgical treatment of choice is a Heller myotomy and offers better long-term results. Symptom relief is established in over 90% of patients for over 5 years of time. The discussion on the access, thoracotomy or laparotomy, has been renewed by the introduction of a minimally invasive laparoscopic approach. Laparoscopic surgery reduces the operative trauma, resulting in distinct advantages for patients. The treatment of achalasia through a laparoscopic approach has been demonstrated to be equally effective as an open operation.

However, in laparoscopy surgeons have to deal with some disadvantages compared to conventional “open” surgery. The first disadvantage relates to visualisation. Working through trocars sets a limit to direct visualisation. The image of the operative field therefore needs to be provided by a camera and to be projected on a tv-screen. Not only does this method of imaging provide a two-dimensional image, which inhibits perception of depth, the projection on a screen also interrupts the natural eye-hand-target working axis. A second disadvantage concerns manipulative capacities. Working with long instruments through fixed entrypoints in the
abdominal wall limits the degrees of freedom of motion. Other issues concerning manipulation are problems with opposite instrument and hand action, scaling of motions and friction on the instruments, caused by valves inside the trocars.

In 1997 telemanipulation systems -also called surgical robotic systems- were first used in gastro-intestinal surgery \(^{19}\). The introduction of these systems aimed at providing a solution towards the difficulties in laparoscopic surgery mentioned. Currently, two robotic telemanipulation systems have EU- and FDA clearance for usage in digestive surgery. The first was the da Vinci system, followed by the Zeus system (Computer Motion, Goleta, Ca, USA).

In the system we used (da Vinci) the surgeon is seated at a console. From this console he conducts three robotic arms, placed on a cart. These arms carry the surgical instruments and the camera and exactly copy the surgeon’s movements. Working with this system, the perception of depth (by a 3D-camera system) and the natural eye-hand-target axis are restored. Manipulation is improved by articulations of the tip of the robotic surgical instruments. Next to this, opposite movement of instruments and hands, tremors and friction of the trocar-valves are eradicated. The option to have motions scaled further contributes to manipulative capacities \(^{5,20,21}\).

For robot-assisted laparoscopic Heller myotomy, literature remains limited to case reports \(^{22-25}\). This was also demonstrated in our cases. The assistance of the robotic system was experienced as very helpful for this specific procedure. Not only does the 3D vision support proper imaging of the circular muscle fibres, the articulated instruments also enable working in a parallel line with the oesophagus, approaching the circular muscle fibres perpendicularly. The minuscule movements needed to safely dissect the musculature while keeping the mucosa intact could be performed with ease and precision. The option to scale down the movements performed by the robotic instruments further contributes to working with the scrutiny needed to complete this procedure. In our experience and current perception, the benefits of the robotic system return the surgical precision of open surgery to the operating surgeon, while maintaining the benefits of minimally invasive surgery for the patient.

The single intraoperative complication we encountered, a mucosal perforation, could not be attributed to the use of the robotic system. In this case, the myotomy was extended distally on the stomach, according to peroperative manometry. At the most distal part, the mucosa was perforated.

However, lack of force feedback might attribute to mucosal perforations in inexperienced hands. The surgeon receives no force feedback in the manipulators and therefore no tactile information of forces that are applied. The 3D visual clues compensate this problem for a great deal, but in our opinion, force feedback remains an essential for future generations of these advanced surgical support devices.

The robotic system set-up time of 15 minutes was not experienced as disturbing. In most cases this time could be incorporated in the time needed by the anaesthesia-team for patient preparation.

The postoperative presence of dysphagia (2/14 patients) in one patient was attributed to the presence of a kink in the aperistaltic oesophagus following the long
myotomy. In retrospect, this patient should not just have had a laparoscopic Heller myotomy, but rather the extensive myotomy, gastropexy and anterior fundoplication, which she finally underwent, in the same session. After this course of action, dysphagia improved substantially although follow-up is still limited (2 months).

In the other patient, we attribute the dysphagia to the postoperative presence of gastro-oesophageal reflux. The subjective symptom of dysphagia could not be related to persistent absence of LOS-relaxation in any of our patients.

The number of two of 14 operated patients experiencing symptoms of gastro-oesophageal reflux postoperatively was comparable to the number mentioned in a recent meta-analysis for Heller myotomies without additional anti-reflux procedure 26.

In conclusion, robot-assisted laparoscopic Heller myotomy was repeatedly demonstrated to be safe and effective in terms of decreasing LOS-pressure and early relief of symptoms. The results of this study clearly support the feasibility of the use of this system in performing a delicate laparoscopic surgical procedure. The use of a robotic system was experienced as highly supportive in manipulation and visualisation by the surgical team involved.
References


