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Technique and results

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Since its first description in 1991, laparoscopic Heller myotomy has been associated with better short-term outcomes and shorter recovery time, compared to open operation and it is now generally accepted as the procedure of choice for achalasia. Despite the well-known short-term benefits of laparoscopy, esophageal perforation still occurs. Robotic technology has recently been introduced into laparoscopic clinical practice with the aim of improving surgical performance and excellent results have been described with robotically assisted Heller myotomy in patients with achalasia. The 3-D visualization, the very steady operative view and, above all, the articulated arms of the da Vinci Robotic Surgical System allow the surgeon to visualize and divide each individual muscolar fiber, easily identifying the submucosal plane at the GE junction. However, no high-quality studies are available in literature. Moreover, from an economic point of wiew, the use of the robotic technology may increase both the costs and the volume of surgeries performed.

KEY WORDS: Achalasia, Robotically assisted myotomy

Introduction

Since its first description in 1991[1], laparoscopic Heller myotomy has been associated with better short-term outcomes and shorter recovery time, compared to open operation. Given this high success rate[2], it was soon generally accepted as the procedure of choice for achalasia over the nonsurgical treatment options, such as medical treatment with calcium channel blockers or nitroglycerin, endoscopic injection of botulinum toxin into the distal esophagus and balloon dilation. In fact, the introduction of laparoscopic Heller myotomy for achalasia was associated with a two-fold increase in use of surgery in the United States during a 12-year period from 1993 to 2005[3].

Despite the well-known benefits of laparoscopy, some studies reported an esophageal perforation rate up to 15%[4]. Although these perforations are usually repaired during the operation without any sequelae, this kind of complication expose the patient to a long hospital stay and the risk for a potentially fatal esophageal leak.

Robotic technology has recently been introduced into laparoscopic clinical practice with the aim of improving surgical performance. Since 2000, when the Food and Drug Administration approved the robotic surgery for applications in general laparoscopic surgery, several authors showed excellent results with robotic Heller esophageal myotomy[5-8]. Despite the lack of randomized trial, the robotic-assisted Heller myotomy in patients with achalasia appears to be associated with a lower risk of perforation, compared with standard laparoscopic operation[9]. The same authors suggest a possible benefit in Quality of life.

The use of a robotic-assisted laparoscopic procedure seems to be particularly useful for those operations where a higher degree of skills is required (i.e. esophageal

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myotomy). In fact, the three-dimensional view with magnification of the operating field, instruments with additional degrees of freedom compared with laparoscopy, adjustable-motion scaling and filtering of tremor, and better ergonomics for the surgeon are all important factors that could lead to a more precise and safe myotomy, reducing in this way the risk of perforation.

Preoperative Evaluation

Symptoms should be assessed according to the modified DeMeester Symptom Scoring System (MDSS)[10], taking into account severity of dysphagia, heartburn and regurgitation.

Before surgery, the upper gastrointestinal tract should be examined radiographically and endoscopically. Achalasia severity is graded at barium esophagogram according to the maximum transverse diameter of the esophagus: grade I < 3.5 cm; grade II 3.5 to 6.0 cm; and grade III > 6.0 cm[11]. Based on the shape of the distal esophagus, achalasia is classified by morphologic type: spindle type (Sp), flash type (Fk), and sigmoid type (Sig). Sigmoid type is diagnosed when the diameter of the esophagus exceeds 6 cm and the distal esophagus is kinked toward the left, outside of the esophagus axis. An endoscopy is performed to rule out malignancies and gastroduodenal pathologic conditions. Moreover, it is useful to repeat an upper endoscopy 1 week before surgery to rule out esophageal candidiasis which could affect the perioperative outcomes, owing to a higher risk of esophageal perforation associated with this condition.

Manometry demonstrates esophageal body aperistalsis and incomplete LES relaxation, adding also useful prognostic informations. A recent study by Zaninotto et al. showed at multivariate analysis, that a high preoperative LES pressure (>30 mm Hg) is an independent predictor of a good response to the treatment, probably reflecting a less severely damaged esophageal muscle function[12]. It was speculated also that patients with a high LES pressure may have a shorter gastric component of their sphincter and are therefore less exposed to insufficient myotomy. Finally a 24-hour esophageal pH should always be done to rule out abnormal gastroesophageal reflux.

Robotically Assisted Heller Myotomy

Patients are usually hospitalized and kept fasting 12 hours prior to surgery.

An intravenous fluid load with 1000-1500 ml of cristalloid solution is administered.

A nasogastric tube is placed the day of surgery and a washout of the esophagus is performed prior to anesthesia to reduce the risk of aspiration during intubation.

A number of robotic surgery devices have been developed and the da Vinci Robotic Surgical System (Intuitive Surgical, Mountain View, California, USA) is the most widely used device worldwide. This consisted of a robotic manipulator with three arms (the central arm held the camera and the two outer arms the surgical instruments) and a remote console, where the operating surgeon sat during the procedure. The room set-up, trocars placement and patient position are the same as that used for others gastroesophageal laparoscopic Robot-assisted procedures[13,14]. Patients are placed in a leg-abducted, mild reverse Trendelenburg position.

The operating surgeon controls the robot at the console; the first and second assistants place the trocars once the pneumoperitoneum has been created, connect the arms and handle the laparoscopic instruments inserted through the accessory trocars. After a 12-mmHg pneumoperitoneum has been created with a Veress needle, three robotic trocars (one 12-mm disposable for the camera, two 7-mm non-disposable) are inserted in the supraumbilical position, and in the left and right midclavicular line below the costal margin. Two additional trocars are placed for exposure. One (10 mm) is inserted in the right anterior axillary line below the costal margin and is used to introduce the liver retractor. The other (12 mm) is inserted in the left anterior axillary line and used for accessory instruments. Operative steps are similar to those of the laparoscopic technique[15]. A standard long myotomy should be extended at least 2 cm on the anterior gastric wall and 6 cm above the gastroesophageal junction on the anterior esophageal wall. An intraoperative endoscopy can be performed to verify the integrity of the mucosa and completeness of the myotomy. In these patients, the section of LES and its subsequent hypotonia and lack of peristalsis, exposes the lower part of the esophagus to the GERD. For this reason the myotomy is often associated with an antireflux procedure[16,17]. The Dor fundoplication should be used as the preferred method to re-establish GER control in these patients. A recent randomized trial comparing the long-term results of Heller myotomy associated with anterior fundoplication (Dor procedure) or total fundoplication (floppy-Nissen procedure), showed that, although both techniques achieved long-term GER control, the recurrence rate of dysphagia was significantly lower among the patients who underwent Dor fundoplication (15% vs. 2.8%, respectively)[18].

Suction drains are not routinely used and nasogastric tubes are avoided because of concerns about mucosal traumatism. A postoperative water-soluble contrast swallow is done on the second postoperative day. Once demonstrated the integrity of the mucosa, oral feeding is then progressively resumed and patients are usually discharged home on the third postoperative day.

Technical considerations

The main risk of the myotomy is to cause a perforation of the mucosa. This is usually caused during the dissection maneuvers or during the intraoperative endoscopy. While in the latter case this complication can be prevented by having the procedure done by an experienced endoscopist, in the former case the use of a robotic-assisted dissection could be of some help. Many authors agree in saying that the robotic technology could exceeds the limitations of laparoscopic instruments allowing a more safe and precise division of the muscolar layers and subsequently reducing the risk of perforation. The 3-D visualization, the very steady operative view and, above all, the articulated arms of the da Vinci Robotic Surgical System allow the surgeon to visualize and divide each individual muscolar fiber, especially at the gastroesophageal junction where the fibers change direction from circular to oblique. In fact, the extension of the myotomy onto the gastric wall is the most critical and challenging part of the operation. The plane between the submucosa and the muscle layer is less evident at this level and an incorrect dissection can lead either to a mucosal injury or an insufficient downward myotomy. Moreover, whether a mucosal perforation occurs, this could be repaired more easily with the robot, avoiding the need for conversion to open surgery.
Several studies supported the safety of robotic-assisted myotomy[5-8]. They all found the robotically assisted Heller myotomy superior to any standard laparoscopic technique. Furthermore a recent metanalysis has reported no esophageal perforations on over 100 patients submitted to robotically assisted Heller myotomy compared with a perforation rate of 11% for standard laparoscopic myotomy[9].

Drawbacks and health care costs

Although the da Vinci system offers certain advantages, it has been associated also with several drawbacks. One of the main disadvantages of robot-assisted laparoscopic procedure is prolonged operating time compared with standard laparoscopy. This is mainly due to the robot set-up time and so it is unlikely to decrease over time. The lack of tensile feedback is another limitation of the device, requiring an intuitive method of hand-eye coordination to improve hand movements. Moreover despite the better ergonomics for the operating surgeon, the assistants' position is far from being ergonomic. They are constantly in contact with the robot's arms, having to move their instruments without coming into conflict with those of the robot. Therefore, a well-trained assistant is always of some importance to overcome these technical difficulties.
Apart from these technical limitations, the high cost associated with the robotic procedures is certainly the major issue. Nowadays the da Vinci Surgical System has been widely adopted. The number of robot-assisted procedures that are performed worldwide has nearly tripled since 2007, from 80,000 to 205,000. Robotic surgical systems have high fixed costs, with prices ranging from $1 million to $2.5 million for each unit. The systems also require costly maintenance and demand the use of additional consumables. A recent paper on this topic examined the cost studies of robot-assisted procedures published since 2005. The authors found that if robot-assisted surgery will replace conventional surgery, it would generate more than $2.5 billion in additional health care costs annually[19].

Conclusion

The use of a robotic-assisted laparoscopic procedure in Heller myotomy for achalasia seems to play a role in lowering the rate of mucosal perforation, this way adding some clinical benefits and not just reproducing the well-known advantages of laparoscopy. The specific characteristics of the da Vinci Surgical System , such as 3-D visualization, steady operative view, articulated arms and better ergonomics, may lead the surgeons to exceed their laparoscopic performance[20] allowing an easier identification of the submucosal plane, a more precise division of the muscolar fibers and also an easier rapair in case of perforation.
However, although reports showed excellent results using the robotic technology in achalasia, no high-quality studies are available in literature[9]. The lack of blinding and randomization are source of bias and so these results should be interpreted with caution.
Moreover, from an economic point of view, the use of the robotic technology may increase both the costs and the volume of surgeries performed. This occurred because competition among hospitals results in great investment in robot surgery in order to attract surgeons and consequently their patients. Therefore, patients seem to prefer to undergo a robotic procedure rather than an alternative technique. In the United States this phenomenon has led to an increase of more than 60% in hospital discharges for prostatectomy between 2005 and 2008[19].
In conclusion, further studies, especially randomized controlled trials, are needed to confirm the advantages that this technique seems to offer with respect to standard laparoscopic Heller myotomy. Future trials should also include health-care oriented outcomes (i.e. cost-effectiveness measures).

Riassunto

L'approccio mini-invasivo per il trattamento chirurgico dell'acalasia ha mostrato, fin dalle sue prime descrizioni nei primi anni 90, notevoli vantaggi in termini di mino-

re morbidità e degenza ospedaliera se comparato con l'approccio laparotomico. Grazie a questi benefici, la miotomia esofagea secondo Heller eseguita per via laparoscopica è diventata ben presto l'approccio di scelta per i pazienti affetti da acalasia rispetto ai trattamenti non chirurgici, quali l'iniezione di tossina botulinica o la dilatazione endoscopica.

La ricerca di una sempre minore invasività in chirurgia, ha portato negli anni 2000 allo sviluppo della tecnologia "robotica". Questa particolare tecnologia di controllo remoto computerizzato, ha lo scopo di migliorare la performance chirurgica sintetizzando i vantaggi della mini-invasività laparoscopica con la manualità propria degli interventi chirurgici classici per via laparoscopica. Questo risulta particolarmente utile quando i limiti della chirurgia laparoscopica (rigidità dgli strumenti, visione bidimensionale) rischiano di pregiudicare il buon esito della procedura. La letteratura ad oggi disponibile sui risultati dell'applicazione della tecnologia robotica al trattamento chirurgico dell'acalasia sembra evidenziare una tendenza verso un minore tasso di perforazioni esofagee intraoperatorie. La visione tridimensionale del robot permetterebbe infatti una migliore visualizzazione delle fibre muscolari esofagee e la più agevole identificazione del piano sottomucoso. Inoltre la maggiore libertà e grado di movimento degli strumenti robotici permetterebbero una più sicura e precisa miotomia anche in corrispondenza della giunzione gastroesofagea, notoriamente il punto a maggior rischio di perforazione dell'intera operazione.

Nonostante questi benefici, la mancanza di feedback tattile, i lunghi tempi operatori e soprattutto i maggiori costi, sono tutti ben noti svantaggi associati alla chirurgia robotica. Trial clinici, possibilmente randomizzati, sono necessari per confermare questi risultati che vanno pertanto interpretati con cautela soprattutto alla luce dei costi di gestione.

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