Review Article on Revisiting Robotic Surgery for Stomach

Role of robotic gastrectomy in modern gastric surgery

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Abstract: Robot assisted gastrectomy entails hope for overcoming laparoscopy limitations in the field of gastric surgery. The robotic system has many inherited advantages in means of angulations, ergonomics, vision and augmented imaging yet his penetrance has been slow. The aim of our review is to highlight the potential benefits and down faults of the robotic approach in gastrectomy and review the current literature in segregated aspects and overall clinical outcome. As the robotic gastrectomy is still at his preliminary stages, we offer some future perspective and our own thoughts on the clinical data gathered so far. By our literature review we may assume that robotic non-inferiority has already been accepted and two major down faults arise from the longer operative time and higher costs. Evidence is accumulating on better lymphadenectomy, reduced blood loss as a surrogate for finer dissection, shorter learning curve and future role in more advance cancers. Future technological advances and clinical experience entails further short and long-term outcome improvement/advantages.

Keywords: Robotic surgery; gastrectomy; minimally invasive surgery (MIS)

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Introduction

As the minimally invasive approach improved short-term outcome and comparable oncologic efficacy have flourished, robotic gastrectomy is being implemented for gastric cancer surgery worldwide in expectation for overcoming the inherent limitation of laparoscopic surgery. Though the high proficiency achieved in laparoscopic gastrectomy, the laparoscopic boundaries as freedom of movement and ergonomics limits, the minimally invasive surgery (MIS) approach for more complex cases. The benefits of robotic surgery that has been proven in fields as prostate (1) and rectal cancer (2) have yet to be proven in the gastric cancer surgery, though some reports for better lymph node harvest (3,4), shorter hospital stay and lesser blood loss have been published (4).The robotic non-inferiority in early gastric cancer has been generally accepted in all published articles. In these reviews we will try to discuss and review the literature in technical and clinical aspects of robotic gastrectomy with suggesting the future fields of interest and role for robotic gastrectomy.

Potential benefits

Degree of motion

The laparoscopic approach offers only four degrees of movement compared to six degrees of freedom for the human arm (shoulder + elbow + wrist) (5). The four degree of laparoscopic movement is achieved secondary to the in/out movement + rotation + vertical movement + horizontal movement (5). Some authors approach the jaws opening a 5th degree of freedom but as it is equal for the open, laparoscopic and robotic approach these degree of freedom will be discarded hereby. The loss of two degrees of freedom impacted the approach to narrow places as the

deep pelvis and organs adjacent to non-mobile tissue (post pancreatic vasculature). The robotic system offers the same six degrees of freedom as the open approach by utilization of a wrist like joints (5,6). These extra degrees of freedom enables easier more versatile approach to problematic to reach area in concordance to open surgery and improves dexterity performance (7). It is worth mentioning that no clinical data is available for the degree of freedom required to perform a task well.

In gastric surgery, this enhanced degree of movement has meaning in suprapancreatic nodal dissection and splenic hilar nodal dissection (4). There are actually a lot of concave area that straight instrument cannot approach without excessive compression of surrounding organs. Robot may give easier approach and reduce surgical stress to the patient though not yet proved (8).

Visualization

The regular laparoscopic approach offers a 2-dimensional (2D) vision while the robotic system harbors an advance 3-dimensional (3D) technology. Though the data concerning the advantages of 3D over 2D have yielded conflicting results, the learning curve of laparoscopic procedure have been shown to shorten secondary to 3D vision (9). Some of the conflicting results may arise from the different time scale of the 3D technique as it has been constantly improving. Not only the learning curve is shorten by the 3D vision but reduction of errors both in experienced surgeons as in novice one has been reported (7,10,11). Some may correctly argue that nowadays 3D vision systems are already available for laparoscopic approach and this section should no longer be argued in robotics.

Though the availability of the 3D laparoscope, the scopist tremor and shortage of skillful scopist, make the robotic 3D view on the upper hand.

Information augmentation

Information augmentation during real time by superimposing the 3D reconstruction of preoperative scan on the real time view offers improved navigation capabilities with potential for finer dissection in complex cases of vascular supply (12).

The use of intravascular indocyanine green (ICG) injection may provide real time evaluation of the blood supply quality to the resection margin there by reducing incidence of ischemic remnant and anastamosis problem while on the same time offering minimized resection in borderline cases (13).

The ICG fluorescence guided lymph node dissection method is reported to have a sensitivity for sentinel node dissection in early gastric cancer of 90-95% (14,15). These sensitivity harbors potential for better lymph node mapping during lymphadenectomy, the new robotic cameras are equipped with infrared detectors enabling ICG tracing in the face of bright light without withholding continues dissection thanks to their ability to incorporate light and infrared vision. The ICG tracing capabilities offers improved lymphadenectomy while potentially guiding the surgeons to deeper dissection in sentinel areas (14). The augmented lymph node visualization also potentiate for the combination of function preserving surgery with thorough lymph node dissection (16).

Mentoring and real time collaboration

The robotic system offers an opportunity for dual console improved mentoring and real time conferencing. Dual console provides improved equal 3D visualization and enables on screen marking thereby offering improvement in surgical training and real time decision cooperation between staff members (17).

Tremor and fine motor performance

The robotic system enables tremor abolition and motor movement scaling and facilitates optional less trauma to the tissue (18). The only paper relating to interleukin 6 (IL-6) and C-reactive protein (CRP) post-gastrectomy didn't prove the above advantage of robotic approach to gastrectomy (8). The robotic surgery as a result of tremor abolition and movement scaling has an easier more precise suturing capabilities by shortening the learning curve and improving these skill performance in narrowed limited workplace as single incision, low pelvis (19,20). The gastroesophageal junction hasn't yet been selectively examined for the above mentioned as a narrow distanced working place but might be extrapolated as similar characteristics of the previous two. The ergonomics and physical stress on the surgeons have been proved to be superior in robotic surgery (21) which might give extra precision in prolonged operations. But the above mentioned wasn't proved in a study, conducted by our group, approaching ergonomics in robotic versus laparoscopic gastrectomy (22).

Robots don't manipulate solely on the port entrance

and thereby reduce the well described fulcrum effect (23). As gastric surgery covers the whole upper abdomen, it fixed port results in fulcrum effect influencing surgical performance.

Solo operation

The 4-hand control and camera control offered by the robotic systems arise the potential for a real "solo" operation as the dependence on the assistant retraction and tissue handling obligated part in laparoscopic and open surgery is overcome (24). The above mentioned not only deals with better surgeon control on the operation but may prove beneficial in the new times of steep shorthand of the total number of surgeons.

Learning curve

Robotic gastrectomy has a short learning curve for experienced laparoscopic surgeons (25,26). The learning curve as being evaluated by reducing the operative time is reported to be less than ten cases. The robotic gastrectomy learning curve is presumed to be shorter compared to the laparoscopic one but most paper published to date haven't report the learning curve of surgeons without prior experience of other minimally invasive gastrectomy.

Pitfalls

Costs

Operating costs are undoubtedly higher for robotic surgery secondary to the disposable instruments price and maintenance (27). Withholding on the above is the actual cost of purchasing a robotic platform. In a recent multicenter Korean trial, it was calculated that a robotic gastrectomy mean cost is $4,490 higher than that of laparoscopy (28). Our group has published similar results in 2012.

Lack of tactile feedback and the importance of seeing every moving arms-catastrophy in robotic gatsrectomy

Reports of patient injuries during robotic surgery and malfunctions of the system were published since the system was released to the market. The majority of the reported injuries were not clearly device-specific, but rather a result of human error, possibly from lack of proper training of the safe use of the device. The lack of tactile feedback harbors the danger for tissue injury while moving the instruments out of sight. Pancreatic injury and even transaction secondary to the force and lack of tactile sensation were reported. The vast majority of device failures was not associated with patient injury, and was estimated at 0.38% (29).

Current clinical outcomes

Number of lymph node dissected in advanced laparoscopic/ open/robotic lymphadenectomy-suprapancreatic area

As previously mentioned the non-inferiority of robotic oncological outcome has been previously published. Most papers reporting outcome actually analyze a minimal experienced robotic surgeon with highly experienced laparoscopy approach of these same surgeons so the non-inferiority in the lymph node dissection may actually harbor better lymphadenectomy potential of the robotic approach (28). The many potential advantages of degree of motion and dexterity was evaluated in a recently published paper by our group showing significantly higher lymph node harvest in robotic gastrectomy at the N2 area and especially around the splenic vessels and hepatoduodenal ligament in suprapancreatic area (4).

Total gastrectomy and esophageal anastamosis

Non-inferiority but no true benefits to date have been shown for robotic total gastrectomy and esophageal anastamosis (30). Though the above mentioned the robotic approach enables a full hand-sewn anastomosis for reconstruction (31,32), which can be facilitated by using a robot-sewing technique, since esophago-jejunal anastomosis is one of the most difficult steps in performing the total gastrectomy.

Intraoperative performance compared to open and laparoscopic surgery

Though most papers reporting robotic gastrectomy shows longer operative time (average 40-50 minutes longer), the main influence is that of robot docking time. In recent report of operative time among experienced surgeons a comparable time was recorded (33).

The mean estimated blood loss shows a tendency for reduced blood loss in comparative study in spite of the lack of experience among robotic surgeons (3,27,34). The estimated reduced blood loss is around 35% of blood loss,

in an era of a well proven bad oncological effect for blood loss and transfusion requirements this advantage may sum up for better long-term oncological outcome.

As the issue of laparoscopic gastrectomy conversion rate hasn't been thoroughly evaluated, it is difficult to evaluate whether the above mentioned robotic advantages will succumb to lower conversion rate. In the recent Korean prospective comparative trial of 223 robotic cases and 211 laparoscopic there were no robotic conversion secondary to technical difficulties and only one case of conversion from laparoscopy secondary to bleeding, while two cases of robotic were converted to open secondary to oncologic safety (16).

Future prospects

The robotic surgery role, in current and future gastric surgery world, is still evolving and as previously mentioned harbors some down faults.

Future advances of instruments as angulating sealer that will use the seven degrees of motion of the robot and easier more flexible robotic systems with reduced docking time are just around the corner and may potentiate robotic advances. As time passes and robotic penetrance will grow more clinical trials for exploring the robotic role in gastric surgery will clarify its benefits/down faults and role in the field. These trials may also influence matters of cost by proving beneficent in the long-term medical cost and potentiate higher reimbursement for the procedure itself. The costs of robotic surgery, as in any other medical field, are expected to drop as competition will rise.

As qualified scopist and experienced well-trained gastric surgeons are on the shortage while on the same time the public demand for MIS with improved short-term outcome is growing the potential for true solo surgery in robotic gastrectomy may prove even more crucial.

Discussion

Robotic gastrectomy as detailed above offers many technical improvements and promises. Though it's inherent technical superiority, the laparoscopic achieved high proficiency level and leaves a very narrow space for superiority in the already minimally invasive conquered field of early distal cancer. With the down side of higher cost, we presume that robotic gastrectomy future lies in penetrance into those fields of gatsrectomy that are now being mostly done by an open approach enabling minimal invasive approach for all gastric resections.

Robotic improved lymphadenectomy and thorough D2 dissection in advanced cancers has some promising preliminary results and should be further evaluated thanks to his improved angulations, tremor reduction and 3D vision.

Total gastrectomy and reconstruction which bares higher conversions and hybrid intervention in the laparoscopic approach may show superiority for robotic and should be thoroughly evaluated.

It is important to note that most of the surgeons use an energy sealer to dissect and coagulate lymph nodes and vessels. These instruments don't have seven degrees of freedom and there by missing part of robotic major benefits. Working with angulating diathermy or improving current robotic sealing instruments may improve robotic surgery outcome.

Robots can help surgeons suture intracorporeally because of the precise 3D view and the instruments with seven degrees of freedoms but specific training and time frame for gathering the needed learning curve may show benefits in future studies as doctors proficiency and experience is constantly improving.

Conclusions

Surgical laparoscopic robotic system is not only a mechanical device but an information device potentially enabling difficult surgeries to be performed easily and safely. Role of surgeon is to develop surgeries using useful technological advancement for the patients. Also, cost-effectiveness is another important issue and appropriateness of clinical practice is vigorously evaluated and should not be overlooked. Both are same important goals for surgeons. As gastric cancer is fatal and common cancer and surgical role is important, robot gastrectomy should be sought to improve survival and quality of life of the patients.

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Footnote

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