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How does the robot affect outcomes? A retrospective review of open, laparoscopic, and robotic Heller myotomy for achalasia

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Abstract
Background Robotic techniques are routinely used in urological and gynecological procedures; however, their role in general surgical procedures is limited. A robotic technique has been successfully adopted for a minimally invasive Heller myotomy procedure for achalasia. This study aims to compare perioperative outcomes following open, laparoscopic, and robotic Heller myotomy.
Methods This study is a multicenter, retrospective analysis utilizing a large administrative database. The University Health System Consortium (UHC) is an alliance between academic medical centers and affiliate hospitals. The UHC database was accessed using International Classification of Diseases, Ninth Revision, Clinical Modification codes and analyzed.
Results 2,683 patients with achalasia underwent Heller myotomy between October 2007 and June 2011. Myotomy was performed by open surgery (OM) in 418 patients, by laparoscopic approach (LM) in 2,116, and by robotic approach (RM) in 149. Comparison between LM and RM groups demonstrated no significant difference in mortality (0.14 vs. 0.0%; $P = 1$), morbidity (5.19 vs. 4.02%; $P = 0.7$), intensive care unit (ICU) admission (6.62 vs. 3.36%; $P = 0.12$), length of stay (LOS) (2.70 ± 3.87 days vs. 2.42 ± 2.69 days; $P = 0.34$), or 30-day readmission (1.41 vs. 2.84%; $P = 0.27$). However, hospital costs were significantly lower for the LM group (US \$7,441 ± 7,897 vs. US \$9,415 ± 5,515; $P = 0.0028$). Comparison between OM and RM demonstrated significant lower morbidity (9.08 vs. 4.02%; $P = 0.02$), ICU admission rate (14.01 vs. 3.36%, $P = 0.0002$), and LOS (4.42 ± 5.25 days vs. 2.42 ± 2.69 days; $P = 0.0001$).
Conclusions The perioperative outcomes are superior in LM and RM groups when compared with OM. The outcomes for the LM and RM group are comparable, with the robotic group having slightly improved results, although with increased costs. We conclude that robotic surgery is equivalent in safety and efficacy to laparoscopic Heller myotomy, and feel that the increased cost should come down as surgeons and manufacturers work together on cost reduction strategies.

Keywords Achalasia · Heller myotomy · Esophagomyotomy · Robotic surgery · Outcomes

Achalasia is a disorder of esophageal motility, characterized by failure of lower esophageal sphincter (LES) relaxation, affecting six in 100,000 individuals. The etiology is unknown; data suggest hereditary, degenerative, autoimmune, and infectious etiologies as possible causes [1]. A number of medical and endoscopic treatments are available for achalasia, but surgical Heller myotomy with fundoplication is recognized as having the best long-term outcome [2, 3]. The goal of myotomy is to improve esophageal emptying by dividing the esophageal and gastric muscle fibers that contribute to the LES mechanism.

Since the first description of myotomy by Ernst Heller in 1913 via a thoracotomy, there have been several modifications to the technique, as well as the approach. Although some surgeons continue to approach the LES through the

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chest, most surgeons prefer either an open abdominal incision or a minimally invasive approach.

Minimally invasive approaches have evolved over the past two decades with successful adoption of laparoscopic and, more recently, robotic technique. Laparoscopic Heller myotomy has not only been shown to be feasible, but also to decrease hospital length of stay (LOS) and thereby lower costs [3]. It has also been shown to have good symptomatic relief, with dysphagia improving greatly after surgery [4, 5].

Prior studies have established that robotically assisted laparoscopic technique for abdominal surgery is feasible and safe, though theoretical advantages of robotic technique were not clinically apparent [6]. Heller myotomy using robotic technology is a safe operation in skilled hands; it has been shown to have fewer complications, and improved quality of life indices postoperatively compared with laparoscopic surgery [7]. Other studies have shown advantages for the use of robotic-assisted technique with other procedures, such as gastrectomy and cholecystectomy [8]. The aim of this study is to compare perioperative outcomes of Heller myotomy performed with open, laparoscopic, and robotic techniques in a large administrative database.

Methods

Database description

The University Health System Consortium (UHC) is an alliance of more than 100 academic medical centers and nearly 200 affiliate hospitals. The UHC database provides data to member institutions for performance improvement purposes and has previously been used in studies [9]. The database contains information on the following perioperative outcomes: mortality, overall morbidity, hospital LOS, intensive care unit (ICU) admission rate, 30 day readmission rate, and hospital costs. The estimated hospital costs are calculated in the UHC database using a ratio of cost/charge method.

Study design

A retrospective study design was used after obtaining institutional review board and UHC approval. A multicenter analysis of patient outcomes and cost was performed using the 4 year discharge data from October 2007 to January 2011 for adult patients (>18 years old). The UHC database was accessed using International Classification of Diseases, Ninth Revision, Clinical Modification (ICD-9-CM) codes for achalasia (530.0), esophagomyotomy (42.7), creation of esophagogastric sphincter competence (44.66), laparoscopic procedure for creation of esophagogastric sphincter competence (44.67), and robotic-assisted procedures (174.2).

Main outcome measures

The data on several surgical outcome variables were analyzed, including observed mortality, overall morbidity, LOS stay, ICU admission, 30 day readmission, as well as hospital costs.

Data analysis

Data are expressed as the frequency percentage for categorical variables, such as mortality, overall morbidity, ICU admission, and 30 day readmission. A chi-square test was used to compare these variables. Mean ± standard deviation was used to express the continuous variables, such as LOS and costs, which were compared using a t test. Data were considered significant at $P < 0.05$. Statistical analysis was performed using Prism, version 5.0, software (Graphpad Software, San Diego, CA).

Results

Between October 2007 and June 2011, 2,683 patients with achalasia underwent surgical esophagomyotomy. Myotomy was performed by open surgery (OM) in 418 patients, by laparoscopic approach (LM) in 2,116, and with robotic assistance (RM) in 149. The three groups were comparable in regards to demographics (Table 1).

Comparison of patient outcomes between LM and RM groups demonstrated no significant difference in mortality (0.14 vs. 0.0%; $P = 1$), morbidity (5.19 vs. 4.02%; $P = 0.7$), ICU admission rate (6.62 vs. 3.36%; $P = 0.12$), LOS (2.70 ± 3.87 days vs. 2.42 ± 2.69 days; $P = 0.34$), or 30 day readmission rate (1.41 vs. 2.84%; $P = 0.27$). However, hospital costs were significantly lower for the LM group (US $7,441 ± 7,897 vs. US $9,415 ± 5,515; $P = 0.0028$) (Table 2).

Comparison of patient outcomes between OM and RM demonstrated significant lower morbidity (9.08 vs. 4.02%; $P = 0.02$), ICU admission rate (14.01 vs. 3.36%, $P = 0.0002$), and LOS (4.42 ± 5.25 days vs. 2.42 ± 2.69 days; $P = 0.0001$). There was not a statistically significant difference in mortality (0.24 vs. 0.0%; $P = 1$), 30 day readmission rate (1.43 vs. 2.84%; $P = 0.3$), or cost (US $9,802 ± 10,111 vs. US $9,415 ± 5,515; $P = 0.65$).

Discussion

Heller myotomy has been well described in the literature for many years. The advent of minimally invasive

Table 1 Demographic characteristics of study population

	OM ($n = 418$)	LM ($n = 2,116$)	RM ($n = 149$)
Age, *n* (%)			
18–30 years	59 (14%)	291 (14%)	21 (14%)
31–50 years	135 (32 %)	724 (34%)	58 (39%)
51–64 years	122 (29%)	592 (28%)	39 (26%)
≥65 years	102 (25%)	509 (24%)	31 (21%)
Gender, *n* (%)			
Male	214 (51%)	1102 (52%)	77 (52%)
Female	204 (49%)	1014 (48%)	72 (48%)
Race, *n* (%)			
White	296 (71%)	1522 (72%)	100 (67%)
Black	56 (13%)	264 (12.5%)	19 (13%)
Hispanic	26 (6%)	106 (5%)	6 (4%)
Native American	4 (1%)	11 (0.5%)	4 (3%)
Asian	6 (1.5%)	42 (2%)	3 (2%)
Other	27 (6.5 %)	149 (7%)	15 (10%)
Unknown	3 (1%)	22 (1%)	2 (1%)

OM open myotomy, *LM* laparoscopic myotomy, *RM* robotic myotomy

Table 2 Comparative analysis between OM, LM, and RM

	OM ($n = 418$)	LM ($n = 2,116$)	RM ($n = 149$)
Mortality (%)	0.24	0.14	0
Morbidity (%)	9.08	5.19	4.02*
LOS (days, mean ± SD)	4.42 ± 5.25	2.70 ± 3.87	2.42 ± 2.69*
ICU admission (%)	14.01	6.62	3.36*
30 day readmission (%)	1.43	1.41	2.84
Cost (US $, mean ± SD)	9.802 ± 10.111	7.441 ± 7.897	9.515 ± 5.515

OM open myotomy, *LM* laparoscopic myotomy, *RM* robotic myotomy, *SD* standard deviation

* $P < 0.05$ compared with OM

techniques, including laparoscopy and robotic surgery, has significantly improved patient outcomes in the perioperative period, due to reduction in postoperative LOS, need for readmission, and postoperative complications [10, 11].

This study clearly shows that minimally invasive techniques, such as robotic or laparoscopic surgery, are superior to open Heller myotomy in the first 30 days of the perioperative period. A number of studies have demonstrated that minimally invasive techniques also have excellent long-term relief of achalasia and the symptoms associated with dysphasia [12–15]. We feel that the benefits of minimally invasive surgery, in a large administrative database such as this, clearly demonstrate that, in patients who are candidates for minimally invasive myotomy, outcomes will be significantly improved over standard open operation.

Heller myotomy performed by laparoscopic technique was described almost 15 years ago. Robotic myotomy is a relatively new surgical technique, and this study suggests that robotic myotomy is beneficial to the patient from the perspective of safety, perioperative mortality, and morbidity. It is clearly superior to open surgery and appears to be equivalent to a pure laparoscopic approach. A number of studies have looked at long-term outcomes of laparoscopic versus robotic Heller myotomy in single-institution case series format and showed equivalency [16–18]. In this large administrative database, we can see that, across multiple hospitals, many patients who receive robotic and laparoscopic myotomies have done equivalently well.

A prior study had shown that robotic surgery may have a benefit in terms of perforation rate, but we could not determine this based on the UHC database [19]. However, our results show no increase in morbidity for the robotic group when compared with the laparoscopic group.

This study reveals some interesting facts about the cost of surgical care, for this procedure and for new technology as it gets adopted. Although, robotic technology is expensive, its costs are not higher compared with the open procedure, which underlines the cost savings from reducing ICU admission and hospital LOS from minimally invasive approach. Interestingly, with wide adoption of laparoscopic technique for other procedures, its cost has been significantly reduced over the past several years. Increase in charges for robotic equipment can clearly be seen and may hinder the adoption of robotic technique. However, we feel that this increased cost should come down as surgeons and manufacturers work together on cost reduction strategies as witnessed in laparoscopic technology.

The limitations of this study include those inherent to any administrative database, although the UHC is widely used and validated. Coding errors for diagnoses range from 0.04 to 0.08% [20]. Despite the above drawbacks, the advantage is, again, that of a large administrative database, which allows measuring and comparing cumulative outcome of all patients undergoing robotic Heller myotomy.

Conclusions

We conclude that robotic surgery is equivalent in safety and efficacy to laparoscopic Heller myotomy, and feel that

increased cost should come down as surgeons and manufacturers work together on cost reduction strategies.

Disclosures Authors Abhijit Shaligram, Jayaraj Unnirevi, Vishal Kothari, Anton Simorov and Dmitry Oleynikov have no conflict of interest or financial ties to disclose.

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