RESEARCH ARTICLE

Duration of surgery and length of stay in patients undergoing robotic versus laparoscopic achalasia surgery

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Abstract

Objective: Objective: To compare robotic versus laparoscopic Heller's cardiomyotomy in terms of operative duration and length of hospital stay in a tertiary care setting.

Method: The single-centre, comparative, cohort study was conducted in 2023 at Dr. Ruth K. M. Pfau, Civil Hospital Karachi, and comprised retrospective and prospective data of all patients who presented with classical achalasia on high-resolution manometry between January 2020 and December 2023. All the patients were investigated with upper gastrointestinal endoscopy and high-resolution manometry. Patients who underwent laparoscopic surgery were allocated to group A, and those who underwent robotic surgery were allocated to group B. The duration of surgery and length of hospital stay were recorded. Intraoperative complications, like oesophageal perforation and bleeding, were also noted. Data was analysed using SPSS 23.

Results: Of the 35 patients with mean age 33.40±7.10 years (range: 20-55 years), 20(57.14%) were in group A and 15(42.86%) were in group B. There were 20(57.14%) female and 15(42.86%) male patients. The mean body mass index was 20.74±3.47kg/m^2, and it was higher in group A compared to group B (p=0.036). Mean duration of surgery was 132.75±23.64 minutes in group A compared to 92.67±7.52 minutes in group B (p<0.001). There were 2(10%) cases of oesophageal perforation in group A and none in group B (p=0.496). The length of hospital stay was 3.25±0.91 days in group A and 2.87±0.74 days in group B (p=0.383). The cost per procedure in group B was US$4,034 compared to US$53 in group A.

Conclusion: Robotic surgery reduced operative time compared to laparoscopy. While two perforations occurred in the laparoscopic group, the substantially higher cost of robotics remains unjustifiable in resource-limited settings, given its lack of clear clinical superiority.

Key Words: Achalasia, Robotic surgical procedures, Laparoscopy, Length of stay, Postoperative complications.

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Introduction

Achalasia is the failure of the lower oesophageal sphincter to relax with absent or abnormal oesophageal peristalsis. Its incidence is around 0.5 to 1.6 per 100,000 population, with recent studies indicating a rise in its occurrence.[1,2] The symptoms include dysphagia and varying degrees of weight-loss. The gold standard for diagnosis is oesophageal manometry. Manometry can detect three types of achalasia, depending upon the contractions of the oesophagus, with classical achalasia having no peristalsis.[3] The treatment is Heller's cardiomyotomy and some form of fundoplication to prevent reflux. There has always been a debate regarding laparoscopic and robotic treatment of achalasia, with some studies showing the superiority of robotics over laparoscopy.[4-6] However, there is a significant increase in cost when using a robotic platform.[7] The current study was planned to compare robotic versus laparoscopic Heller's cardiomyotomy in terms of operative duration and length of hospital stay (LOS) in a tertiary care setting.

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Patients and Methods

After obtaining approval from the Institutional Review Board, a single-centre, comparative, cohort study was conducted in 2023 at Dr. Ruth K. M. Pfau, Civil Hospital Karachi, and comprised retrospective and prospective data of all patients who presented with classical achalasia on high-resolution manometry between January 2020 and December 2023. A consecutive sampling technique was employed for both the retrospective review and the prospective enrolment. The sample size was calculated using the formula for comparing two independent means with alpha (α) value 0.05, power 80% and effect size δ=24 minutes derived from published meta-analysis.[8] Retrospective data was searched from January 2020 to February 2023, while prospective enrolment was done up to December 2023. To ensure data consistency across both phases, a standardised data extraction proforma was used to ensure rigorous capture of intraoperative variables and patient-reported metrics absent in historical records. Prospective patients provided written consent, while retrospective data used waived consent. Patients in whom conversion occurred during surgery, that is, laparoscopic to open surgery, or robotic to laparoscopic, patients with a previous history of oesophageal or gastric surgery, previous endoscopic dilatation of achalasia, and those with missing records or follow-ups were excluded.

The patients who underwent laparoscopic Heller's cardiomyotomy with Dr. Jean Dor (DOR) fundoplication were allocated to group A, while those who underwent robotic Heller's cardiomyotomy with DOR fundoplication based on the availability of robotic platform (DaVinci Si Surgical System, Intuitive Surgical, Inc., Sunnyvale, CA, USA) were allocated to group B.

In group A, standard laparoscopic port placements were done with the surgeon standing between the legs, and liver retraction was done using a Nathanson liver retractor. The myotomy was extended from 5cm above the gastroesophageal junction to 2.5-3cm onto the stomach. In addition, anterior fundoplication was done using the DOR technique. In group B, the port placement was standard, and the patient cart was parked towards the left shoulder of the patient.

The duration of surgery in laparoscopy was taken after ports placement when the instruments were inside the abdomen till the withdrawal of the instruments. Similarly, in robotic surgery, it was taken after the placement of ports and docking of the patient cart when the instruments were inside the abdomen till the withdrawal of the instruments. Port placement and closure were not included in the time duration of the surgery. Complications, like oesophageal perforation and bleeding, were noted. Single prophylactic dose of ceftriaxone was given at the time of induction. Deep vein thrombosis (DVT) prophylaxis was done with intermittent use of pneumatic compression device. All patients had a nasogastric (NG) tube inserted at the time of induction which were removed on the first postoperative day unless there was perforation of mucosa in which case it was retained for three days. The patients were discharged when tolerating orally.

Cost estimates were done by considering the cost of the acquisition of the equipment and accessories, the cost of accessories or disposables per case and annual maintenance cost.[9] The number of cases done by robotic platform was calculated from the last five years, and was found to be 150 per year, while that of laparoscopy was 600 per year. The cost of acquiring the complete set of equipment was divided by the shelf-life of the equipment i.e. 10 years for robotics and 5 years for laparoscopy. This annual cost was divided by the number of cases each year. The cost of disposables/accessories was taken out for each case. Maintenance cost, i.e. 10% of the cost of the platform, was divided by the number of cases per year to get the per-case cost. The life of laparoscopic reusable hand instruments was kept at one year, and replacement cost was added to the maintenance cost. All costs were presented in US Dollars (USD), using the conversion rate of 1 USD = 278.77 Pakistani rupee (PKR) at the time of analysis.

Data was analysed using SPSS 23. Continuous variables were presented as mean ± standard deviation (SD), while categorical variables were presented as frequencies and percentages. Data normality was assessed using the Shapiro-Wilk test. For intergroup comparisons, an independent samples t-test was used for normally distributed continuous variables. The Mann-Whitney U test was used for non-normally distributed continuous variables. The chi-square test was used for categorical variables, while Fisher's exact test was used for the comparison of oesophageal perforation rates due to the low expected cell count. The relationship between continuous variables and the primary outcomes was assessed using Pearson's correlation coefficient. P<0.05 was considered statistically significant.

Results

Of the 35 patients with mean age 33.40±7.10 years (range: 20-55 years), 20(57.14%) were in group A and 15(42.86%) were in group B. Overall, 28(80%) patients were identified from the retrospective cohort, and 7(20%) from the

Table-1: Descriptive data.

	N	Mean±SD		p
Age				
Laparoscopic	20	33.4±7.10	35.15±8.33	0.069
Robotic	15		31.07±4.23	
BMI				
Laparoscopic	20	20.74±3.47	21.80±3.77	0.036
Robotic	15		19.33±2.49	
DOS				
Laparoscopic	20	115.57±27.21	132.75±23.64	0.0001
Robotic	15		92.67±7.52	
LOS				
Laparoscopic	20	3.09±0.85	3.25±0.91	0.383
Robotic	15		2.87±0.74	

SD: Standard deviation, BMI: Body mass index, DOS: Duration of surgery, LOS: Length of hospital stay.

Table-2: Intergroup comparison of cost estimates in terms of United States dollar (US$).

Cost	Robotic	Laparoscopic
Platform cost (PC)	1,076,146	71,743
Annual platform cost. PC / Shelf Life (SL) 10years for robot and 5 years for laparoscopic	1,076,146/10 =107,614	71,743/5 =14,348
Platform cost for the patient. Annual cases 150 robotics and 600 laparoscopies.	717	24
Accessories / disposables per procedure. 10 cases per instrument for robotics	2,600	
Annual maintenance	107,614	17,218
Maintenance cost per patient	107,614/150 =717	17,218/600 =29
Total cost per procedure.	4,034	53

US$ 1 = PKR278.77.

prospective cohort. There were 20(57.14%) female and 15(42.86%) male patients. The mean body mass index (BMI) was 20.74±3.47kg/m^2, and it was higher in group A compared to group B (p=0.036). Mean duration of surgery was 132.75±23.64 minutes in group A compared to 92.67±7.52 minutes in group B (p<0.001). There were 2(10%) cases of oesophageal perforation in group A and none in group B (p=0.496). The length of hospital stay was 3.25±0.91 days in group A and 2.87±0.74 days in group B (p=0.383) (Table 1).

The cost per procedure in group B was US$4,034 compared to US$53 in group A (Table 2).

Discussion

The precise aetiology of achalasia is not fully understood, but it is thought to be an immune-mediated disorder, potentially triggered by a viral infection in genetically susceptible individuals, leading to the loss of inhibitory neurons in the oesophageal myenteric plexus.[10] There appears to be no gender predisposition and most of the patients are aged 30-60 years.[11] The current study showed a slight female predominance 57.1% and a relatively young mean age of 32.25 years. In a study by Trieu et al.[12, 12]11% of the patients were aged 18-44 years with a mean of 33.56 although the overall mean age was 66 years. Similarly, 1.48% patients were aged 1-17 years. In a study by Raza et al.,[13] the age ranged 25-57 years with a mean of 40.83±10.45 years. Data may signify that the younger population is at risk in this part of the world.

The main presentation of patients with achalasia is dysphagia. Recent studies have focused on manometric disturbances and obesity. In a study by Newberry et al.,[14] 70% of the patients with achalasia were overweight or obese. However, these patients were at increased risk of malnutrition due to rapid weight-loss because of dysphagia. The presentation and diagnosis of achalasia may be delayed for several years, leading to weight-loss and decreased BMI at presentation. In the current study, the mean BMI was 20.74±3.47kg/m^2, with 31.4% of the patients being underweight i.e. BMI <18.5kg/m^2. These patients may have delayed presentation or diagnosis although this was not assessed in the current study. There was no significant difference between the BMI and gender (p=0.43), with mean BMI of 20.20±4.09kg/m^2 and 21.15±2.97kg/m^2 among males and females, respectively. An interesting secondary finding was that within the robotic cohort, patients with a lower BMI (<18.5kg/m^2) had a significantly longer operative time than those with a normal BMI. This counterintuitive finding may be related to the anatomical challenges associated with malnutrition in advanced achalasia. Patients with severe, long-standing disease and significant weight-loss may have a more tortuous or dilated oesophagus, and less peri-oesophageal adipose tissue, which can obscure surgical planes and make the dissection and myotomy more technically demanding.[10,14] While the robotic system provides enhanced dexterity, these complex anatomical variations can still prolong the time required for safe and precise execution of the procedure. This observation warrants further investigation in larger studies to better understand the patient-specific factors that influence operative difficulty in robotic foregut surgery.

The standard treatment of achalasia cardia is minimally invasive surgery. Laparoscopy was considered the gold standard. Since the introduction of robotics, there have been many studies comparing the two modalities. In a systematic review and meta-analysis by Ataya et al.[8], robotic surgery was associated with lower rate of complications and shorter LOS. The oesophageal perforation was lower in robotic group with an odds ratio of 0.36 (p=0.02). In the current study, there were two oesophageal perforations during the procedure, and both were in the laparoscopic group. This was not statistically significant (p=0.49). Another meta-analysis by Xie et al.,[15] the only statistically significant difference between the two groups was oesophageal perforation (p=0.0005). This shows that robotic surgery is associated with improved patient safety, and this was also evident in the current study.

The length of surgery may have cost implications because of increased operation theatre (OT) time, and can lead to surgeon fatigue, leading to poor clinical outcomes. In the meta-analysis by Ataya et al.,[8] the mean operative time was 23.95 minutes longer in the robotic group ($p<0.00001$). In this study, however, the duration of surgery was significantly shorter in the robotic group ($p<0.0001$), with a mean difference of 40 minutes. This could be due to the way that operative time was calculated, i.e. starting from when the ports were inserted to when the instruments were withdrawn from the ports. The docking time and port insertion and closure time was not taken in the operative time. This was done since docking was also being taught to juniors, and sometimes took more time than usual. Similarly, port placement and closure was also assigned to juniors under supervision for training. The higher operative times for the robotic platform in the meta-analysis by Ataya et al.[8] could be due to the addition of docking time. In addition, during the start of robotic training, there is considerable time spent on the docking and surgery, as the surgeon is in the learning phase. If this phase is included, then the operative time will increase overall. Consequently, while the current results demonstrate a faster console operative time for robotics, they should not be interpreted as the total time the patient is in the operating room. In this study, the early cases of robotic and laparoscopic Heller's cardiomyotomy were not taken into consideration. In a multicentre study by Horgan et al.[16] the mean operative time between laparoscopy and robotic Heller's cardiomyotomy was comparable as the surgeon's experience increased. In another meta-analysis by Milone et al.[17] there was no difference in the operative time between the laparoscopy and robotic groups.

The LOS is usually comparable between the groups. However, if there are any complications during surgery, like oesophageal perforation, then the stay may increase. Milone et al.[17] and Gass et al.[18] showed no difference in LOS between the laparoscopic and robotic groups. In another meta-analysis by Ataya et al.[8] the LOS was shorter in the robotic group with a mean difference of -0.24 ($p<0.00001$). In the current study, the mean LOS was 2.87 ± 0.74 versus 3.25 ± 0.91 in the robotic and laparoscopy groups, respectively ($p=0.19$). This was because of the two cases of oesophageal perforations in the laparoscopy group. However, the difference was not statistically significant. This was probably because of the fact that the groups were not equal. Shorter LOS translates to cost savings and bed availability for surgery, and may have a greater impact among the robotic patients since the cost of robotic surgery is higher than that of laparoscopy.

The feasibility of performing robotic surgery in a public-sector hospital of a developing country is a major challenge. Since the industrial drive is towards robotics, it will be futile if this technology is not properly utilised in a resource-depleted country. Cost estimations done on the robotic and laparoscopic platform in the current study gave a staggering difference of USD4,000 vs USD50 per case. It is important to note that the result is sensitive to key assumptions, particularly the annual case volume and the equipment shelf-life. A higher robotic volume or a longer operational lifespan would lower the per-case cost, though it would likely remain higher than laparoscopy in similar settings. According to an analysis by Ho C et al.[19] the cost of robotic surgery can be made comparable to other platforms when considering the shorter duration of postoperative LOS and by increasing the number of cases done on the platform. However, in the current study, LOS was comparable between laparoscopy and robotic groups. Patient logistics and attitude could be a factor for reluctance of early discharge since a large proportion of patients were poor and travelled long distances to reach a tertiary care hospital for treatment. Such patients are reluctant to go back early to their place of abode due to scarce medical facilities. Therefore, while robotic surgery demonstrated technical benefits in the study, its economic model remains disconnected from the practical realities and pressing healthcare priorities of the study setting.

The current study has several limitations. First, the incorporation of retrospective and prospective data, while improving sample size, introduces heterogeneity in data-collection protocols that may have affected outcome consistency. A larger, more balanced sample might have provided a more definitive comparison, particularly for less frequent complications. Secondly the non-randomised, convenience-based allocation of patients to the surgical groups, driven by the availability of the robotic platform, is a significant source of potential selection bias. Besides, the robotic group was smaller than the laparoscopic group primarily due to the limited availability of the robotic platform during the study period, which was a shared institutional resource. Thirdly, as a single-centre study, the findings may lack generalisability to broader populations, particularly in settings with differing surgical expertise or resource availability.

Conclusion

The duration of surgery was significantly shorter in the robotic group. The LOS was shorter in the robotic group, but this was not significant. There were no oesophageal perforations during surgery in the robotic group, indicating its benefit in terms of patient safety. However, the justification of the robotic option remains challenging in resource-constrained settings over laparoscopy, considering the economics, and the attitude of local patients for whom LOS is not a concern.

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SG: Concept, data acquisition, analysis, interpretation and drafting.
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