

# Oncologic Resection in Laparoscopic Versus Robotic Transhiatal Esophagectomy

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## ABSTRACT

**Background and Objectives:** As the use of robotic surgery continues to increase, little is known about robotic oncologic outcomes compared with traditional methods in esophagectomy. The aim of this study was to examine the perioperative oncologic outcomes of patients undergoing laparoscopic versus robot-assisted transhiatal esophagectomy (THE).

**Methods:** Thirty-six consecutive patients who underwent laparoscopic and robot-assisted THE for malignant disease over a 3-year period were identified in a retrospective database. Eighteen patients underwent robotic-assisted THE with cervical anastomosis, and 18 patients underwent laparoscopic THE. All procedures were performed by a single foregut and thoracic surgeon.

**Results:** Patient demographics were similar between the 2 groups with no significant differences. Lymph node yields for both laparoscopic and robot-assisted THE were similar at 13.9 and 14.3, respectively ( $P = .90$ ). Ninety-four percent of each group underwent R0 margins, but only 1 patient from each modality had microscopic positive margins. All of the robot-assisted patients underwent neoadjuvant chemoradiation, whereas 83.3% underwent neoadjuvant therapy in the laparoscopy group ( $P = .23$ ). Clinical and pathologic stagings were similar in each group. There

was 1 death after laparoscopic surgery in a cirrhotic patient and no mortalities among the robot-assisted THE patients ( $P = .99$ ). One patient from each group experienced an anastomotic leak, but neither patient required further intervention.

**Conclusions:** Laparoscopic and robot-assisted THEs yield similar perioperative oncologic results including lymph node yield and margin status. In the transition from laparoscopic surgery, robotic surgery should be considered oncologically noninferior compared with laparoscopy.

**Key Words:** esophagectomy, robot, robotic, transhiatal, laparoscopy.

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## INTRODUCTION

Much has been written concerning the transition from open to laparoscopic transhiatal esophagectomy (THE) with cervical anastomosis.<sup>1-7</sup> Among the benefits of the minimally invasive approach are shorter hospital length of stay, decreased postoperative complications, and lower intraoperative blood loss, while achieving similar oncologic outcomes.<sup>8,9</sup>

Despite significant advances in laparoscopy, robotic surgery has increased in volume.<sup>10</sup> Robotic surgery among general surgeons is increasing, especially in the realm of foregut surgeries.<sup>11</sup> The robotic platform offers several advantages over laparoscopy, including improved stereoscopic visualization, tremor stabilization, wristed instruments for greatly improved mobility, and improved surgeon ergonomics.<sup>12</sup> Disadvantages include increased operative time, need for specialized training, and increased cost.<sup>11,13</sup> There is also an inherent learning curve that may have a negative effect on oncologic outcomes, although studies have not proved this definitively.<sup>14,15</sup>

The transition from open surgery to laparoscopy has provided significant oncologic data, but the same cannot be said about the transition from laparoscopy to robotic esophagectomy. The robotic data that are available have focused more on the impact of cost and postoperative

pain, with a paucity of data relating to oncologic metrics.<sup>16,17,18</sup> Little data have been published regarding the operative oncologic outcomes of robotic surgery in general<sup>19,20,21</sup> With the increased focus on health care costs and outcomes-driven data, more information is needed to determine the efficacy of robotic surgery with regard to oncologic procedures. The purpose of this report was to examine the perioperative oncologic outcomes of patients undergoing laparoscopic versus robot-assisted THE.

## MATERIALS AND METHODS

A retrospective database was created of 36 consecutive patients who underwent minimally invasive THE from 2012 to 2015. During this time, our institution was in the process of making the transition from laparoscopic to robotic-assisted THE. Half of the patients<sup>18</sup> underwent laparoscopic THE while the other half<sup>18</sup> underwent robotic-assisted THE during the same time period. The decision to use one approach over the other was largely related to availability of the robotic platform. Patient demographics, operative details, and perioperative oncologic outcomes including pathology reports were evaluated. Patients who underwent THE for benign disease and those scheduled for a planned open procedure from the onset were excluded from the database. Institutional review board approval was obtained, and appropriate statistical calculations were performed, including Student's *t* test and Fisher's exact test using SPSS Statistics Version 1.0.0–2740 (IBM Corp). A value of  $P < .05$  was considered statistically significant.

All procedures were performed by a single experienced foregut surgeon and experienced thoracic surgeon at a single institution. Details of the standardized procedure include dividing the short gastric vessels followed by periesophageal mediastinal dissection, ligation of the left gastric artery, performance of an upper midline mini-laparotomy with the creation of a stapled nontubularized gastric conduit, pyloroplasty, placement of feeding jejunostomy, and cervical gastroesophageal anastomosis. The

cervical anastomosis was constructed using a stapled technique in the manner of Orringer et al.<sup>23</sup> All patients were placed in the intensive care unit postoperatively. Video esophagram was routinely obtained on postoperative day 5. Anastomotic leaks were diagnosed radiologically and clinically. Postoperative complications were categorized according to the Clavien-Dindo classification with grade III complications or greater defined as major.<sup>24</sup>

## RESULTS

Patient demographics for each group are given in Table 1. The robotic group had a slightly older population than the laparoscopic group with a mean age of 61.9 compared with 58.9 years ( $P = .28$ ). There was a preponderance of males in each group with 16 (88.9%) of 18 patients being male in the laparoscopic group and 17 (94.4%) of 18 being male in the robotic group ( $P = 1.0$ ). Mean body mass index was similar at 27.5 and 27.6 kg/m<sup>2</sup> for each group ( $P = .94$ ). All procedures were done for malignancy.

Mean operative time was similar at  $164 \pm 23.1$  (range 135–228) minutes in the laparoscopic group and  $168 \pm 24.0$  (range 127–212) minutes in the robotic group (Table 2). There was 1 (5.6%) postoperative anastomotic leak in each group ( $P = 1.00$ ), but neither patient required additional intervention beyond opening the cervical incision. There were 2 (11.1%) major complications (Clavien-Dindo III and above) in the laparoscopic group compared with one (5.6%) in the robotic group ( $P = 1.00$ ). There was 1 death in the laparoscopy group involving a known cirrhotic patient who developed fulminant liver failure postoperatively. There were no deaths in the robotic group. Mean hospital length of stay was  $9.8 \pm 4.7$  (range 7–27) days for the laparoscopic group and  $9.9 \pm 4.0$  d (range 7–20) days for the robotic group ( $P = .88$ ). Patients in the laparoscopic group spent an average of  $2.7 \pm 6.1$  (range 1–27) days in the intensive care unit, whereas the robotic group patients spent an average of  $1.7 \pm 2.4$  (range 1–11) days ( $P = .54$ ).

**Table 1.**  
Patient Demographics

	Laparoscopy (n = 18)	Robotic (n = 18)	<i>P</i> Value
Age, y (range)	58.9 (40 to 70)	61.9 (42 to 76)	.28
Men, n (%)	16 (88.9)	17 (94.4)	1.00
Body mass index, kg/m <sup>2</sup> (range)	27.5 (19.2 to 39.4)	27.6 (20.7 to 38.2)	.94
Malignancy, n (%)	18 (100)	18 (100)	1.00

**Table 2.**  
Operative Outcomes

	Laparoscopy (n = 18)	Robotic (n = 18)	P Value
Mean operative time, min (range)	164 (135 to 228)	168 (127 to 212)	.59
Anastomotic leak, n (%)	1 (5.6)	1 (5.6)	1.00
Major complication (Dindo-Clavien grade >III)	2 (11.2)	1 (5.6)	1.00
Mortality	1 (5.6)	0 (0)	1.00
Hospital length of stay, d (range)	9.8 (7 to 27)	9.9 (7 to 20)	.88
Intensive care unit length of stay, d (range)	3.2 (1 to 27)	1.7 (1 to 11)	.54

Oncologic outcomes are given in Table 3. Most patients in each group were operated on for esophageal adenocarcinoma: 15 (83.3%) versus 14 (77.8%) ( $P = 1.00$ ) in the laparoscopic and robotic groups, respectively. The remaining patients were resected for squamous cell carcinoma. All the robotic group patients received neoadjuvant chemoradiation, but only 15 (83.3%) received it in the laparoscopic group ( $P = .23$ ). Average lymph node yield was slightly lower in the laparoscopic patients at  $13.9 \pm 8.5$  (range 2–28) compared to  $14.2 \pm 7.8$  (range 4–30) in the robotic cohort ( $P = .90$ ). The number of patients with positive nodes was the same in each group (33.3%). There were no patients with grossly positive margins (R2) in either group, and 1 (5.6%) patient in each group had positive microscopic margins (R1). Three (16.7%) patients in each group demonstrated complete pathologic response to treatment.

## DISCUSSION

In comparing laparoscopic and robotic THE at a nonuniversity tertiary care center, the data demonstrate no significant differences in the operative oncologic outcomes. As one of the first studies uniquely evaluating the oncologic efficiency of robotic THE, this study presents evidence of equivalency between laparoscopy and robotic-assisted laparoscopy for esophagectomy. There are numerous reports in the literature regarding the long-term oncologic outcomes of open and laparoscopic esophagectomies<sup>25,26</sup> as well as the thoracic versus abdominal approach.<sup>27,28</sup> In contrast, very little has been written comparing the robotic versus laparoscopic transhiatal approach with regard to oncologic measures.<sup>29</sup>

Multiple studies have evaluated outcomes of the transhiatal laparoscopic technique, beginning with Luketich et al. in 2000.<sup>30</sup> The minimally invasive approach to esophagectomy has been shown to decrease total hospital length of stay, lower postoperative morbidity, and

decrease total hospital costs.<sup>31</sup> Other studies have evaluated a single institution's results of robotic THE<sup>22,29</sup> reporting moderate operative times, low rates of conversion, and comparable hospital length of stays. These studies do not compare and contrast their robotic outcomes with laparoscopic outcomes, which makes this study unique.

The adoption of the robotic platform in gastrointestinal surgery has been slowly increasing, but data demonstrating superiority or equivalence to laparoscopy remain scant.<sup>32</sup> The question must be asked, do the stated advantages of robotic surgery directly lead to improved operative oncologic outcomes? The paucity of data showing superior outcomes over laparoscopy is likely due to several complex factors. Robotic surgery is nearly identical to laparoscopy in the surgical approach and technical aspects of the given surgery. However, the increased magnification and the ergonomics of the robot might suggest that this approach would yield a higher R0 rate and nodal retrieval, a theory that was not directly studied but inferred in a review authored by Seto et al. Citing results of twelve previous studies, they note R0 rates of 95% or greater in two of the larger cohorts.<sup>38B</sup> Other factors include the potential for the surgeon to take on more complex cases with the robot, due to improved visualization and better ergonomics. If this were true, this would bias against an improved operative oncologic outcome. Mori et al. described a robotic transhiatal approach and advanced lymphadenectomy with similar oncologic outcomes to that of an open transthoracic approach.<sup>33,34</sup> Other studies have shown that robotic assisted esophagectomy is technically feasible and has proven good short-term oncologic outcomes.<sup>35</sup> Abbott et al. report a cohort of 134 patients finding that the complication rate in patients over the age of 70 years is comparable to younger patients.<sup>36</sup> They also report favorable outcomes for patient with larger body mass index, with comparable operative

**Table 3.**  
Operative Oncologic Outcomes

Outcome, n (%) or n (range)	Laparoscopy (n = 18)	Robotic (n = 18)	P Value
Number of adenocarcinomas	15 (83.3)	14 (77.8)	1.00
Neoadjuvant chemoradiation	15 (83.3)	18 (100)	.23
Average lymph node yield	13.9 (2 to 28)	14.28 (4 to 30)	.90
Number of patients with positive nodes	6 (33.3)	6 (33.3)	1.00
Average number of positive nodes	3.3 (1 to 6)	5.0 (1 to 11)	.35
Disease-free gross margins (R2)	18 (100)	18 (100)	1.00
Disease-free microscopic margins (R1)	17 (94.4)	17 (94.4)	1.00
Pathologic complete response	3 (16.7)	3 (16.7)	1.00
Pathologic stage			
0	4 (22.2)	4 (22.2)	
1a	4 (22.2)	4 (22.2)	
1b	1 (5.5)	0	
2a	0	2 (11.1)	
2b	3 (16.7)	3 (16.7)	
3a	3 (16.7)	2 (11.1)	
3b	3 (16.7)	1 (5.5)	
3c	0	2 (11.1)	
Clinical T stage (T)			
T1	3 (16.7)	0	
T2	2 (11.1)	4 (22.2)	
T3	12 (66.7)	14 (77.8)	
Pathologic T stage (pT)			
pT0	0	4 (22.2)	
pTis	0	1 (5.5)	
pT1	4 (22.2)	5 (27.7)	
pT2	1 (5.5)	4 (22.2)	
pT3	9 (50)	4 (22.2)	
Clinical nodal staging (N)			
N0	6 (33.3)	6 (33.3)	
N1	8 (44.4)	12 (66.7)	
N2	0	0	
N3	0	0	
Pathologic nodal staging (pN)			
pNx	4 (22.2)	0	
pN0	12 (66.7)	12 (66.7)	
pN1	3 (16.7)	1 (5.5)	
pN2	3 (16.7)	3 (16.7)	
pN3	0	2 (11.1)	

times and postoperative complication rates. In the future, the robotic platform may be used to accomplish surgeries not currently thought possible with laparoscopy.

It would be expected that our data would expose a decreased nodal count among the robotic group as all robot-assisted patients received neoadjuvant chemotherapy. Interestingly, the difference in number of nodes retrieved was not found to be statistically significant between the laparoscopic group and the robotic group despite the difference in number of patients receiving neoadjuvant chemotherapy. The cause for this is unclear; however, improved visualization and maneuverability may have resulted in increased retrieval of nodal tissue. Further research would be required to determine this scientifically.

Although the robotic learning curve is not completely defined,<sup>37</sup> in the authors' experience, the transition to robotic esophagectomy is minimal for the advanced laparoscopic surgeon. We have advocated the lack of intracorporeal suturing makes THE an appropriate stepping-stone for robotic surgery. This study suffers from its retrospective nature, lack of long-term mortality data, and smaller volume for analysis. In addition, the location of the lymph node yields was not clearly delineated in the pathology reports. The advantage of having a direct comparison of laparoscopy versus robotic outcomes by a single foregut surgeon, however, draws us closer to advancing the role of robotics in foregut surgery.

## CONCLUSION

This study shows that robotic esophagectomy is not inferior to laparoscopic THE when performed by an experienced laparoscopic foregut surgeon. At our institution, there were no identifiable differences, oncologically, between robotic and laparoscopic outcomes. A larger prospective study would be necessary to unequivocally answer this important clinical question.

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