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Feasibility of Robot-Assisted Feeding Jejunostomy Tube with Barbed Sutures during Esophagectomy

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Keywords: Esophagectomy; Jejunostomy; RAMIE; Barbed sutures; Malnutrition.

Abstract

Objective: Malnutrition is common in patients with esophageal cancer. A Feeding Jejunostomy (FJ) for enteral feeding is an effective method to improve nutritional status.

The objective of this study was to evaluate the surgical technique and advantages of Robot-Assisted Minimally Invasive Esophagectomy (RAMIE) during surgical placement of the FJ and compare it to the open procedure. Secondly the use of barbed sutures to fix the FJ to the abdominal wall was also assessed.

Methods: In this single-center study we examined the clinical data of patients who underwent esophageal resection with FJ-placement during 2012 and 2019. The placement was performed either robot-assisted or by open surgery.

Results: The study included 204 patients who underwent esophagectomy for various benign and malignant conditions. The mean Body-Mass-Index (BMI) was significantly higher within the RAMIE group (27.3 *vs.* 25.7) (p=0.035). FJ-associated complications were described in 3.7 % of the RAMIE group and in 5.7 % of the Open group (p=0.51). In the RAMIE group, one small bowel obstruction (0.7%), one jejunal fistula (0.7%), one wound infection (0.7%) and two catheter dislocations (1.6%) occurred. In the Open group one wound infection (1.4%) and three catheter dislocations (4.3%) developed. There was an FJ-associated death in the Open group and none in the RAMIE-group (p=0.16).

Conclusions: The robot-assisted placement of the FJ appears safe compared to open surgery, with low perioperative morbidity even in patients with a higher BMI. It was shown that use of barbed sutures during the jejunostomy optimizes surgical steps and outcome.

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Introduction

Esophageal Cancer (EC) is still one of the most aggressive epithelial tumors and the incidence is increasing [1]. Esophagectomy is the cornerstone of multimodal therapy of locally-advanced esophageal cancer [2,3].

A crucial point that seriously affects the operative outcome is nutrition during the entire therapy process [4]. Patients suffering from EC are often malnourished even before the operation, as dysphagia is one of the earliest symptoms. This usually results in significantly reduced eating habits and dramatic weight loss. It can be directly related to a tumor-associated overall catabolic state, and may be exacerbated by the side effects of chemo-radiation treatment, mainly nausea and anorexia. Several studies have demonstrated the importance of perioperative nutritional optimization before esophageal surgery [4]. Enteral nutrition is generally preferred to parenteral nutrition, as it is associated with fewer complications and enhanced recovery [5]. Enteral nutrition after surgery can be accomplished via oral intake or through a feeding tube. The benefits of early enteral nutrition include improved immune function, preserved gastrointestinal mucosal integrity, decreased infectious complications, and improved postoperative outcomes [6-8]. Even if the postoperative course is uneventful, patients' oral nutrition may be restricted for some time. During this time, the postoperative calorie requirement can be covered enterally using an inserted Feeding Jejunostomy (FJ). The necessity for a FJ before neoadjuvant therapy should be determined individually, based on the level of preoperative obstruction and weight loss [9].

Minimally-invasive surgery was introduced to reduce surgical trauma and postoperative morbidity. However, conventional thoraco-laparoscopic procedures are limited by two-dimensional vision, impaired hand-eye coordination and limited freedom of movement [10-12]. These impairments have been significantly minimized by the establishment of Robot-Assisted Minimally Invasive Esophagectomy (RAMIE), as we reported previously [13,14]. The resulting fine precision of the surgical steps not only increased oncological quality, allowing a more precise preparation of the surgical site and a more accurate reconstruction of the anastomoses, but also facilitates a rapid and easier insertion of an FJ. This particular surgical step is clearly advantageous using the robot, which enables greater movement within the narrow space of the abdominal wall. In addition, it may lower the rate of complications, which are known to occur with the commonly used laparoscopic FJ-placement [15,16].

Thus, we aimed to evaluate the surgical technique and advantages of RAMIE during the surgical placement of the FJ. In addition, we wanted to evaluate the use of barbed sutures to fix the FJ to the abdominal wall. At our clinic, we have already published successful results using these sutures and determined that the fixation method is suitable during RAMIE using the appropriate surgical instruments [17].

After six years of experience and up to 220 operations, we wanted to use this study to carry out the first evaluation of robotic FJ systems during esophageal resection. To date, open FJ system placement has often been the procedure of choice for catheterization in esophageal resection without robotic support [15, 18]. Now we want to compare it to the robot-assisted procedure.

Materials and methods

Study population

Patients who underwent esophageal resection with FJ-placement between January 1st 2012, and December 31st 2019, were identified from a prospectively maintained database. 204 patients from our department were eligible for the study. For all included patients, a FJ placement was performed during esophageal resection. The data analyzed included demographics (age, gender, Body Mass Index (BMI)), American Society of Anesthesiologists (ASA) score, indication for esophageal resection, TNM classification, surgical procedure, reconstruction type and the daVinci® version of the robotic system. Main outcome measures included FJ associated complications, such as small bowel obstruction, jejunal fistula, dislodged FJ-tube, and abdominal wall site infection. Hospitalization, intensive care, and death due to the FJ system were also recorded. The study was approved by the local ethics committee of the UKSH Campus Kiel and the Medical Faculty, Kiel University according to their guidelines (reference no. D 474/17).

Open approach

A complete description of the open FJ-tube system has already been described in the work of D'Cruz et al. [19]. In the following section, the steps of FJ placement in esophagectomy are described in detail.

At the end of the abdominal part of an open esophagectomy, the transverse mesocolon is lifted and the ligament of Treitz is identified. About 40 cm distal to that, the jejunum is incised mesenterically and a feeding tube is inserted and placed about 20 cm to the aboral side. Now the probe is fixed to the jejunum by means of a pursestring suture (PDS 4.0 Ethicon Inc., Somerville, NJ, USA) and then the catheter exit point is sewn over with a seroserotic suture (PDS 4.0 Ethicon Inc., Somerville, NJ, USA) in the form of a Witzel fistula over a length of approximately 4 cm. The catheter is lead out in the left middle abdomen and fixed at skin level with a thread. The intraabdominal jejunal loop is fixed to the ventral abdominal wall with 4 (PDS 4.0 Ethicon Inc., Somerville, NJ, USA) single button sutures.

Robot-assisted approach

A detailed description of the surgical procedure for esophagectomy has been described by us previously [14]. The following section describes in detail the steps of the FJ placement during esophagectomy.

A FJ tube for early postoperative enteral nutrition is routinely placed at our clinic during the abdominal part of the esophageal resection. We favor a port setup with a total of six trocars for the abdominal part. One 8-mm port for each robot arm, one 12-mm assistant trocar, which is operated by the table assistant, and one 5-mm trocar for liver retraction. The first port (arm 2) is placed using the first entry technique, just supraumbilical, followed by the next trocar in the left medioclavicular line in the same transverse plane, but at least 8 cm away from the first (arm 3). In the same transversal plane, another port is placed as far-left laterally as possible (arm 4). Similarly, the next port (arm 1) is placed far-right laterally. The 12-mm assistant trocar is then placed slightly caudal to the plane of the other ports, slightly medial to the right medioclavicular line, and will later be used for insertion of the laparoscopic stapler by the table assistant.

After abdominal lymphadenectomy, mobilization of the stomach and distal esophagus and the construction of the stomach tube, the FJ tube is placed. Accordingly, the proximal jejunum is identified and a location is selected approximately 30 cm distal to the ligament of Treitz. A needle holder is then inserted via arm 3. A fixation suture is made using Stratafix™ 2/0 (STRATAFIX Knotless Tissue Control Devices, Ethicon Inc., Somerville, NJ, USA), in which the jejunal loop is fixed to the fascia in the left middle abdomen. In this case, a constant tension should be ensured without overly pulling the barbed sutures (Figure 1). To avoid torsion, it should be noted that the oral jejunal limb is always located on the left side of the image and the aboral jejunal limb on the right side (Figure 2). After completion of the fixation suture, a hollow needle is used to percutaneously puncture the jejunal loop and the FJ is inserted (Covidien, Deutschland), filling the sling with water. The jejunal loop is fixed to the abdominal wall in a circular sequence around the FJ entry point, again using Stratafix™ 2/0. The rotation of the 30º camera by 180° towards the abdominal wall can significantly improve the overview (Figure 3). The fixation suture is fixed using an OMNIFinger™ Articulating Endoscopic Clip Applier (Grena, London, UK) to prevent the suture from coming loose again. The application of a Witzel fistula is completely avoided (Figure 4).

Statistical analysis

The statistical analysis was done with SPSS 20.0 software (IBM, Armonk, NY). Independent sample t-test and Mann-Whitney U-test were used to compare continuous variables, while the chi-square test was used for categorical variables. 95% confidence intervals (95% CIs) and $p<0.05$ was considered significant.

Results

During the study period, 204 patients underwent an esophagectomy in which an FJ was placed. We divided the cohort into two groups, according to whether the FJ placement was performed by RAMIE (134 (65.6%) patients) or by an open procedure (70 (34.4%) patients).

Table 1 gives a full overview of the demographic data. The mean age was significantly lower in the RAMIE group than the open group (66±9 years *vs.* 69±11 years, respectively; p=0.016), while the BMI was significantly higher (27.3±4.86 kg/m^2 *vs.* 25.7±5.77 kg/m^2; p=0.035). Most patients in both groups were male (RAMIE 83.6%, open 72.9%; p=0.07), and the majority of patients were classed as ASA III (RAMIE 64.2%, open 65.7%; p=0.06). The most common indication for esophageal resection was the presence of cancer (adenocarcinoma: RAMIE 84.3%, open 65.7%; squamous cell carcinoma: RAMIE 10.4%, open 22.9%; p=0.1). Very few patients were operated on for an undescribed benignancy, such as achalasia (RAMIE 1 (0.7%) patient, open; 1 (1.4%) patient), Boerhaave (open; 1 (1.4%) patient) or Barrett's esophagus (RAMIE; 2 (1.5%) patients, open 1 (1.4%) patient). The Ivor-Lewis procedure was used in 84.3% of patients in the RAMIE group and 55.7% in the open group. The McKeown technique was used in only 8.2% of RAMIE patients and 24.3% of open patients. Further surgical procedures included the transhiatal procedure (RAMIE 5.2%, open 20%) and the Robot-Assisted Cervical Esophagectomy (RACE) (2.2% in the RAMIE group).

An FJ-related complication was reported in 3.7% of RAMIE patients and 5.7% of open patients. In the RAMIE cohort (n=5 complications), there was a dislocation of the small bowel tube in two cases, a small bowel obstruction, a small bowel fistula and a wound infection in the area of the abdominal wall in one case each. In the open cohort (n=4 complications), there was a dislocation of the feeding tube in three cases and a wound infection of the abdominal wall in another case. One patient in the open group died as a result of FJ placement, when dislocation of the feeding tube with subsequent fulminant peritonitis with pronounced sepsis occurred. All complication data are given in (Table 2).

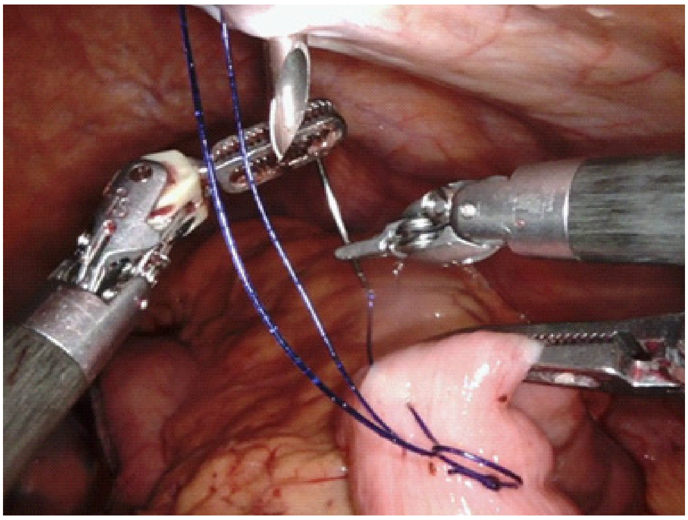

Figure 1: Accordingly, the proximal jejunum is identified 30 cm distal to the ligament of Treitz. A needle holder is then inserted and a fixation suture is made using barbed sutures (Stratafix™ 2/0).

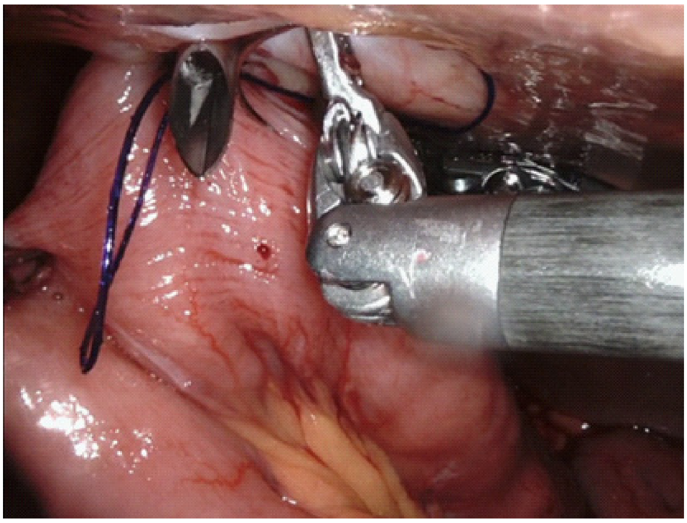

Figure 2: To avoid torsion, the oral jejunal limb is always located on the left side of the image and the aboral jejunal limb on the right side.

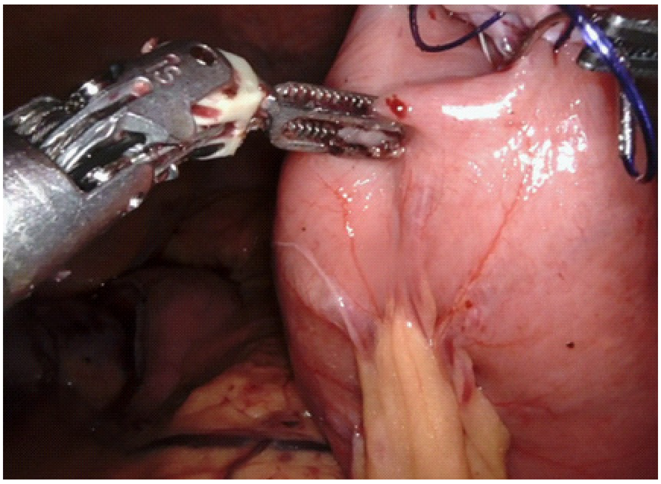

Figure 3: The FJ is inserted. The jejunal loop is fixed to the abdominal wall in a circular sequence around the FJ entry point, again using barbed sutures (Stratafix^{TM} 2/0).

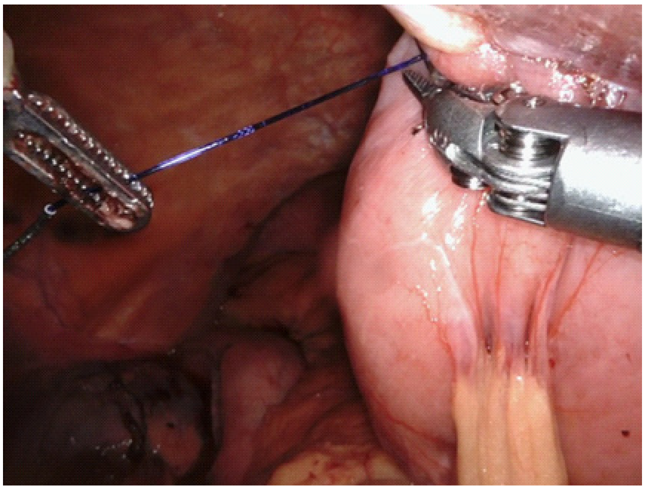

Figure 4: The fixation suture is fixed using a OMNIFinger^{TM} Articulating Endoscopic Clip Applier to prevent the suture from coming loose again.

Table 1: Demographics and Procedure.

	RAMIE	Open	P value	Total
All (%)	134 (65.6)	70 (34.4)		204
Mean age (years, SD)	66 ± 9	69 ± 11	0.016	
Body mass index (kg/m², SD)	27.31 ± 4.86	25.7 ± 5.77	0.035	
male	112 (83.6)	51 (72.9)		163
female	22 (16.4)	19 (27.1)		41
ASA (%)			0.06	
ASA I	3 (2.2)	1 (1.4)		4
ASA II	44 (32.8)	18 (25.7)		62
ASA III	86 (64.2)	46 (65.7)		132
ASA IV	1 (0.7)	5 (7.1)		6
Indication (%)			0.11	
adenocarcinoma	113 (84.3)	46 (65.7)		159
squamous cell carcinoma	14 (10.4)	16 (22.9)		30
chronic inflammation	3 (2.2)	3 (4.3)		6
neuroendocrine tumor	1 (0.7)	1 (1.4)		2
boerhaave	0 (0.0)	1 (1.4)		1
barret	2 (1.5)	1 (1.4)		3
melanoma	0 (0.0)	1 (1.4)		1
achalasia	1 (0.7)	1 (1.4)		2
Procedure			0.00	
Ivor Lewis	113 (84.3)	39 (55.7)		152
Mc Keown	11 (8.2)	17 (24.3)		28
RACE	3 (2.2)	0 (0.0)		3
transhiatal	7 (5.2)	14 (20)		21

RAMIE: Robot-Assisted Minimally Invasive Esophagectomy; SD: Standard Deviation; ASA: American Association of Anesthetists; RACE: Robot-Assisted Cervical Esophagectomy.

Table 2: Complications.

	RAMIE	Open	P value	Total
All (%)	134 (65.6)	70 (34.4)		204
ICU-Stay (%)			0.22	
yes	132 (98.5)	67 (95.7)		199
no	2 (1.5)	3 (4.3)		5
ICU-stay (days)	8 ± 18	6 ± 9	0.43	
FJ-associated complication (%)			0.51	
no	129 (96.3)	66 (94.3)		195
yes	5 (3.7)	4 (5.7)		9
small bowel obstruction	1 (0.7)			
jejunal fistula	1 (0.7)			
dislodged FJ-tube	2 (1.6)	3 (4.3)		
FJ-tube abdominal wall site infection	1 (0.7)	1 (1.4)		
FJ-associated deceased (%)			0.16	
no	134 (100)	69 (98.6)		203
yes	0 (0.0)	1 (1.4)		1

RAMIE: Robot-Assisted Minimally Invasive Esophagectomy; ICU: Intensive Care Unit; FJ: Feeding Jejunostomy.

Discussion

Placement of a FJ tube for enteral feeding is the most common adjunct feeding procedure to accompany esophagectomy. It is thought to benefit the patient by providing early enteral nutrition, which is superior to parenteral nutrition [20-22]. Several studies have shown that jejunostomy feeding in the early postoperative period is safe and does not negatively impact survival in esophageal cancer [23]. However, FJ tubes can be associated with few but severe complications such as wound infection and wound dehiscence but also pulmonary and systemic infections, which increase overall morbidity and mortality [24,25]. In the case of entirely robot-assisted esophagectomy, however, the applicability of the FJ system with a possible surgical extension is often questioned.

In RAMIE, we exclusively used barbed sutures to fix the FJ and here report the first results using this surgical method with conservative FJ fixation (carried out using traditional technology with a Witzel fistula and fixation on the abdominal wall). The complication and mortality rates in our study were low, with no significant difference between the robotic and the conventional group, indicating that we achieved a significantly reduced complication and mortality rate compared to the literature [15,26,27].

In our analysis of 204 patients undergoing esophagectomy, the most common indication was esophagogastric carcinoma. Comparing RAMIE with open surgery, we have demonstrated that there were no significant differences in overall mortality (p=0.16), ICU stay (p=0.43) or FJ-associated complications (p=0.51). This aspect is particularly interesting in view of the fact that the RAMIE cohort had a significantly higher BMI than the open cohort. The finding is consistent with the results of Samel et al., who also reported no significant differences in morbidity in robotic procedures, apart from a significant increase in operating time with increasing BMI [28].

In our study, minor complications were wound infections and catheter dislocations, while major complications comprised small bowel obstruction and jejunal fistula. The rate of FJ-related complications was low in both groups, well below the complication rates of up to 16% for similar complications (mainly wound infections) described in the literature [29,30]. Weijs et al. found that FJ tubes were associated with wound infection rates of 0.4% to 16% and mortality rates from 0% to 0.5% [25]. Focusing on the abdominal wall infection in our cohort, the rate was 0.7% in the RAMIE group and 1.4% in the open group. Surgical site infection is commonly cited as a frequent source of postoperative morbidity related to jejunal feeding tubes [31]. A review of the literature reported an infection rate ranging from 0-12.5% [27,32].

A common late complication is cutaneous jejunal fistula, particularly when the tube is required for long-term enteral access. In their retrospective chart review, Young et al. described an occurrence of FJ-associated fistula in 3.7% of the investigated cohort [33]. In our collective, the fistula rate was 0% in the open and 0.7% in the RAMIE group. Young et al. associated the occurrence of a fistula with long-term placement of the tube. Therefore, removal of the catheter is recommended as soon as the oral dietary regimen is completed.

Feeding-tube dislodgement was the most common complication in our cohort, affecting 1.6% of RAMIE patients and 4.3% of open patients. These results are overall comparable to the available literature, where dislocation rates from 0 to 20% are described [16,26,34]. One of the causes of catheter dislocation is the way in which the jejunum loop is fixed to the abdominal wall. Different methods have been described to retract and anchor the jejunum to the anterior abdominal wall. Some studies describe the use of T-fasteners or transabdominal sutures to keep the jejunum secured [26,31,35,36]. Our preference is to use intracorporal barbed sutures. Although the difference between the open and RAMIE groups was not significant, the lower rate of catheter displacement does indicate a tendency towards more secure procedures within the RAMIE group. A Witzel fistula was placed in the open feeding tube and the jejunostomy was fixed to the abdominal wall with a retaining suture. In the RAMIE group, we were able to use the instruments already mounted for the robot-assisted surgery of the abdominal section. This provides a much better overview of the surgical area and eliminates the need to change suture materials. Another decisive difference was the use of barbed sutures. We have already shown in several studies from our clinic that their use is safe [17] and correlates to a reduction in surgery time [37]. The time saving can be explained by the omission of the Witzel tunnel installation, which also reduces the risk of idiopathic stenosis and no need for a suture guidance by the table assistant. These aspects make the robot-assisted jejunostomy placement a safe and fast surgical procedure during esophageal resection, therefore making it superior to open FJ placement.

There are conflicting results in the literature regarding the effect of FJ tube placement on the length of in-hospital stay [38]. Al-Temimi et al. reported the postoperative impact of the outcome of FJ placement during esophagectomy. They found a shorter hospital stay in patients with an anastomotic insufficiency when an FJ was present [39]. Our findings showed a comparable length of hospital stay between RAMIE (28 days) and open patients (27 days).

There are some limitations to our study. It is a retrospective review and may therefore lack the rigor in data collection that would be possible in a prospective study. Preoperative factors such as neoadjuvant chemo-radiation were not collected, which may have an impact on the risk of perioperative complications. Despite these limitations, our findings regarding FJ tube placement during esophagectomy were gathered from a large series of open and robot-assisted jejunostomy catheter placements to date suggesting a benefit for the patient in the postoperative course.

In a large consecutive series of FJ placements, we found that robot-assisted placement of the feeding tube is safe and feasible compared to open surgery, with low perioperative morbidity even in patients with a higher BMI. It was shown that use of barbed sutures during the jejunostomy optimizes this surgical step and its outcome. Future studies on a larger cohort will clarify how this knowledge can be translated into improved therapy in these patients.

Conflicts of interest

Thomas Becker received the da Vinci® Xi robotic surgical system from Intuitive Surgical Sàrl for the purpose of clinical research. Jan-Hendrik Egberts is a proctor for Intuitive Surgical. Author Florian Richter, Author Thorben Moeller, Author Anne-Sophie Mehdorn and Author Jan-Niclas Kersebaum declare that they have no conflict of interest

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