Original Article

Technical notes and outcomes of robot-assisted and laparoscopic jejunostomy placement for tube feeding after esophagectomy

B. Feike Kingma[1#], Matias M. Turchi[2#], Romina Lovera[2], Mauricio Ramirez[2], Adolfo Badaloni[2], Richard van Hillegersberg[1], Jelle P. Ruurda[1#], Alejandro Nieponice[2,3#]

[1]University Medical Center Utrecht, University Utrecht, Utrecht, The Netherlands; [2]Hospital Universitario Fundación Favaloro, Buenos Aires, Argentina; [3]Instituto de Medicina Traslacional, Trasplante y Biongenieria, CONICET, Buenos Aires, Argentina

Contributions: (I) Conception and design: BF Kingma, MM Turchi, JP Ruurda, A Nieponice; (II) Administrative support: BF Kingma, MM Turchi, R Lovera, M Ramirez; (III) Provision of study materials or patients: R van Hillegersberg, A Badaloni, JP Ruurda, A Nieponice; (IV) Collection and assembly of data: BF Kingma, MM Turchi, R Lovera, M Ramirez; (V) Data analysis and interpretation: BF Kingma, MM Turchi; (VI) Manuscript writing: All authors; (VII) Final approval of manuscript: All authors.

[#]These authors contributed equally to this work.

Correspondence to: Alejandro Nieponice, MD, PhD. Chief, Esophageal Unit, Department of Surgery, Hospital Universitario Fundación Favaloro, Av. Belgrano 1746, C1093 AAS, Buenos Aires, Argentina. Email: anieponi@ffavaloro.org.

Background: Recent studies reported considerable jejunostomy-related morbidity after esophagectomy, questioning the appropriateness of jejunostomy tube feeding for esophageal cancer patients. This study aimed to describe a technique for (robot-assisted) laparoscopic jejunostomy tube placement and to report its associated outcomes in patients undergoing minimally invasive esophagectomy (MIE).

Methods: In this observational cohort study, patients who underwent MIE with (robot-assisted) laparoscopic jejunostomy tube placement were included from the prospective databases of two centers (2010–2019). Main endpoints included the incidence of jejunostomy-related complications, the duration of jejunostomy tube feeding, and weight change between surgery and 3- and 6-month follow-up. Patient characteristics were compared between patients who had jejunostomy-related complications versus patients who did not.

Results: Jejunostomy-related complications occurred in 13 out of 93 patients (14%) and all involved infections. No intestinal torsions occurred in this cohort. Re-operation for jejunostomy-related infection was required in 1 patient (1%). Pre-existent comorbidity (100% *vs.* 71%, P=0.033), and diabetes mellitus in particular (31% *vs.* 9%, P=0.044), were significantly more common in patients with jejunostomy-related infections compared to patients without such complications. Jejunostomy tubes were removed earlier in patients with jejunostomy-related complications [median day 21 (IQR, 11–61) *vs.* day 37 (IQR, 28–72), P=0.049].

Conclusions: Minimally invasive jejunostomy tube placement with additional anti-rotation fixation, either robotically or laparoscopically, is a safe and advisable way of establishing the enteral feeding route in patients undergoing MIE.

Keywords: Esophagectomy; robotics; minimally invasive surgery; jejunostomy; artificial feeding

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Introduction

Esophagectomy is the core of curative treatment for esophageal cancer, yielding a 5-year survival rate of 40–50% when preceded by neoadjuvant chemo(radio)therapy (1,2). A paradigm shift towards minimally invasive techniques occurred over the last years (3), as randomized trials found

that both minimally invasive esophagectomy (MIE) and robot-assisted MIE (RAMIE) achieve good oncological results and offer benefits over an open approach in terms of blood loss, postoperative pain, pulmonary complications, and functional recovery (4-6). Nonetheless, MIE and RAMIE are still associated with an overall morbidity rate of approximately 60%, which is mainly explained by pulmonary complications and anastomotic leakage (7,8).

Aiming to minimize the risk of aspiration pneumonia and to protect the newly formed esophagogastric anastomosis, patients are often kept on a nil by mouth diet for the first few days after esophagectomy (9,10). Enteral tube feeding is mostly preferred during this period, which can be provided through a surgical jejunostomy or an endoscopically inserted naso-enteric tube. Whereas jejunostomy tubes may be associated with more serious complications requiring re-operations (e.g., intestinal torsions, intra-abdominal abscess), naso-enteric tubes might increase patient discomfort and dislocate in 20–35% of patients (11). Based on currently available literature, jejunostomy tubes seem preferable over nasoduodenal tube feeding for patients undergoing esophagectomy, as they are associated with better quality of life at 1 week after surgery, less tube dislocations (either intentional by the patient or otherwise), and may be used in combination with an early oral feeding protocol (12,13). These findings suggest that jejunostomy placement is still justified as a routine part of the esophagectomy procedure, warranting attempts to identify the technique that has the lowest morbidity.

Prior studies suggested that jejunostomy-related complications are common in patients undergoing esophagectomy (11). For example, a recent study found that intestinal torsions at the jejunostomy site occurred in 17% of patients after esophagectomy for cancer, which led the authors to question the appropriateness of this feeding strategy for routine care (14). However, the technique for jejunostomy placement seems to be unstandardized according to current literature. In a previous small case series that investigated the outcomes of a laparoscopic technique for jejunostomy tube placement with anti-rotation fixation to the abdominal wall, no severe complications occurred (15). Fixating the jejunum over a longer segment might mechanically decrease the rotational mobility at the jejunostomy site itself, reducing the incidence of this potentially severe complication. Comparable methods are now commonly used (e.g., the Stamm method for gastrostomy creation) and seem solid, but data on the outcomes of these techniques are largely lacking. Furthermore, the risk factors for jejunostomy-related complications are largely unclear.

The current study aimed to describe the technical elements and outcomes of a technique for jejunostomy tube placement with the essential step of anti-rotation fixation, which is facilitated by using an endoscope and (robot-assisted) laparoscopic instruments to get overview of the anterior abdominal wall and fixate the jejunal segment to it. The jejunostomy is created by placing a purse-string suture around the tube followed by anti-rotation fixation of the jejunal segment to the anterior abdominal wall. This technique might be beneficial in reducing the risk of intestinal torsion and avoids the need for an additional incision, which represents a step forward in minimally invasive surgery. This study reports the short-term outcomes of this technique and hypothesizes that it is safe and associated with low jejunostomy-related morbidity. In addition, this study intended to identify patient- and treatment characteristics that are associated with jejunostomy-related complications.

We present the following article in accordance with the STROBE reporting checklist (available at http://dx.doi.org/10.21037/aoe-21-4).

Methods

Design and patient population

The institutional prospective databases of the University Medical Center Utrecht (Utrecht, The Netherlands) and Hospital Universitario Fundación Favaloro (Buenos Aires, Argentina) were used to select all patients who underwent (robot-assisted) MIE with minimally invasive jejunostomy tube placement for cancer between 2010 and 2019. No specific exclusion criteria were defined. This study was performed in accordance with the Declaration of Helsinki (as revised in 2013). The institutional reviews boards of the participating centers approved this study and the need for written informed consent was waived because of the retrospective study design and use of anonymized data.

Technique for jejunostomy tube placement

Robot-assisted or conventional laparoscopy was used to place a jejunostomy tube at the end of the abdominal phase during two-stage transthoracic esophagectomy. The trocar port positions are shown in *Figure 1*. In the robotic approach as performed in the UMC Utrecht, the 5 mm

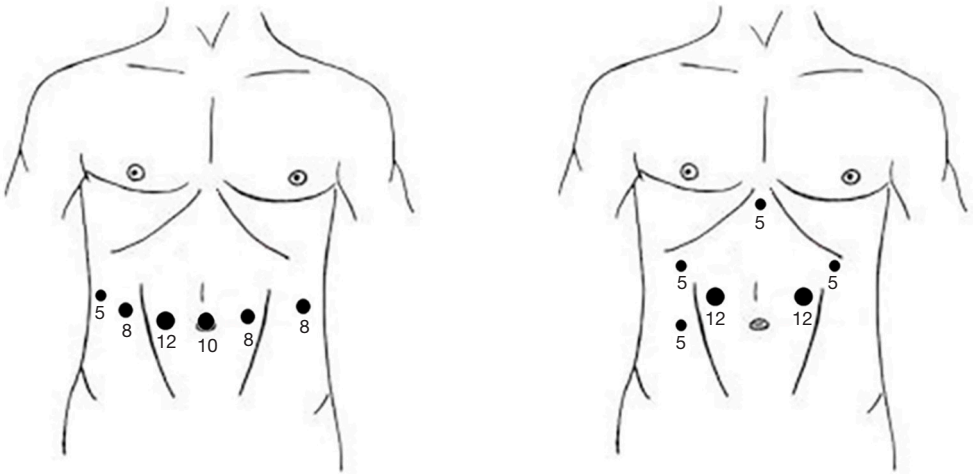

Figure 1 Trocar port arrangement in robot-assisted esophagectomy (left) and conventional minimally invasive esophagectomy (right).

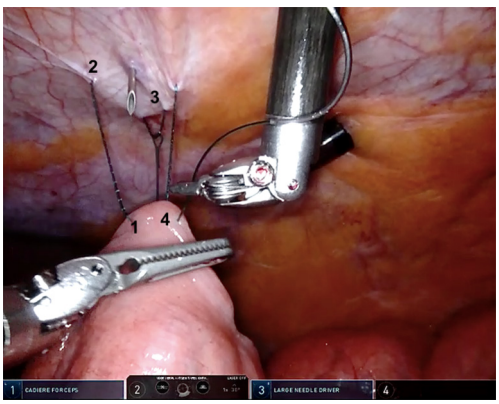

Figure 2 Initial attachment of the jejunal segment on the posterior side of the desired jejunostomy tube entry point from laparoscopic perspective (left side of the patient). (I) The purse-string suture is initiated by an autoadjustable stitch through the selected jejunal segment. (II) The following stitch is made on the posterior side of the desired jejunostomy from laparoscopic perspective (left side of the patient). (III) The autoadjustable suture is guided through its own loop, followed by another stitch through the abdominal wall. (IV) The next purse-string stitch is placed through the jejunum.

port is used for the liver retractor, the 8 mm ports are used for the robotic instruments, and the 12 mm port is used for the camera throughout the procedure. For jejunostomy tube placement, the instrument in the most lateral 8 mm trocar port on the left (from patient perspective) is removed. A Cadiere forceps and large robotic needle driver are introduced through the other 8 mm trocar ports while the camera remains in the 12 mm port. In the conventional laparoscopic approach as performed in Fundación Favaloro, the Dorsey grasper and laparoscopic needle driver are used.

Key elements of the procedure involve a purse string suture around the tube and fixation of the jejunum to the anterior abdominal wall, which are somewhat similar to the laparoscopic Stamm technique for surgical placement of a gastrostomy tube. First, a suitable post-Treitz jejunal segment was selected. A needle was then introduced through the abdominal wall at the desired point of entrance for the jejunostomy tube (usually in the upper left abdominal quadrant), followed by attachment of the selected jejunal segment to the abdominal wall with an autoadjustable 3.0 suture (V-Loc, Medtronic, USA) (*Figures 2,3*). These steps were performed vice versa in the conventional laparoscopic cases. The needle was then pierced into the jejunum and the Seldinger technique was applied to insert a 9 to 14 French tube distally into the jejunum (*Figure 4*). Autoadjustable purse-string sutures were used to attach the jejunum to the abdominal wall around the tube (*Figure 5*). Finally, anti-rotation fixation of the jejunum was performed by one suture at the proximal side (*Figure 6*) and one suture at the distal side (*Figure 7*), or by a running suture over 3–4 centimeters in distal direction. The sutures were placed 1–2 centimeters from the tube. The jejunostomy tube was fixated to the skin by means of a suture and postoperatively kept in place until the patient could be fed adequately via the oral route or until complications necessitated prompt removal.

Outcome measures and data collection

The primary outcome was the rate of jejunostomy-related

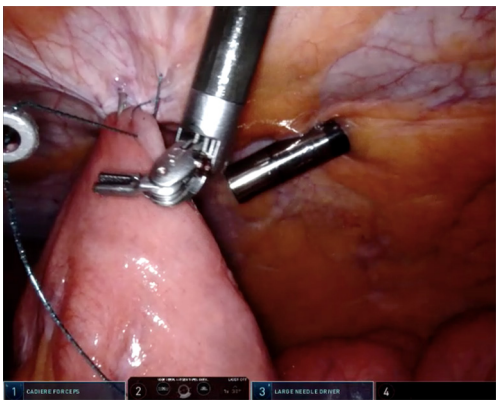

Figure 3 Attachment of the jejunal segment on the right side of the jejunostomy from laparoscopic perspective (caudal side of the patient).

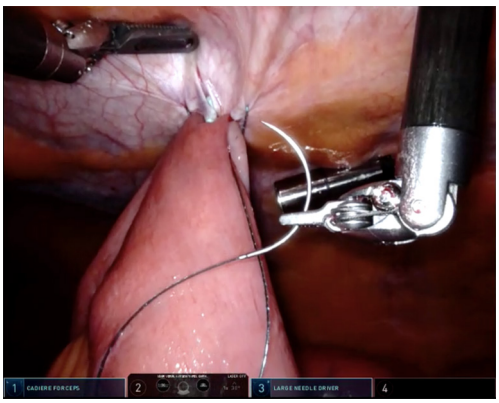

Figure 4 Insertion of the jejunostomy tube into the jejunum in distal direction.

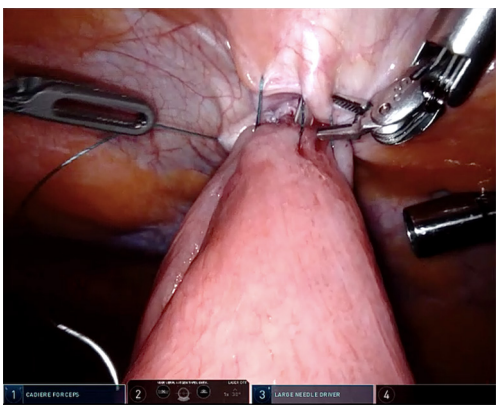

Figure 5 Attachment of the jejunum on the anterior side of the jejunostomy tube from laparoscopic perspective (right side of the patient).

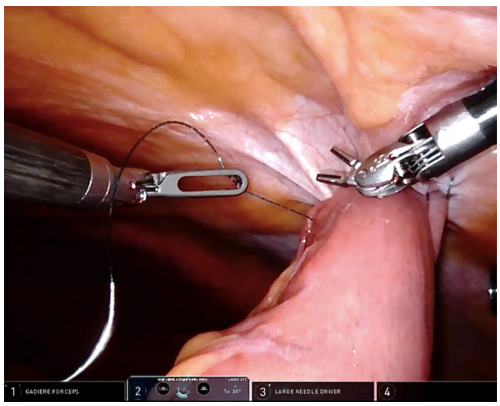

Figure 6 Proximal anti-rotation fixation (cranial to the jejunostomy site) by means of an autoadjustable suture.

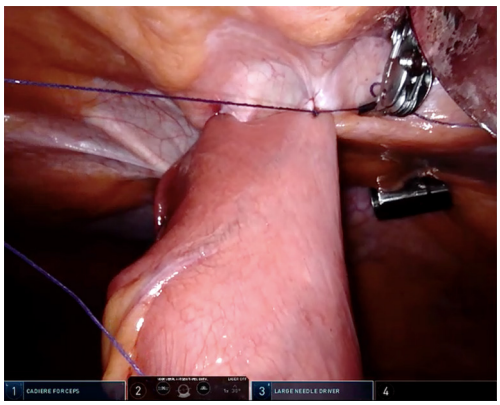

Figure 7 Distal anti-rotation fixation (caudal to the jejunostomy site) by means of an autoadjustable suture.

complications until the day of removing the jejunostomy tube, including infections, tube dislocations, or intestinal torsions. Other postoperative complications were scored until 30 days after surgery and defined according to the Esophagectomy Complications Consensus Group (ECCG) agreements (16). All complications were graded by means of the Clavien-Dindo classification system (17). The duration of jejunostomy tube feeding and the postoperative weight at 3 and 6 months after surgery were also evaluated. The prospective databases of the participating institutions were complemented by retrospective review of patient files to collect the required data. In case of missing follow-up data, the numbers of complete cases were reported and the outcomes were

Table 1 Overall postoperative morbidity and mortality in 93 patients who underwent (robot-assisted) MIE with minimally invasive jejunostomy tube placement

Parameter	N	(%)
Complications, yes		
Any	63	–67
Pulmonary (including pneumonia)	34	–37
Anastomotic leakage	30	–32
Chylothorax	10	–11
Recurrent laryngeal nerve injury	8	–7
Clavien-Dindo of the most severe complications		
No complication	31	–33
Clavien-Dindo 1	1	–1
Clavien-Dindo 2	23	–25
Clavien-Dindo 3a	13	–14
Clavien-Dindo 3b	11	–12
Clavien-Dindo 4	13	–14
Clavien-Dindo 5	1	–1
Length of hospital stay, days [IQR]	12	[8–20]
Re-admission <30 days after discharge		
Yes	12	–13
No	79	–87
Unknown	2	
Mortality (in-hospital or <30 days after surgery)	1	–1

IQR, interquartile range.

evaluated for this group.

Statistical analyses

All statistical analyses were performed by using SPSS 21.0 (Armonk, USA). Categorial data were shown as counts with percentages. Means with standard deviations or medians with ranges were calculated for continuous outcomes, depending on the distribution of data. To identify potential factors associated with jejunostomy-related complications, exploratory univariable analyses were performed comparing the characteristics of patient who developed jejunostomy-related complications were compared to those of patients who did not develop such complications. Chi-square tests (for categorical data), student's *t*-tests (for normally distributed continuous data), or Mann-Whitney U tests (for non-normally distributed continuous data) were performed. A two-sided $P<0.05$ was considered to indicate a statistically significant difference. The limited sample size did not allow for a multivariable analysis to evaluate whether factors were predictive of jejunostomy-related complications.

Results

Patient population

A total of 93 patients (59 patients in hospital A and 34 patients in hospital B) were included. Patients were predominantly male (n=72, 77%) and the mean age was 62.9 years (±10.3 years). The median body mass index (BMI) was 26.5 kg/m^2 [IQR, 24.0–29.2 kg/m^2] and comorbidity was present in the majority of patients (n=70, 75%). The tumor was usually located in the distal esophagus (n=46, 50%) or esophagogastric junction (n=41, 44%). Neoadjuvant therapy was mostly provided (n=77, 83%), followed by esophagectomy by an Ivor-Lewis (n=73, 79%) or McKeown (n=20, 22%) approach. Jejunostomy tube placement was performed robotically (n=16, 17%) or by conventional laparoscopy (n=77, 83%). The overall morbidity and mortality rates were 67% and 1%, respectively, as is detailed in *Table 1*.

Jejunostomy-related complications

The data on postoperative jejunostomy-related complications were complete. Jejunostomy-related complications were observed in 13 cases (14%), which involved 12 skin infections and 1 abdominal wall abscess. No jejunostomy-related mortality occurred. The complications were classified as Clavien-Dindo 1 in 1 patient (1%), Clavien-Dindo 2 in 9 patients (10%), Clavien-Dindo 3a in 3 patients (3%), and Clavien-Dindo 3b in 1 patient (1%). The jejunostomy tube was removed because of infectious complications in 6 patients (7%), on median postoperative day 11 [IQR, 8–14]. One re-operation under general anesthesia (i.e., Clavien-Dindo 3b) was required to manage jejunostomy-related infection. During this re-operation at postoperative day 11, an abdominal wall abscess was found, likely caused by a defect in the jejunostomy tube. The jejunostomy tube was replaced and remained functional until it was removed in response to adequate oral intake on the 56th day after esophagectomy.

The other re-interventions (i.e., Clavien-Dindo 3a) involved bed-side incision of a skin abscess in 2 cases and replacement of the jejunostomy tube under X-ray vision in 1 case.

Table 2 shows the characteristics of patients with jejunostomy-related complications versus patients without such complications. In patients with jejunostomy-related complications, a higher incidence of overall comorbidity (100% *vs.* 71%, P=0.033) and diabetes mellitus in particular (31% *vs.* 9%, P=0.044) were found when compared to patients without jejunostomy-related complications.

Duration of jejunostomy feeding and postoperative weight

Overall, patients had their jejunostomy tube in place for a median of 35 days [IQR, 27–71 days]. The jejunostomy tube was removed significantly earlier in patients with jejunostomy-related complications than in those who had an uneventful course regarding their jejunostomy [median day 21 (IQR, 11–61) *vs.* day 37 (IQR, 28–72), P=0.049]. Data regarding weight were available for 80 out of the 94 patients at 3 months postoperative follow-up (85%) and for 70 out of the 94 patients at 6 months postoperative follow-up (75%). Between surgery and 3 months postoperative follow-up, these patients lost a median of 5.9% [IQR, 2.8–11.8%] of their body weight. At 6 months postoperative follow-up, a median weight loss of 6.9% [IQR, 3.0–14.7%] was observed.

Table 2 Characteristics of patients with jejunostomy-related complications (n=13) versus patients without jejunostomy-related complications (n=80)

Parameter	Complication (n=13)		No complication (n=80)		P
	N	(%)	N	(%)	
Center					0.439
A	7	–54	52	–65	
B	6	–46	28	–35	
Age in years, mean (± SD)	62.2	–10.5	66.9	–8	0.129
Gender					
Male	10	–77	62	–77	>0.999
Female	3	–23	18	–23	
BMI in kg/m^2, median [IQR]	28	[26.0–29.2]	25.8	[23.9–29.3]	0.099
Comorbidity, yes					
Any	13	–100	57	–71	0.033
Cardiovascular	7	–54	34	–43	0.445
Respiratory	1	–8	12	–15	0.685
Diabetes	4	–31	7	–9	0.044
Tumor location					
Middle third	1	–8	5	–6	>0.999
Distal third or GE-junction	13	–92	75	–94	
Tumor histology					0.918
Adenocarcinoma	10	–77	60	–75	
Squamous cell carcinoma	3	–23	19	–24	
Other	0	0	1	–1	

Table 2 (*continued*)

Table 2 (*continued*)

Parameter	Complication (n=13)		No complication (n=80)		P
	N	(%)	N	(%)	
Neoadjuvant therapy					0.272
Chemoradiotherapy	10	–77	48	–60	
Chemotherapy	0	0	18	–23	
Radiotherapy	0	0	1	–1	
None	3	–23	13	–16	
Abdominal approach					
Conventional laparoscopy	11	–85	66	–83	>0.999
Robot-assisted laparoscopy	2	–15	14	–17	
Pathological T stage					0.449
pT0	2	–15	24	–30	
pT1	5	–39	18	–23	
pT2	1	–8	16	–20	
pT3	5	–39	21	–26	
pT4	0	0	1	–1	
Pathological N stage					0.525
pN0	9	–69	57	–71	
pN1	3	–23	10	–13	
pN2	0	0	8	–10	
pN3	1	–8	5	–6	
Completeness of resection					
R0	13	–100	76	–95	>0.999
R1-2	0	0	4	–5	

Pathological T and N staging were performed according to the American Joint Commission on Cander (AJCC) staging guidelines. BMI, body mass index; GE-junction, gastro-esophageal junction; IQR, interquartile range.

Discussion

Summary of findings

In this multicenter study that describes a technique for minimally invasive jejunostomy tube placement with additional anti-rotation fixation, jejunostomy-related complications occurred in 13 patients (14%). Pre-existent comorbidity (100% *vs.* 71%), specifically diabetes mellitus (31% *vs.* 9%), was observed significantly more frequently in patients who had jejunostomy-related complications when compared to patients without such complications. All jejunostomy-related complications involved infections and a re-operation was required in only 1 patient (1%). No intestinal obstructions due to torsion at the jejunostomy site were found in this study. Although the jejunostomy tube was removed significantly earlier in patients with jejunostomy-related complications than in patients without complications (median day 21 *vs.* day 37), no difference was observed regarding the change in body weight at 3- and 6-month postoperative follow-up.

Intestinal torsions

The current findings are contradictory to several recent

reports of serious jejunostomy-associated morbidity and intestinal torsions occurring at the jejunostomy site. In one study, bowel obstructions due to intestinal torsion were found in 12% of patients who had a jejunostomy after esophagectomy (18). In another, the torsion rate was even as high as 17% (14). As intestinal torsions frequently require a re-operation, these findings may be interpreted as rationale to refrain from the routine use of jejunostomy tube feeding in the perioperative care of esophageal cancer patients. However, it should be noted that the authors of these studies used a technique that involved fixation of the jejunum only at the site of the jejunostomy (14,18). An older study already reported an intestinal torsion rate of 2% when placing a jejunostomy with extra anti-rotation fixation by an open Witzel approach (19). With the currently evaluated minimally invasive Seldinger technique using anti-rotation sutures, at least similar results were achieved in our study that evaluated anti-rotation fixation by means of two comparable methods (i.e., a torsion rate of 0%). These results demonstrate that the incidence of intestinal torsions can be very low after esophagectomy. Hence, concerns for intestinal torsions should probably not be the main reason to opt for alternative feeding routes (e.g., nasojejunal tube or total parenteral feeding) in patients undergoing MIE.

Jejunostomy site infections

In this study, infection of the jejunostomy was observed in 14% of all included patients, which is in line with available literature on laparoscopic jejunostomy tube placement (20). Notably, diabetic comorbidity was significantly more common in the group of patients with jejunostomy-related complications. Whereas one older study reported that infections at the jejunostomy site were seen in 40% of diabetic patients undergoing open bariatric surgery (21), the current study is the first to confirm a significant association between diabetic comorbidity and jejunostomy-related complications in patients undergoing MIE. Although the exact mechanisms are not well understood, diabetes is a known risk factor for surgical site infections (22). A previous systematic review showed that postoperative hyperglycemia might be the most important independent predictor for surgical site infections (23). However, while postoperative hyperglycemia could potentially represent a modifiable risk factor, a Cochrane review concluded that there currently is insufficient evidence to support the hypothesis that aggressive postoperative glucose management reduces surgical site infections (24). Considering this literature, it seems that physicians should basically aim at hygienic care for the jejunostomy and early detection of potential infections. One could also argue that jejunostomy tubes should be avoided in diabetic patients undergoing MIE. Feeding through a nasojejunal tube might be a suitable alternative for these patients, although it must be noted that tube dislocation is a common drawback of that strategy.

Infections at the jejunostomy site can be serious and require re-operation, as was the case in one patient in this study. In this particular case, an abdominal wall abscess developed after a robotic procedure, which turned out to be caused by a leak in the feeding tube. In all likelihood, the feeding tube was punctured at the level of the abdominal wall when attaching the jejunum to the abdominal wall with an autoadjustable suture, which remained unnoticed due to the absence of tactile feedback in robotic surgery. As a result, nutrition leaked into the abdominal wall, causing abscess formation. Whereas robotic assistance provides certain technical benefits in terms of camera stability and dexterity, which facilitates suturing towards the abdominal wall and probably reduces operative time for minimally invasive jejunostomy tube placement, the absence of tactile feedback should be bared in mind.

Strengths and limitations

This study derives strength from its multicenter study design and focus on a detailed description of the technique that is used for minimally invasive placement of a jejunostomy tube in two expert centers for esophageal surgery. However, the number of included patients was relatively small and the median duration of jejunostomy tube feeding was limited. Therefore, uncommon jejunostomy-related complications might have been missed, especially those that may occur with long-term jejunostomy tube feeding. Intestinal torsions around the jejunostomy site might occur long after cessation of jejunostomy tube feeding and such events could not be identified with the current follow-up. Larger studies are required to clarify the complete complication profile of the presented technique. Lastly, it must be mentioned that the currently reported anastomotic leakage rate was high in relation to recent benchmarks. This might be explained by the experienced learning curve of a hand-sewn intrathoracic anastomosis in RAMIE (25), as the anastomotic leakage rate is 14% in our most recent series.

Future studies

At present, there are no high-quality studies available to determine whether a laparoscopic approach should be preferred over an open approach to jejunostomy placement. However, a recent retrospective study suggested that laparoscopic jejunostomy placement has lower overall morbidity when compared to a mini-laparotomy approach (20.8% *vs.* 10.5%) (26). Furthermore, multiple laparoscopic techniques have been suggested. In a case series of 206 patients, a laparoscopic double semi purse-string suturing technique for jejunostomy placement was reported to have acceptable overall morbidity (16.5%) with only 1 event of intestinal torsion (0.5%) (27). Although their technique has similarities to our currently reported purse-string technique, no antirotation sutures were placed. Future studies are required to adequately compare laparoscopic versus open jejunostomy placement techniques and to further evaluate the clinical role of antirotation sutures.

Conclusions

Minimally invasive surgery, either robotically or laparoscopically, allows the surgeon a clear overview of both the jejunum and the anterior abdominal, which facilitates the placement of a jejunostomy that is additionally fixated to the anterior abdominal wall to reduce the risk of intestinal torsion. This study showed that the presented technique was safe for patients undergoing esophagectomy in this study. No short-term intestinal torsions at the jejunostomy site were found and only infectious complications occurred, which could be successfully managed without a re-operation in the majority of cases. Pre-existent comorbidity, and diabetes in particular, were significantly associated with the incidence of jejunostomy-related complications. Based on these results, the current technique may be advisable to establish the enteral feeding route in MIE.

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Footnote

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Ethical Statement: The authors are accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved. This study was performed in accordance with the Declaration of Helsinki (as revised in 2013). The institutional reviews boards of the participating centers approved this study and the need for written informed consent was waived because of the retrospective study design and use of anonymized data.

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