



# Morbidity after transanal endoscopic microsurgery: risk factors for postoperative complications and the design of a 1-day surgery program

Xavier Serra-Aracil<sup>1</sup> · Maritxell Labró-Ciurans<sup>1</sup> · Pere Rebasá<sup>1</sup> · Laura Mora-López<sup>1</sup> · Anna Pallisera-Lloveras<sup>1</sup> · Sheila Serra-Pla<sup>1</sup> · Raquel Gracia-Roman<sup>1</sup> · Salvador Navarro-Soto<sup>1</sup>

Received: 28 March 2018 / Accepted: 5 September 2018 / Published online: 10 September 2018  
© Springer Science+Business Media, LLC, part of Springer Nature 2018

## Abstract

**Background** Transanal endoscopic microsurgery (TEM) is a minimally invasive procedure with low morbidity. The definition of risk factors for postoperative complications would help to identify the patients likely to require more care and surveillance in an ambulatory or 1-day surgery (A-OdS) program. The main endpoints are overall 30-day morbidity and relevant morbidity. The secondary objectives are to detect risk factors for complications, rehospitalization, and the time of occurrence of the postoperative complications, and to describe the adverse effects following hospitalization that the A-OdS program would avoid.

**Methods** This is an observational study of consecutive patients undergoing TEM between June 2004 and December 2016. Overall and relevant morbidity based on the Clavien–Dindo (Cl–D) classification were recorded, as were demographic, preoperative, surgical, and pathology variables. Univariate and multivariate analyses of the risk factors were carried out.

**Results** Six hundred and ninety patients underwent surgery, of whom 639 were included in the study. Overall morbidity rate was 151/639 patients (23.6%); the clinically relevant morbidity rate was 36/639 (Cl–D > II) (5.6%) and mortality 2/639 (0.3%). The most frequent complication was rectal bleeding, recorded in 16.9% (108/639 patients) and grade I in 86/108 patients (78.9%). The period with the greatest risk of complications was the first 2 days. The rehospitalization rate after 48 h was 7%. The risk factors for complications were as follows: tumor size > 6 cm (OR 3.2, 95% CI 1.3–7.8), anti-platelet medication (OR 2.3, 95% CI 1.1–5.1), and surgeon's experience < 150 procedures (OR 2.0, 95% CI 1–4.1).

**Conclusions** TEM is a safe procedure. The low rates of morbidity, re-hospitalization, and postoperative complications in the first 2 days after surgery make the procedure suitable for A-OdS.

**Keywords** TEM · Morbidity · Risk factors · 1-day surgery

Total mesorectum excision (TME) is the conventional surgical treatment for rectal cancer [1]. This technique controls the disease, but it is associated with substantial postoperative morbidity and mortality and also with genitourinary alterations [2]. The median hospital stay is 8 days in laparoscopic surgery and 9 days in open surgery [3]. Rectal tumors such as adenomas and early rectal cancers can be treated with

local surgery, a technique that achieves lower postoperative morbidity and mortality rates [4].

Transanal endoscopic microsurgery (TEM), described by Buess et al. [5] in the 1980s, allows the treatment of tumors up to 20 cm from the anal verge. With the creation of a pneumorectum, the margins of the lesion can be accurately defined. More recently, transanal endoscopic operation (TEO) [6], which incorporates a high-definition monitor, and TransAnal Minimally Invasive Surgery (TAMIS) [7] with a single port system have simplified the technique and the equipment required.

The application of strict selection criteria and a clearly defined surgical technique achieves good outcomes in terms of postoperative morbidity and mortality, function, and curability. Given that TEM is a minimally invasive procedure

✉ Xavier Serra-Aracil  
xserraa@gmail.com

<sup>1</sup> Coloproctology Unit, General and Digestive Surgery Service, Parc Tauli University Hospital, Sabadell, Universitat Autònoma de Barcelona, Parc Tauli s/n, 08208 Sabadell, Barcelona, Spain

with low morbidity, an ambulatory or 1-day surgery (A-OdS) program is a possibility in these patients. Defining the risk factors for postoperative complications would allow us to identify patients likely to require more care and surveillance in an ambulatory or 1-day surgery (A-OdS) program. Few studies to date have assessed TEM in an outpatient regimen or have identified risk factors for postoperative complications [8, 9].

The main endpoints of the study were overall 30-day morbidity according to the Clavien–Dindo classification (Cl–D) [10] and relevant morbidity (defined as Cl–D > II). Secondary objectives were as follows: to detect risk factors related to postoperative complications (POC), rehospitalization, and the time of occurrence of the POC, and to describe the adverse effects following hospitalization that the A-OdS program would avoid.

## Materials and methods

### Study design

This is an observational study with prospective data recording in consecutive patients undergoing TEM.

### Patients

All the patients were operated upon by five surgeons at the Coloproctology Unit of our center between June 2004 and December 2016. The patients who were candidates for TEM underwent preoperative examination following the previously described protocol [11]. They were classified into five groups according to preoperative indication: group I with curative intention (benign tumors, which after ultrasound (u) and magnetic resonance imaging (MRI) were staged as u-MRI T0-1 and u-MRI N0); group II, with curative intent (low-grade adenocarcinomas, u-MRI T0-1 and u-MRI N0); group III, consensus indication (low-grade adenocarcinomas, u-MRI T2 and u-MRI N0, who reject radical surgery); group IV, palliative indication; and group V, atypical indications [12].

### Inclusion criteria

Patients in preoperative indication groups I to IV undergoing TEM during the recruitment period.

### Exclusion criteria

Patients in group V (atypical indications); in many cases, these patients undergo surgical treatments that are not directly related to tumor excision.

## Patient preparation and TEM surgical technique

Preoperative preparation was carried out in accordance with the protocol [11]. Antibiotic prophylaxis (ceftriaxone 1 g/iv and metronidazole 500 mg/iv 30 min before surgery) and thromboembolic prophylaxis (enoxaparin 40 mg/subcutaneous). Anesthesia was mainly general, unless the anesthesiologist decided that spinal anesthesia was feasible. The techniques used for the local excision were either TEM (Richard Wolf, Knittlingen, Germany) or TEO (Karl Storz GmbH, Tuttlingen, Germany) [6]. As per protocol, full-thickness total excision of the rectal wall was performed with suture of the defect [11]. Diet was then started and the patient was mobilized the next day, being discharged between the second and third days post-surgery. In view of the results obtained, in the last 2 years oral tolerance and mobilization have been started 6–8 h after surgery and patients have been discharged at 24–48 h.

Postoperative morbidity was assessed at an outpatient visit 30 days after surgery. Subsequently, patients followed a specific protocol depending on the definitive pathology [11].

### Main variable

Overall 30-day morbidity according to the Cl–D [8] and clinically relevant morbidity (defined when the POC was Cl–D > II, i.e., IIIa, IIIb, IVa, IVb, or V).

## Study variables and morbidity risk factors

### Preoperative: demographic, patient-related, and tumor-related

Patients receiving anti-platelet medication abandoned this treatment one week before surgery and were administered acetylsalicylic acid 100 mg/day during the hospital stay. Patients treated with anticoagulants changed to a heparin protocol.

Tumor size was based on a similar Scala et al.'s classification which defines rectal tumors as small when < 3 cm in diameter, large when 3–6 cm and giant when > 6 cm [13].

Surgeons' experience: following Barendse et al. [14], surgeon 1 was the one with the most experience, with > 150 cases; surgeons 2, 3, and 4 had average experience (35–150 cases) and surgeon 5 had the least experience (< 35 cases).

Postoperative variables: 30-day morbidity and mortality (Cl–D). Comprehensive Complication Index (CCI) score [15] an “index based on the Cl–D classification which summarizes the postoperative course with a new morbidity scale ranging from 0 (no complication) to 100 (death)”. Morbidity not associated with TEM but associated with hospitalization;

the day of appearance of the first complication, and hospital re-admission (hospitalization or observation in the emergency room for more than 24 h).

Rectal bleeding, the main POC, was defined as more than 100 ml of red blood from the anus evaluated by the nurse, or a similar amount in the toilet bowl that cannot be quantified. If the patient returned to the hospital's emergency department, rectal bleeding was tested and evaluated in the same way.

Since January 2005, the morbidity of all patients admitted to both the Colorectal Unit and the Department of General and Digestive Surgery has been prospectively recorded. The assessment of adverse effects is peer-reviewed [16]. The present study was approved by the Local Institutional Ethics Committee (CEIC: 2016-636), and complied with the criteria of the Declaration of Helsinki. The STROBE guidelines for observational studies were followed.

### Statistical methods

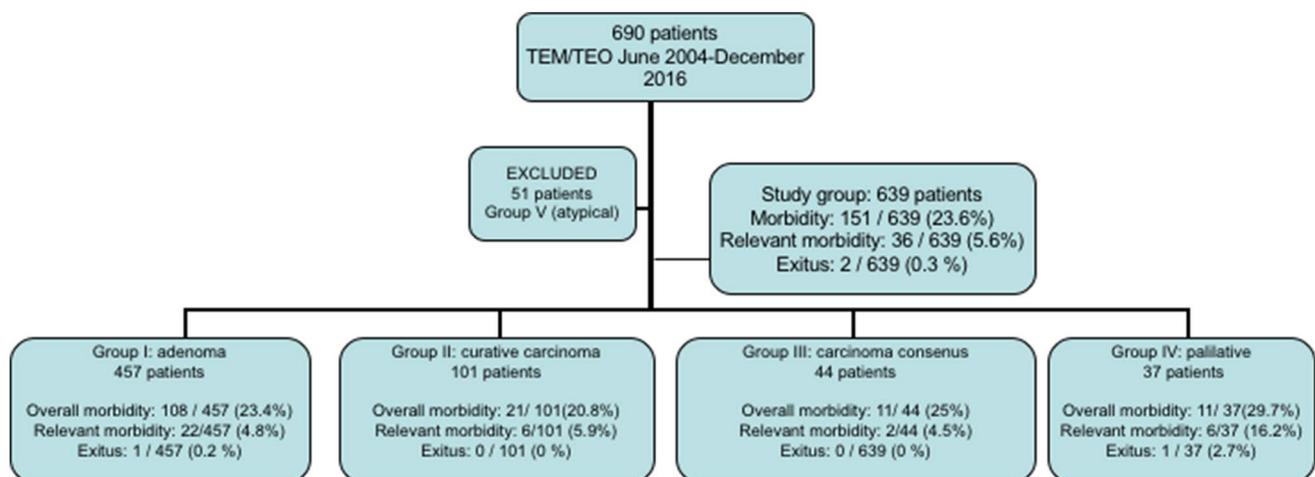
The SPSS program version 23 was used. Due to the prospective nature of the data collection, no values were missing. In the description of the quantitative variables, the values of the mean and standard deviation or median and interquartile range (IQR) were given when the normality conditions were not met. The categorical variables were presented as absolute numbers and percentages. The univariate statistical analysis of the quantitative variables, with independent groups, was carried out using the Student's *t* test provided that its conditions of application were met; otherwise the Mann–Whitney U or Kruskal–Wallis test was applied. For categorical variables, Pearson's  $\chi^2$  test or Fisher's exact test was used, depending on the conditions. A *p* value < 0.05 was considered statistically significant, with a confidence interval of 95%.

Statistically significant variables, or those with a trend toward significance ( $p < 0.2$ ), were introduced in the multivariate analysis of relevant morbidity. Logistic regression analysis was used to identify predictors of relevant morbidity.

### Results

During the study period, 690 patients underwent TEM. Fifty-one patients with atypical indications were excluded. Figure 1 shows the patients included (639) distributed according to their preoperative indication group. The overall morbidity rate was 23.6% (151/639 patients), the relevant morbidity rate 5.6% (36/639) and the mortality rate 0.3% (2/639). The two deaths were a 54-year-old cirrhotic male awaiting liver transplantation who underwent surgery for a large villous adenoma (preoperative group I); he had no POC related to the surgery, but in the third postoperative week developed a digestive hemorrhage due to angiodysplasia of the right colon, coagulopathy and leading to death. The other case was an 82-year-old patient with high comorbidity and rectal adenocarcinoma stage T2 with palliative indication (group IV), who presented septic shock due to fecaloid peritonitis following an inadvertent intraperitoneal perforation, leading to multi-organ failure and death.

Table 1 shows the descriptive analysis of the series. Serious complications (CI–D III to V) occurred in only 36 patients (5.6%). Fifteen patients out of 639 (2.34%) had morbidity stage IIIb; of these, seven were re-operated with TEM for rectal bleeding. One patient was converted to abdominal surgery due to technical difficulties. In two patients with suspicion of inadvertent perforation due to massive pneumoperitoneum and abdominal pain, a laparotomy was performed which did not reveal pathology (one of them had a loop colostomy). Two



**Fig. 1** Patients' flow chart. Relevant morbidity: CI–D > II (IIIa, IIIb, IVa, IVb, V)

**Table 1** Descriptive analysis of 639 patients (indication groups I–IV)

Variables		Result (n = 639)	
Demographic. Preoperative	Age (median-IQRs-range)	71 years (IQR 16 years)(31–92 years)	
	Sex	Male	389 (60.9%)
		Female	250 (39.1%)
	ASA	I	20 (3.1%)
		II	332 (52.0%)
III		231 (36.2%)	
IV		56 (8.8%)	
Tumor-related	Distance from anal verge (median-IQR-range)	7 cm (IQR 5 cm) (2–22 cm)	
	Size (median-IQRs-range)	4 cm (IQR 2 cm) (1–12 cm)	
	Location by quadrant	Anterior	167 (26.1%)
		Left lateral	164 (25.7%)
Posterior		181 (28.3%)	
Right lateral		127 (19.9%)	
Surgical	Surgical time (median-IQRs-range)	70 min (IQR 50 min) (265–20 min)	
	Peritoneal perforation	45 (7.0%)	
	Conversion to open surgery	1 (0.2%)	
	Type of anesthetic	General	576 (90.1%)
		Local	63 (9.9%)
	Full-thickness wall excision	632 (98.9%)	
	Single-piece excision	616 (96.4%)	
	Closure of defect	Complete	556 (87.01%)
		Partial	79 (12.36%)
		None	4 (0.63%)
Surgeon's experience	> 150 TEM/TEM	308 (48.2%)	
	35–150 TEM/TEO	236 (36.9%)	
	< 35 TEM/TEO	95 (14.9%)	
TEM or TEO	TEM	342(53.5%)	
	TEO	297 (46.3%)	
Postoperative	Hospital stay (median-IQRs-range)	3 days (IQR 2 days) (0–31 days)	
	Overall morbidity	151(23.63%)	
	Clavien–Dindo (Cl–D) classification grade	Cl–D grade I	93/639 (14.6%)
		Cl–D grade II	22/639 (3.4%)
		Cl–D grade IIIa	11/639 (1.7%)
		Cl–D grade IIIb	15/639 (2.3%)
		Cl–D grade IVa	7/639 (1.1%)
		Cl–D grade IVb	1/639 (0.2%)
	Mortality	Cl–D grade V	2/639 (0.3%)
	Overall CCI (median-IQR-range)	0 (IQR 0) (0–100)	
	CCI-patients with morbidity (median-IQR-range)	151 patients	12.2 (IQR 17.52) (8.7–100)
	Clinically relevant morbidity (Cl–D ≥ III)		36 (5.6%)
	Asymptomatic fever post-TEM		57 (8.92%)
Patients readmitted	45 (7.0%)	Cl–D I 25/45 (55.6%)	
		Cl–D II 6/45 (13.3%)	
		Cl–D IIIa 7/45 (15.6%)	
		Cl–D IIIb 5/45 (11.1%)	
		Cl–D IVa 2/45 (4.4%)	
		Cl–D IVb 0/45 (0%)	
Definitive pathology	Adenoma	382 (59.78%)	
	Adenocarcinoma	212 (33.18%)	
	None pathology	45 (7.04%)	

**Table 1** (continued)

Variables	Result (n = 639)
Affected margins	42 (6.57%)

*IQRs* interquartile ranges, *Cl–D* Clavien–Dindo, *CCI* Comprehensive Complication Index, *ASA* American Society of Anesthesiologists

patients had perianal abscesses, one of which required three debridements and subsequent colostomy. Three patients presented recto-vaginal fistulas which were treated by colostomy and subsequent repair. Seven presented stage IVa complications: two rectal bleeding and hemodynamic instability, three cardiac decompensations, one stroke, and another who could not be extubated due to bronchospasm. One patient with grade IVb had shock due to heart failure following atrial fibrillation.

The CCI, which reflects the relative importance of the complications of a procedure, presented a median score of 0 (IQR 0). Assessing only those patients who presented complications, the CCI was 12.2 (IQR 17.52). An effect rarely reported in previous studies is the presence of asymptomatic fever in the immediate postoperative period (day 1 or 2): we recorded this in 57 of the patients (8.92%). Forty-five patients (7%) were readmitted to hospital.

Table 2 divides the 214 complications recorded in the study according to type. The most frequent POC was rectal bleeding, recorded in 108 patients (129 episodes/214, 60.3%), which was grade I in 86 patients (78.9%), grade II in two (1.8%), grade IIIa in ten (9.2%), grade IIIb in eight (7.3%), and grade IVa in two (1.8%). Urinary morbidity was recorded in 27 of 639 patients (7.3%), accounting for 23 of the 214 POC (10.7%). Seventy-five patients (11.7%) suffered POC which we attributed to their being hospitalized.

Figure 2 shows the risk of appearance of complications according to postoperative day. Although most of the complications appeared during the first 2 days, a non-negligible risk persisted between 7 and 11 days.

Table 3 displays the univariate analysis of all possible factors related to overall and relevant morbidity. The ASA classification, surgical time, and surgeon's experience presented statistically significant differences in both types of morbidity.

After the multivariate analysis including all the variables with significance < 0.2 for relevant morbidity, the predictors obtained were as follows: tumor size > 6 cm (OR 3.2, 95% CI 1.3–7.8), previous anti-platelet medication (OR 2.3, 95% CI 1.1–5.1) and surgeon's experience < 150 (OR 2, 95% CI 1–4.1).

## Discussion

TEM achieves oncological results comparable to those of TME in the treatment of selected rectal lesions (large adenomas and early rectal cancers [17, 18]). The overall

morbidity figures for TEM range between 7.7 and 31.4% [8, 19], depending on the criteria used to record the complications. In our study, in which complications were recorded prospectively, we found a rate of 23.64%, graded according to the Cl–D classification [8]. More than half of these complications did not require more than simple observation (Cl–D grade I), and clinically relevant morbidity (Cl–D > II) was recorded in only 5.6% of patients. In descriptions and comparisons of morbidity, it is important that studies should apply the same criteria, and the Cl–D classification makes this possible [20].

The CCI [15] facilitates comparisons of patients with more than one complication, since its algorithm includes all postoperative events and their respective grades of severity [21]. As we have seen, TEM is a procedure associated with low morbidity. We do not know of any previous reports of TEM morbidity in relation to the CCI. We confirmed that as a minimally invasive procedure, the global median of the TEM series is 0 (IQR 0). Assessing the CCI only in patients with morbidity, the index remained low (median 12.2, IQR 17.52).

With regard to the techniques used for local exeresis, in classical endoanal resection (ER) complications are infrequent. The main drawbacks are the poor surgical results in comparison to TEM, such as free margins (71% in ER vs. 90% in TEM) and single-piece excision (65% of ER vs. 94% of TEM) [22]. In our study, we reported a free margin rate of 93.4% and a single-piece excision rate of 96.4%. A randomized study by our group demonstrated similar efficacy using TEM and TEO [23].

The most frequent complications after TEM are of urinary origin or rectal bleeding. In some studies, urinary morbidity was the most frequent, with rates between 5.9 and 10.8% [4, 24]. In the present study, urinary morbidity was recorded in 7.3% of patients. In the event of rectal bleeding, we adopt a wait-and-see approach; if it persists, we perform endoscopic control (as occurred in ten patients, 9%); if it does not resolve, we reoperate, again using TEM (nine patients, 8.1%). In our study, none of these patients required abdominal surgery. Other series also describe rectal bleeding as the most frequent complication, with rates between 27% [14], 14% [25] and a rate of 9% using TAMIS [20].

Postoperative asymptomatic fever in TEM is defined as fever that appears in the first 24–48 h without other symptoms or focus, and reaching a figure as high as 39 °C. In our study, 57 patients (8.92%) presented postoperative

**Table 2** Description of complications related to TEM

Total no. of patients with complications related to surgery	151/639 (23.63%)
No. of surgical complications detected	214
Rectal bleeding	129/214 (60.3%)
Urinary complications	34/214 (15.9%)
AUR	19/214 (8.9%)
UTI	8/214 (3.7%)
Hematuria and traumatic urine catheter insertion	5/214 (2.3%)
Infectious complications	23/214 (10.7%)
Abscess	8/214 (3.7%)
Pneumoperitoneum/retropneumoperitoneum/pneumomediastinum	4/214 (1.9%)
Recto-vaginal fistula	5/214 (2.3%)
Other	7/214 (3.3%)
Cardiac complication	11/214 (5.1%)
Heart arrhythmia	4/214 (1.9%)
Heart failure or ALE	6/214 (2.8%)
Shock of unknown origin	1/214 (0.5%)
Respiratory complication	7/214 (3.3%)
Bronchospasm	2/214 (0.1%)
Pneumonia	2/214 (0.1%)
Others	3/214 (1.4%)
Pain levels above normal	3/214 (1.4%)
Others	7/214 (3.3%)
Total no. of patients with complications due to hospitalization	75/639 (11.7%)
Total complications due to hospitalization	94
Clinically relevant hospital morbidity <sup>a</sup>	4/639 (0.63%)
Catheter extravasation	46/94 (48.9%)
Phlebitis	27/94 (28.7%)
Reaction to medication	12/94 (12.8%)
Falls	4/94 (4.3%)
Delirium	1/94 (1.1%)
Stage 1 sacral ulcer	1/94 (1.1%)
Vomiting	2/94 (2.1%)
Hydroelectrolytic alteration	1/94 (1.1%)

AUR acute urine retention, UTI urinary tract infection, ALE acute lung edema

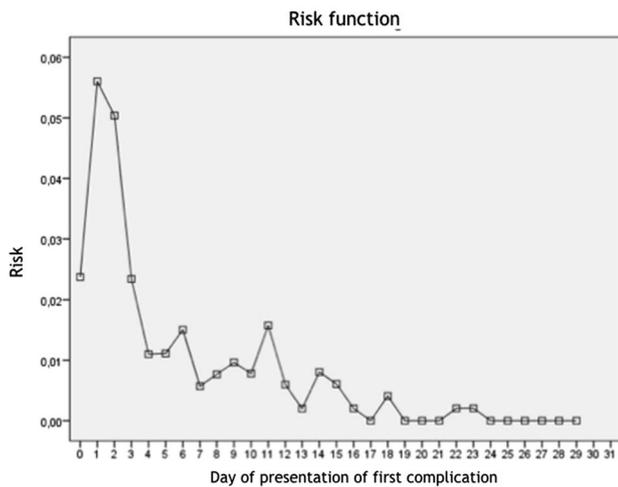
<sup>a</sup>Cl–D grade 2 or more

asymptomatic fever; the fever was not associated with leukocytosis or abdominal or pelvic pain, and reverted with antipyretics. A more complex situation is the association of fever with abdominal pain and leukocytosis, which has been termed post-TEM syndrome [26]. In two patients in our study, this complication obliged us to perform exploratory laparotomies which did not reveal pathology.

Some studies report the dehiscence of the suture of the defect after TEM [8, 24]. In our study, we do not record this event because we do not consider it to be clinically relevant; nevertheless, its consequences (usually rectal bleeding or suppuration) should be monitored. Intraoperative blood loss is usually one of the factors considered in relation to

postoperative morbidity. In TEM, due to the use of the ultrasonic scalpel bleeding is uncommon, and the median blood loss does not surpass 10 ml [27].

The low morbidity associated with TEM makes it possible to reduce post-surgery hospital stay. However, few studies have reported results with short hospital stay (i.e., ambulatory or 24 h). One study achieved discharge on the same day as surgery in 80% of 175 patients [8]; in another, 46 of 96 patients (48%) were treated on an outpatient basis and 24 (25%) had a stay of 23 h [9]. It is important to establish the risk factors for postoperative complications of TEM in order to ensure the reliability and safety of these early discharge programs. In our study, we analyzed all the possible



**Fig. 2** Function of risk of appearance of the first complication

factors related to morbidity from the point of view of the patient's characteristics, rectal tumor, surgical technique, and surgeon's experience (Table 3).

The predictive factors found after the multivariate analysis were anti-platelet medication, lesion size > 6 cm and lesser experience of the surgeon. Some studies have associated age, duration of surgery and lesions of more than 5.7 cm in size with increased hospital stay [9]. Others report that lateral location, lesions > 2 cm and distance > 8 cm from the anal verge are related to higher overall morbidity and the appearance of rectal bleeding [28] but others do not find any predictors of morbidity [25].

The experience of the surgeon has already been described as an independent factor in the results obtained with various colorectal surgeries [29]. In TEM, a surgeon is considered an expert after 35 procedures [14]. In our study, we differentiate between non-expert surgeons (fewer than 35 procedures, but supervised by an expert surgeon), expert surgeon (over 35 procedures), and highly expert surgeon (over 150 procedures). The highly expert surgeon obtained the best results and surgeon's experience emerged as an independent factor of protection against morbidity.

We have not found any previous studies in the literature that have focused on the day of appearance of complications. Initially, we thought that a considerable proportion of the complications occurred after hospital discharge. As shown in Fig. 2, although the majority appear in the first 24–48 h, the risk of complications between 7 and 11 days is not negligible. However, relevant morbidity is low (5.6%) and the re-admission to hospital after a hospital stay of 3 days is also low (7%). All these features allow us to include this procedure in an A-OdS program.

Based on our results, we recommend that patients who do not present any risk factors for overall or relevant morbidity should be included in the ambulatory program, and the rest in the 1-day surgery program. With the relevant morbidity rate of 5.6% and the re-admission rate of 7%, we do not favor prolonged preventive hospitalization but prefer to perform home controls in the patients at highest risk.

The limitations of the study are those inherent in observational studies. Its single-center design and the fact that almost all the surgeons are experts in TEM may reduce its external validity.

Among the study's strong points are its inclusion of one of the most extensive series of TEM described in the literature, and the prospective nature of data collection, which means that no values were lost. The study was conducted by the same team of expert surgeons and used the same patient selection protocol, preoperative preparation, surgical technique and morbidity classification with the CI–D and CCI classifications.

## Conclusions

The morbidity and mortality rates associated with TEM are low, especially clinically relevant morbidity (CI–D grade > II). Rectal bleeding is the most frequent POC, it is always important, but only rarely of clinical importance. The low rates of re-hospitalization and appearance of POCs within 48 h of surgery make the procedure suitable for A-OdS.

**Table 3** Univariate analysis of risk factors in overall and relevant morbidity

	No morbidity ( <i>n</i> = 488)	Overall morbidity ( <i>n</i> = 151)	<i>p</i> value	No morbidity ( <i>n</i> = 605)	Relevant morbidity ( <i>n</i> = 36)	<i>p</i> value
<b>Sex</b>						
Male	289 (74.3%)	100 (25.7%)	0.128 <sup>a</sup>	370 (95.1%)	19 (4.9%)	0.38 <sup>b</sup>
Female	199 (79.6%)	51 (20.4%)		233(93.2%)	17(6.8%)	
<b>Age</b>						
< 60 years	111 (79.9%)	28 (20.1%)	<b>0.038<sup>b</sup></b>	132 (95%)	7 (5%)	0.752 <sup>a</sup>
60–80 years	301 (77.8%)	86 (22.2%)		366 (94.6%)	21 (5.4%)	
> 80 years	76 (67.3%)	37 (32.7%)		105 (92.9%)	8 (7.1%)	
<b>Indication group</b>						
I: curative. Adenoma	349 (76.4%)	108 (23.6%)	0.739 <sup>b</sup>	435 (95.2%)	22 (4.8%)	<b>0.037<sup>a</sup></b>
II: curative. Carcinoma	80 (79.2%)	21 (20.8%)		95 (94.1%)	6 (5.9%)	
III: consensus. Carcinoma	33 (75.0%)	11 (25.0%)		42 (95.5%)	2 (5.5%)	
IV: palliative. Carcinoma	26 (70.3%)	11 (29.7%)		31 (83.8%)	6 (16.2%)	
<b>ASA</b>						
IV	35 (62.5%)	21 (37.5%)	<b>0.032<sup>b</sup></b>	47 (83.9%)	9 (16.1%)	<b>0.005<sup>a</sup></b>
III	172 (74.5%)	59 (25.5%)		219 (94.8%)	12 (5.2%)	
II	265 (79.8%)	67 (20.2%)		318 (95.8%)	14 (4.2%)	
I	16 (80%)	4 (20%)		19 (95%)	1 (5%)	
<b>Anticoagulants</b>						
Yes	31 (72.1%)	12 (27.9%)	0.463 <sup>a</sup>	39 (90.7%)	4(9.3%)	0.293 <sup>b</sup>
No	457 (76.7%)	139 (23.3%)		564 (94.6%)	32 (5.4%)	
<b>Anti-platelet medication</b>						
Yes	67 (65.0%)	36 (35.0%)	<b>0.005<sup>a</sup></b>	93 (90.3%)	10 (9.7%)	0.061 <sup>b</sup>
No	421 (78.5%)	115 (21.5%)		510 (95.1%)	26 (4.9%)	
<b>HBP</b>						
Yes	225 (74.5%)	77 (25.5%)	0.306 <sup>a</sup>	283 (93.7%)	19 (6.3%)	0.499 <sup>b</sup>
No	263 (78.0%)	74 (22.0%)		320 (95%)	17 (5%)	
<b>Diabetes mellitus</b>						
Yes	81 (73.0%)	30 (27.0%)	0.390 <sup>a</sup>	107 (96.4%)	4 (3.6%)	0.373 <sup>b</sup>
No	407 (77.1%)	121 (22.9%)		496 (93.9%)	32 (6.1%)	
<b>Heart disease</b>						
Yes	90 (69.8%)	39 (30.2%)	0.063 <sup>a</sup>	117 (90.7%)	12 (9.3%)	0.054 <sup>b</sup>
No	398 (78.0%)	112 (22.0%)		486 (95.3%)	24 (4.7%)	
<b>Lung disease</b>						
Yes	111 (77.1%)	33 (22.9%)	0.911 <sup>a</sup>	137 (95.1%)	7 (4.9%)	0.837 <sup>b</sup>
No	377 (76.2%)	118 (23.8%)		466 (94.1%)	29 (5.9%)	
<b>Hematological disease</b>						
Yes	4 (50.0%)	4 (50.0%)	0.094 <sup>a</sup>	7 (87.5%)	1 (12.5%)	0.373 <sup>b</sup>
No	484 (76.4%)	147 (23.3%)		596 (94.5%)	35 (5.5%)	
<b>Chronic kidney failure</b>						
Yes	24 (77.4%)	7 (22.6%)	> 0.99 <sup>a</sup>	29 (93.5%)	2 (6.5%)	0.691 <sup>b</sup>
No	464 (76.3%)	144 (23.7%)		574 (94.4%)	34 (5.6%)	
<b>Distance from anal verge</b>						
High > 12 cm	43 (87.8%)	6 (12.2%)	<b>0.005<sup>b</sup></b>	47 (95.9%)	2 (4.1%)	0.132 <sup>c</sup>
Medium 6–12 cm	242 (79.2%)	61 (20.1%)		291 (96%)	12 (4%)	
Low < 6 cm	203 (70.7%)	84 (29.3%)		265 (92.3%)	22 (7.7)	
<b>Tumor size</b>						
Large > 6 cm	34 (64.2%)	19 (35.8%)	0.060 <sup>b</sup>	46 (86.8%)	7 (13.2%)	<b>0.029<sup>c</sup></b>
Medium 3–6 cm	286 (76.3%)	89(23.7%)		354 (94.4%)	21 (5.6%)	
Small < 3 cm	168 (79.6%)	43 (20.4%)		203 (96.2%)	8 (3.8%)	

**Table 3** (continued)

	No morbidity ( <i>n</i> = 488)	Overall morbidity ( <i>n</i> = 151)	<i>p</i> value	No morbidity ( <i>n</i> = 605)	Relevant morbidity ( <i>n</i> = 36)	<i>p</i> value
<b>Location</b>						
Right and left lateral	220(75.6%)	71 (24.4%)	<b>0.006<sup>a</sup></b>	275 (94.5%)	16 (5.5%)	<b>0.122<sup>c</sup></b>
Anterior	116 (69.5%)	51 (30.5%)		153 (91.6%)	14 (8.4%)	
Posterior	152 (84.0%)	29 (16.0%)		175 (96.7%)	6 (3.3%)	
<b>Anesthetic</b>						
Loco-regional	48 (76.2%)	15 (23.8%)	> 0.99 <sup>a</sup>	60 (95.2%)	3 (4.8%)	> 0.99 <sup>b</sup>
General	440 (76.4%)	136 (23.6%)		543 (94.3%)	33 (5.7%)	
<b>TEM or TEO</b>						
TEM	274 (79.9%)	69 (20.1%)	<b>0.024<sup>b</sup></b>	323 (94.4%)	19 (5.6%)	0.965 <sup>a</sup>
TEO	214 (72.3%)	82 (27.7%)		279 (94.3%)	17 (5.7%)	
<b>Suture of defect</b>						
No suture	3 (75.0%)	1 (25.0%)	0.189 <sup>b</sup>	3 (75%)	1 (25%)	0.093
Partial suture	53 (67.1%)	26 (32.9%)		72 (91.1%)	7 (8.9%)	
Complete suture	432 (77.7%)	124 (22.3%)		528 (95%)	28 (5%)	
<b>Peritoneal perforation</b>						
Yes	34 (75.6%)	11 (24.4%)	0.857 <sup>a</sup>	39 (88.6%)	5 (11.4%)	0.093 <sup>a</sup>
No	454 (76.4%)	140 (23.6%)		564 (94.8%)	31 (5.2%)	
<b>Surgical time</b>						
Long > 120'	58 (66.7%)	29 (33.3%)	<b>0.001<sup>b</sup></b>	79 (90.8%)	8 (9.2%)	<b>0.012</b>
Medium 60–120'	218 (73.2%)	80 (26.8%)		276 (92.6%)	22 (7.4%)	
Short < 60'	212 (83.5%)	42 (16.5%)		248 (97.6%)	6 (2.4%)	
<b>Surgeon's experience</b>						
> 150 TEM/TEM	255 (82.8%)	53 (17.2%)	<b>0.001<sup>a</sup></b>	296 (96.4%)	12 (3.6%)	<b>0.017<sup>a</sup></b>
35–150 TEM/TEO	90 (71.4%)	36 (28.6%)		112 (89.7%)	14 (10.3%)	
< 35 TEM/TEO	143 (69.8%)	62(30.2%)		195 (95.1%)	10 (4.9%)	

Statistically significant values ( $p < 0.05$ ) are given in bold

TEO transanal endoscopic operation, HBP high blood pressure, CRT chemoradiotherapy, IQR interquartile range, ASA American Society of Anesthesiologists Classification. Relevant morbidity: Clavien–Dindo > II (IIIa, IIIb, IVa, IVb, V)

<sup>a</sup>Fisher's exact statistic. Bilateral exact significance

<sup>b</sup>Pearson's chi-squared

<sup>c</sup>Linear association

**Acknowledgements** We thank the rest of the members of the Coloproctology Unit for applying the study protocol. We thank Cristina Gomez Vigo for correcting the manuscript and Michael Maudsley for helping with the English.

**Author contributions** All the authors agree to the submission of the paper. All the authors contributed to the design and writing of the paper.

### Compliance with ethical standards

**Disclosures** Xavier Serra-Aracil X, Maritxell Labró-Ciurans, Pere Rebas, Laura Mora-López, Anna Pallisera, Sheila Serra-Pla, Raquel Gracia-Roman, and Salvador Navarro-Soto have no conflicts of interest or financial ties to disclose.

### References

1. Heald RJ, Ryall RDH (1986) Recurrence and survival after total mesorectal excision for rectal cancer. *Lancet* 1:1479–1482
2. Law WL, Chu KW (2004) Anterior resection for rectal cancer with mesorectal excision: a prospective evaluation of 622 patients. *Ann Surg* 240:260–268
3. van der Pas MH, Haglind E, Cuesta MA, Fürst A, Lacy AM, Hop WC, Bonjer HJ, COlorectal cancer Laparoscopic or Open Resection II (COLOR II) Study Group (2013) COlorectal cancer Laparoscopic or Open Resection II (COLOR II) Study Group. Laparoscopic versus open surgery for rectal cancer (COLOR II): short-term outcomes of a randomised, phase 3 trial. *Lancet Oncol* 14:210–218
4. Kumar AS, Coralic J, Kelleher DC, Sidani S, Kolli K, Smith LE (2013) Complications of transanal endoscopic microsurgery are rare and minor: a single institution's analysis and comparison to existing data. *Dis Colon Rectum* 56:295–300

5. Buess G, Theiss R, Günther M, Hutterer F, Pichlmaier H (1985) Transanal endoscopic microsurgery. *Leber Magen Darm* 15:271–279
6. Rocha JJ, Feres O (2008) Transanal endoscopic operation: a new proposal. *Acta Cir Bras* 23(Suppl 1):93–104 (**discussion 104**)
7. Atallah S, Albert M, Larach S (2010) Transanal minimally invasive surgery: a giant leap forward. *Surg Endosc* 24:2200–2205
8. Laliberte AS, Lebrun A, Drolet S, Bouchard P, Bouchard A (2015) Transanal endoscopic microsurgery as an outpatient procedure is feasible and safe. *Surg Endosc* 29:3454–3459
9. Ford SJ, Wheeler JM, Borley NR (2010) Factors influencing selection for a day-case or 23-h stay procedure in transanal endoscopic microsurgery. *Br J Surg* 97:410–414
10. Dindo D, Demartines N, Clavien PA (2004) Classification of surgical complications: a new proposal with evaluation in a cohort of 6336 patients and results of a survey. *Ann Surg* 240:205–213
11. Serra-Aracil X, Mora-Lopez L, Alcantara-Moral M, Caro-Tarrago A, Gomez-Diaz CJ, Navarro-Soto S (2014) Transanal endoscopic surgery in rectal cancer. *World J Gastroenterol* 20:11538–11545
12. Serra-Aracil X, Mora-Lopez L, Alcantara-Moral M, Corredera-Cantarín C, Gomez-Diaz C, Navarro-Soto S (2014) Atypical indications for transanal endoscopic microsurgery to avoid major surgery. *Tech Coloproctol* 18:157–164
13. Scala A, Gravante G, Dastur N, Sorge R, Simson JN (2012) Transanal endoscopic microsurgery in small, large, and giant rectal adenomas. *Arch Surg* 147:1093–1100
14. Barendse RM, Dijkgraaf MG, Rolf UR, Bijnen AB, Consten EC, Hoff C, Dekker E, Fockens P, Bemelman WA, de Graaf EJ (2013) Colorectal surgeons' learning curve of transanal endoscopic microsurgery. *Surg Endosc* 27:3591–3602
15. Slankamenac K, Graf R, Barkun J, Puhán MA, Clavien PA (2013) The Comprehensive Complication Index: a novel continuous scale to measure surgical morbidity. *Ann Surg* 258:1–7
16. Rebasa P, Mora L, Luna A, Montmany S, Vallverdú H, Navarro S (2009) Continuous monitoring of adverse events: influence on the quality of care and the incidence of errors in general surgery. *World J Surg* 33:191–198
17. Althumairi AA, Gearhart SL (2015) Local excision for early rectal cancer: transanal endoscopic microsurgery and beyond. *J Gastrointest Oncol* 6:296–306
18. Ramirez JM, Elia M, Cordoba E, Gracia JA, Aguilera V (2016) Current controversies in transanal surgery for rectal cancer. *Surg Laparosc Endosc Percutan Tech* 26:431–438
19. Allaix ME, Arezzo A, Caldart M, Festa F, Morino M (2009) Transanal endoscopic microsurgery for rectal neoplasms: experience of 300 consecutive cases. *Dis Colon Rectum* 52:1831–1836
20. Lee L, Burke JP, deBeche-Adams T, Nassif G, Martin-Perez B, Monson JR, Albert MR, Atallah SB (2017) Transanal minimally invasive surgery for local excision of benign and malignant rectal neoplasia: outcomes from 200 consecutive cases with midterm follow up. *Ann Surg*. <https://doi.org/10.1097/SLA.00000000000002190>
21. Clavien PA, Vetter D, Staiger RD, Slankamenac K, Mehra T, Graf R, Puhán MA (2017) The Comprehensive Complication Index (CCI®): added value and clinical perspectives 3 years “down the line”. *Ann Surg* 265:1045–1050
22. Moore JS, Cataldo PA, Osler T, Hyman NH (2008) Transanal endoscopic microsurgery is more effective than traditional transanal excision for resection of rectal masses. *Dis Colon Rectum* 51:1026–1030 (**discussion 1030–1031**)
23. Serra-Aracil X, Mora-Lopez L, Alcantara-Moral M, Caro-Tarrago A, Navarro-Soto S (2014) Transanal endoscopic microsurgery with 3-D (TEM) or high-definition 2-D transanal endoscopic operation (TEO) for rectal tumors. A prospective, randomized clinical trial. *Int J Colorectal Dis* 29:605–610
24. Tsai BM, Finne CO, Nordenstam JF, Christoforidis D, Madoff RD, Mellgren A (2010) Transanal endoscopic microsurgery resection of rectal tumors: outcomes and recommendations. *Dis Colon Rectum* 53:16–23
25. Restivo A, Zorcolo L, D'Alia G, Cocco F, Cossu A, Scintu F, Casula G (2016) Risk of complications and long-term functional alterations after local excision of rectal tumors with transanal endoscopic microsurgery (TEM). *Int J Colorectal Dis* 31:257–266
26. Brown C, Raval MJ, Phang PT, Karimuddin AA (2017) The surgical defect after transanal endoscopic microsurgery: open versus closed management. *Surg Endosc* 31:1078–1082
27. Darwood RJ, Wheeler JM, Borley NR (2008) Transanal endoscopic microsurgery is a safe and reliable technique even for complex rectal lesions. *Br J Surg* 95(7):915–918
28. Kreissler-Haag D, Schuld J, Lindemann W, König J, Hildebrandt U, Schilling M (2008) Complications after transanal endoscopic microsurgical resection correlate with location of rectal neoplasms. *Surg Endosc* 22:612–616
29. García-Granero E, Navarro F, Cerdán Santacruz C, Frasson M, García-Granero A, Marinello F, Flor-Lorente B, Espí A (2017) Individual surgeon is an independent risk factor for leak after double-stapled colorectal anastomosis: an institutional analysis of 800 patients. *Surgery* 162:1006–1016