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Trans-perineal minimally invasive surgery during laparoscopic abdominoperineal resection for low rectal cancer

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Abstract

Background Laparoscopic abdominoperineal resection (APR) for low rectal cancer (LRC) is performed worldwide. However, APR involves technical difficulties and often causes intractable perineal complications. Therefore, a novel and secure technique during APR is required to overcome these critical issues. Although the usefulness of the endoscopic trans-anal approach has been documented, no series of the endoscopic trans-perineal approach during laparoscopic APR for LRC has been reported.

Methods Trans-perineal minimally invasive surgery (TpMIS) has been used during laparoscopic APR in our institution since April 2014. TpMIS is defined as an endoscopic trans-perineal approach using a single-port device and laparoscopic instruments. In this study, we retrospectively evaluated 50 consecutive patients with LRC who underwent laparoscopic APR at our institution from February 2011 to June 2017 and compared the outcomes of the patients who underwent TpMIS [trans-perineal APR (TpAPR) group, $n=21$] versus the conventional trans-perineal approach (conventional group, $n=29$). We investigated our experiences with TpMIS in detail and evaluated the safety and utility of TpMIS for patients with LRC. Moreover, major features and difficulties of TpMIS were examined from a surgical viewpoint.

Results Intraoperative blood loss (median (range) 55 (10–600) vs. 120 (20–1650) ml) and severe perineal wound infection (Clavien–Dindo grade 3, 0 vs. 5 cases) were significantly lower in the TpAPR than conventional group. TpMIS led to a shortened hospital stay (median (range), 14 (10–74) vs. 23 (10–84) days), and neither mortality nor conversion to open surgery occurred in the TpAPR group.

Conclusions Magnified visualization via endoscopy provided more accurate dissection and less blood loss during surgery. Minimal skin incisions enabled a reduction in postoperative perineal complications, and consequently shortened the hospital stay. TpMIS during laparoscopic APR is safe and beneficial for patients with LRC.

Keywords Rectal cancer · Abdominoperineal resection · Endoscopic trans-perineal approach · Minimally invasive surgery · Laparoscopy · Perineal complication

Multidisciplinary therapy, including surgery, chemotherapy, and radiotherapy, has improved the oncological outcomes of patients with rectal cancer [1–3]. Surgical resection still has a central role as a curative treatment [4–6], although neoadjuvant and/or adjuvant treatments with chemotherapy and/or radiotherapy are also important [7–10]. Abdominoperineal resection (APR), which was first described by Miles in 1908 [11], is a standard surgical procedure for patients with locally advanced low rectal cancer (LRC). The performance of local dissection of the levator ani muscle should be based on tumor extension. Compared with conventional APR, extra-levator APR reduces the risks of an insufficient margin with a tumor remnant and unexpected perforation with exposure of the tumor [12]. Furthermore, the initial introduction and subsequent popularization of total mesorectal excision (TME) for locally advanced LRC have enabled a reduction in the frequency of local recurrence and an inappropriate circumferential resection margin (CRM) [13]. Only an optimal TME with a reliable CRM improves the local recurrence

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rate and cancer-free survival [14]. Therefore, adequate local control is crucial for patients with rectal cancer.

Laparoscopic surgeries for LRC, such as low anterior resection (LAR), intersphincteric resection (ISR), and APR, are performed worldwide, and their safety and feasibility have been described [15]. Compared with conventional open surgery, laparoscopic surgery generally has many advantages, including better cosmesis, less postoperative pain, less operative stress, earlier postoperative recovery, earlier meal ingestion, a shorter hospital stay, and a higher quality of life [15–17]. Several randomized clinical trials and meta-analyses have clearly demonstrated that laparoscopic surgery contributes to both short-term and long-term oncological outcomes in the field of rectal cancer [18–22]. Laparoscopic APR has the advantages of a shorter hospital stay, less postoperative analgesia, faster peristaltic recovery (earlier first flatus), and better urinary function compared with conventional open APR [23, 24].

The endoscopy-assisted distal-to-proximal approach was recently developed for patients with LRC. Furthermore, the safety and feasibility of trans-anal TME have been demonstrated [25–27]. To achieve adequate and reliable TME, the endoscopic trans-anal approach usually combines the standard trans-abdominal approach. Moreover, especially for patients with a narrow pelvis, bulky tumor, or obesity, this technique overcomes technical difficulties that are encountered during LAR and ISR [28]. However, to the best of our knowledge, no series of the endoscopic trans-perineal approach during laparoscopic APR has been reported.

In our institution, trans-perineal minimally invasive surgery (TpMIS) has been used for laparoscopic APR in patients with LRC since April 2014. TpMIS is defined as the endoscopic trans-perineal approach using a single-port device and laparoscopic instruments. In this study, we investigated our own experience with TpMIS in detail, and evaluated the safety and utility of TpMIS for patients with LRC. Moreover, major features and difficulties during TpMIS were examined from a surgical viewpoint.

Patients and methods

Patients

In total, 50 consecutive patients with LRC who underwent laparoscopic APR with or without TpMIS at our institution from February 2011 to June 2017 were retrospectively reviewed in this study. All patients routinely underwent preoperative investigations, including physical examinations, biochemical tests, detailed imaging studies, rectocolonoscopy, and pathological analyses with a cancer marker panel assay. A pathological diagnosis of adenocarcinoma was carefully made by at least two pathologists. The preoperative stage was determined based on colonoscopy, enhanced computed tomography, computed tomography rectocolonography, and magnetic resonance imaging. Based on these findings, a definitive diagnosis of LRC was preoperatively made in all patients. Tumors were classified according to the Japanese classification for LRC in 2013 (i.e., Japanese Classification of Colorectal Carcinoma, 8th edition, Tokyo, Japan) [29].

Although preoperative chemoradiation therapy is the standard treatment for advanced LRC in United States and Europe, it is not considered the first choice for advanced LRC according to the Japanese guideline for LRC (i.e., Japanese Society for Cancer of the Colon and Rectum Guideline, Tokyo, Japan) [30]. Despite this fact, some Japanese institutes have introduced a Western strategy for locally advanced LRC, mainly for local control. We have also introduced neoadjuvant chemotherapy without radiotherapy as a clinical trial to improve oncological outcomes for patients with locally advanced LRC (i.e., cT3/cT4a or cN+ and cM0 status according to the Japanese classification) [31]. The 5-fluorouracil and oxaliplatin regimen combined with bevacizumab or panitumumab was used for this locally advanced population as neoadjuvant chemotherapy based on the K-RAS or All-RAS status. Four to six courses of these chemotherapeutic regimens were performed, with an interval 4–8 weeks from neoadjuvant chemotherapy to elective surgery in each course. Postoperative complications were evaluated according to the Clavien–Dindo classification [32].

The indications for APR are based on our own criteria of tumor and patient factors. In brief, APR is clearly indicated if LRC involves the levator ani muscle or external anal sphincter and/or a distal margin cannot be guaranteed using the sphincter-preserving procedure. ISR may be associated with some severe complications (e.g., anastomotic leakage with fatal outcome or worsened quality of life due to fecal dysfunction). Therefore, factors such as age (≥ 75 years) and performance status (≥ 2) might indicate the need for APR, even in ISR candidates [33].

This study was approved by the Institutional Review Board of our hospital. All patients involved in this study provided written informed consent authorizing the use and disclosure of their protected health information.

Classification

In this study, we defined a laparoscopic trans-abdominal approach with TpMIS as trans-perineal APR (TpAPR). We divided 50 consecutive patients with LRC who underwent laparoscopic APR into two groups based on the surgical procedures performed with or without TpMIS: a laparoscopic trans-abdominal approach with TpMIS (TpAPR group, $n = 21$) and a laparoscopic trans-abdominal approach with

the conventional trans-perineal approach (conventional group, $n = 29$). Since April 2014, almost all patients with LRC who fulfilled our institutional criteria for APR have undergone TpAPR. Actually, TpAPR using two-team approach requires at least two surgical teams and two sets of laparoscopic/endoscopic apparatus. We employ this technique only when surgeons and instruments are available at our hospital. For this reason (i.e., a shortage of surgeons and/or a limitation of laparoscopic/endoscopic apparatus), only four patients in the present study underwent the conventional trans-perineal approach after the introduction of this technique. The transitional annual changes in the numbers of patients in both groups are shown in Fig. 1.

Surgical procedures of TpAPR

Our surgical procedures were previously described in detail elsewhere [28]. The key points are summarized below.

Laparoscopic trans-abdominal approach

The patient was placed in the lithotomy position. The operator initially stood on the right side of the patient. The first assistant and laparoscopist were positioned on the left side and behind the operator, respectively (Fig. 2). After establishment of CO_2 pneumoperitoneum of 8–10 mmHg through the umbilical port, a flexible laparoscope was introduced via the umbilical port, and we used a three-dimensional laparoscopic system (Endoeye Flex 3D, EVIS EXERA III; Olympus, Tokyo, Japan). Four additional operating ports were then placed in the lower abdomen, and proper, stable pneumoperitoneum was maintained during surgery using an air-sealing system (AirSeal System; SurgiQuest, Milford, CT, USA). Medial to lateral mobilization of the left colon

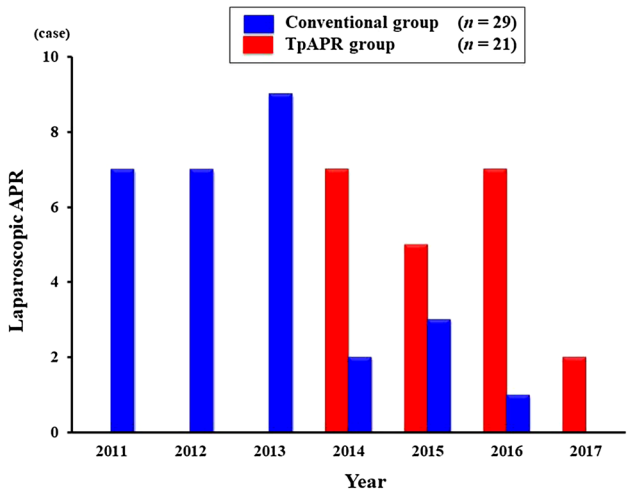

Fig. 1 Transitional changes in our institution. Annual changes in the number of patients in both groups are shown

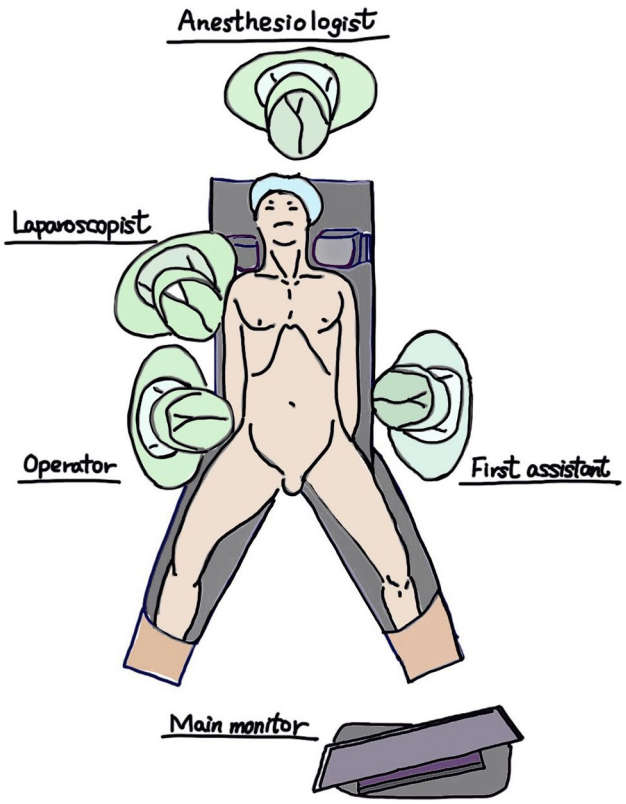

Fig. 2 Positioning of the surgeons during the laparoscopic trans-abdominal approach

was performed as possible. Thereafter, intentional dissection of lymph nodes (LNs) was completed as D3 dissection, which was defined by the Japanese guideline for LRC in 2014 [30], with sacrifice of the inferior mesenteric artery. The left colic artery and inferior mesenteric vein were routinely ligated and then cut at an adequate level for LN dissection. The mesorectal plane was dissected without injury to the autonomic nervous system, and the hypogastric nerves and pelvic plexus were preserved. Following laparoscopic dissection as deep as the coccyx posteriorly and prostate anteriorly, conversion to TpMIS from the laparoscopic trans-abdominal approach was considered. Lateral LN dissection (LLND) was performed laparoscopically for patients with lateral pelvic LN swelling (i.e., LNs with a short-axis diameter of ≥ 5 mm on computed tomography or magnetic resonance imaging). Prophylactic LLND is not routinely performed in our institution. A drainage tube was laparoscopically placed in the pelvic cavity after completion of the trans-perineal approach.

Surgical procedures of TpMIS

During TpMIS, the operator, first assistant, second assistant, and laparoscopist were positioned as shown in Fig. 3. At

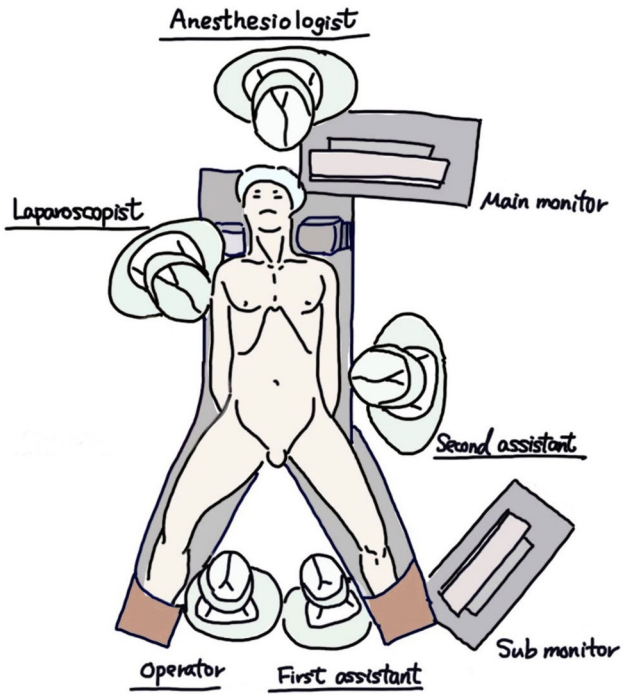

Fig. 3 Positioning of the surgeons during trans-perineal minimally invasive surgery

least four surgeons were required. Skin incisions for TpMIS and the conventional trans-perineal approach are shown in Fig. 4. A purse-string suture was securely placed at the anus, and a skin incision was then made around the tightly closed anus (Fig. 5A). An adequate skin flap was circumferentially made, and a single-port device (GelPOINT Mini Advanced Access Platform; Applied Medical, Inc., Rancho Santa Margarita, CA, USA) was attached using a circular skin flap (Fig. 5B). The fat tissue of the ischioanal fossa was circumferentially divided until the levator ani muscle was widely exposed. Anterior dissection was carefully performed just behind the transverse perineal muscle (Fig. 6A). Dissection of the levator ani muscle was started at the tip of the coccyx and extended to the bilateral sides (Fig. 6B, C), and local dissection of the levator ani muscle was adequately performed according to the tumor extension (Fig. 7A). On the anterior side, the arms of the puborectalis sling and perineal body were carefully divided (Fig. 6D, E). On the anterior side, the dissection line was obscure due to the anatomical complexity, and the dissection could easily proceed toward the anterior-lateral side of the prostate (Fig. 7B). The decision regarding the optimal dissection line on the anterior side was performed by visual assistance of trans-abdominal

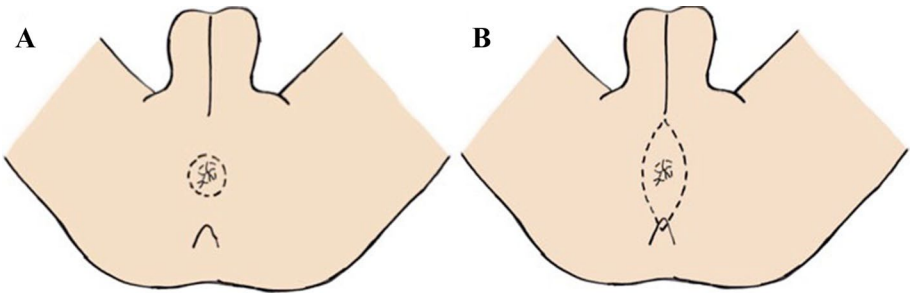

Fig. 4 Schemas of skin incisions for TpMIS and the conventional trans-perineal approach. **A** A skin incision was made around the tightly closed anus for TpMIS. An adequate skin flap worked well to fit a single-port device. **B** A fusiform incision was required in the conventional trans-perineal approach. The top of the anterior side was made at the level of the perineal body, and the posterior side reached the inferior edge of the coccyx. *TpMIS* trans-perineal minimally invasive surgery

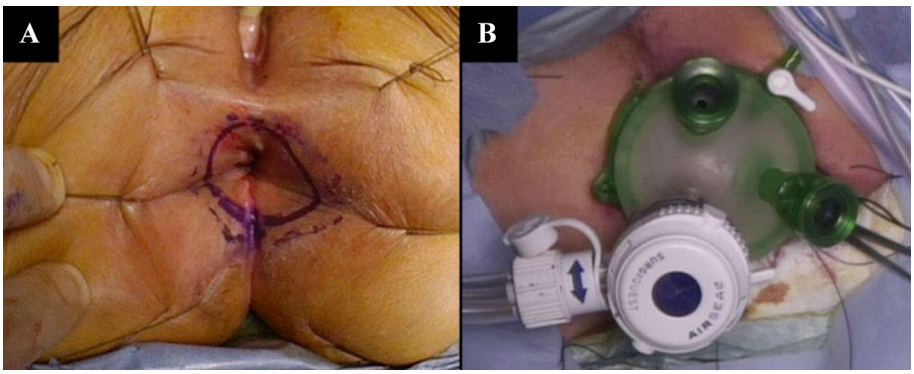

Fig. 5 Attachment of a single-port device for TpMIS. An adequate skin flap was circumferentially made, and a single-port device was attached for TpMIS. *TpMIS* trans-perineal minimally invasive surgery

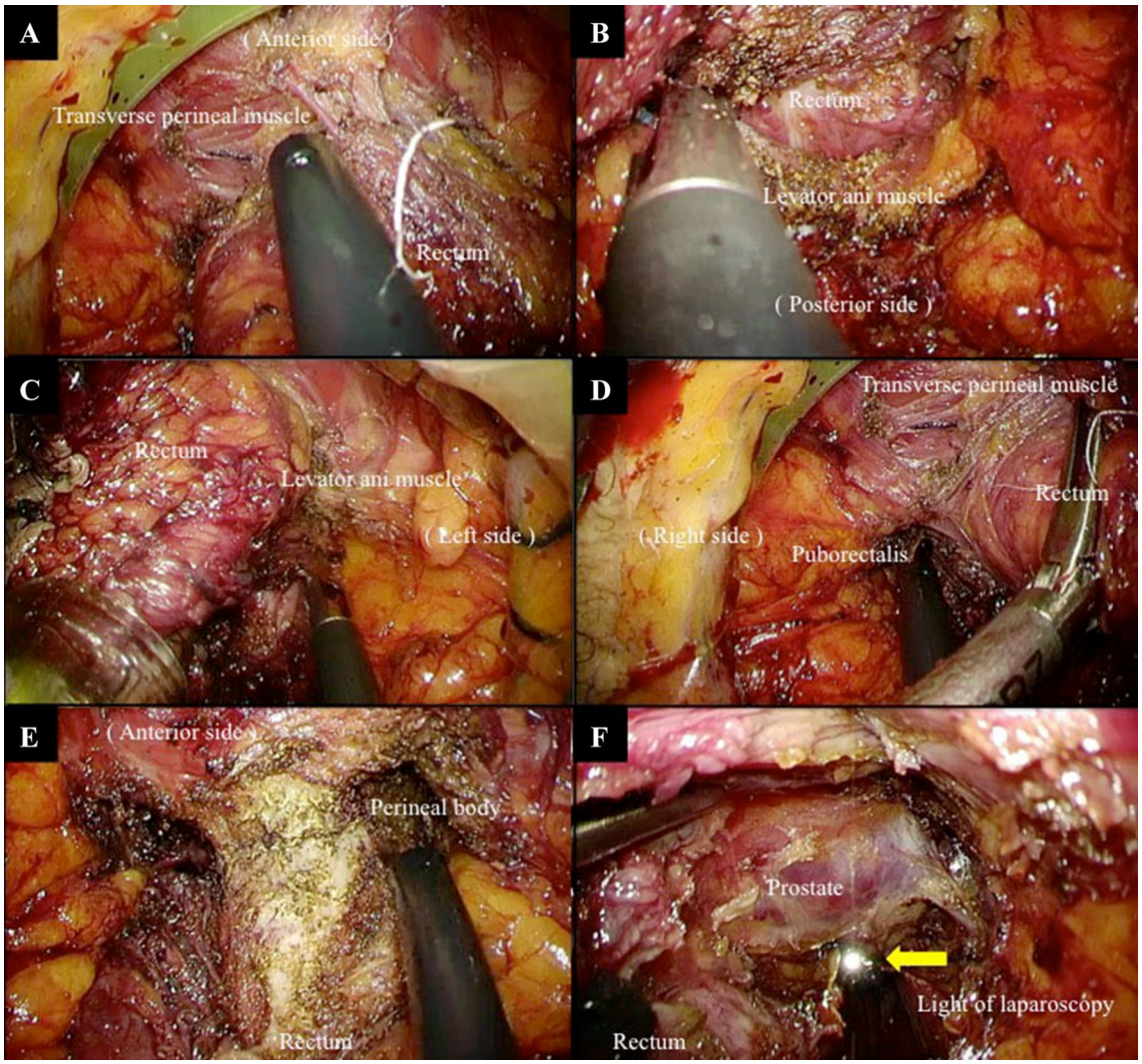

Fig. 6 Intraoperative findings during trans-perineal minimally invasive surgery. **A** Anterior dissection was performed just behind the transverse perineal muscle. **B, C** Dissection of the levator ani muscle was extended from the posterior to bilateral sides. **D, E** At the anterior side, the arms of the puborectalis sling and perineal body were carefully divided. **F** To avoid unexpected injury to the anterior tissues (e.g., prostate and urethra), we attempted to decide on the optimal dissection line of the anterior side under visual assistance of trans-abdominal laparoscopy because this dissection can be easily misled. Although this simultaneous procedure required two surgical teams, anatomical recognition and adequate dissection were obtained. Laparoscopic light from the trans-abdominal side was observed (arrow)

laparoscopy (Fig. 7B). This was performed to avoid unexpected injury to the anterior tissues (i.e., urethra or prostate) (Fig. 6F). Simultaneous performance of these procedures by two surgical teams is crucial to avoid unexpected injuries.

Statistical analysis

Data are presented as mean ± standard deviation. The Mann–Whitney U test and χ^2 test were used for unpaired continuous or discontinuous variables between two groups. Statistical calculations were performed using StatView software Version 5.0 (SAS Institute Inc., Cary, NC, USA). Values of $p < 0.05$ were considered statistically significant, and values of $p \geq 0.05$ were considered not significant.

Results

Patients' profiles

The patients' profiles are shown in Table 1. The mean age of the patients in the TpAPR and conventional groups was 69.8 ± 9.4 and 66.3 ± 8.8 years, respectively. There were no significant differences in sex, mean body mass index, or American Society of Anesthesiologists score between the

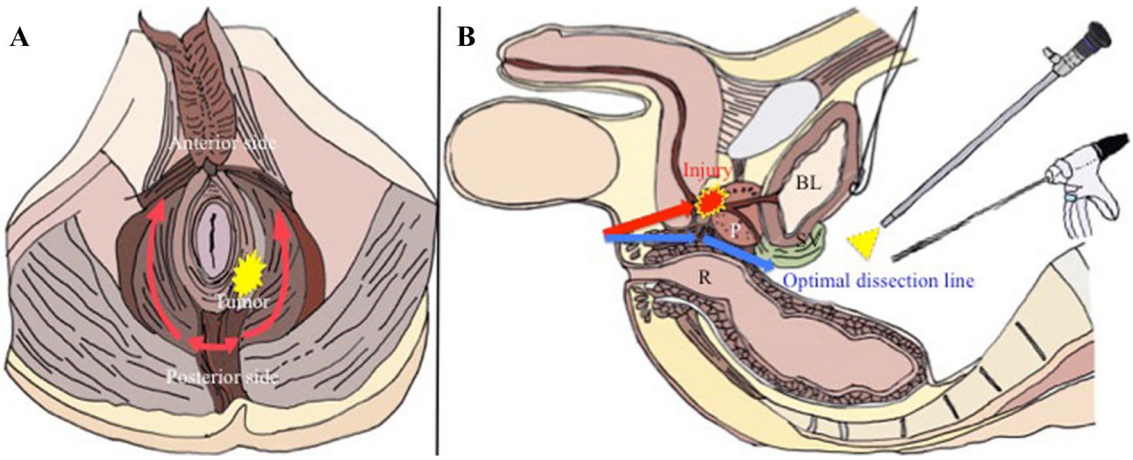

Fig. 7 Schemas of important features and challenges during transperineal minimally invasive surgery. **A** Dissection of the levator ani muscle was extended from the posterior to bilateral sides (red arrows). Local dissection of the levator ani muscle was adequately performed according to tumor extension (yellow star). On the anterior side, the arms of the puborectalis sling and perineal body were carefully divided. **B** Dissection could easily proceed toward the anterior-lateral side (red arrow), and unexpected injury of the anterior tissues (red star) was possible. We attempted to decide on the optimal dissection line of this side (blue arrows) under visual assistance in transabdominal laparoscopy. *BL* bladder, *P* prostate, *SV* seminal vesicle, *R* rectum. (Color figure online)

Table 1 Patients' profiles

	TpAPR ($n=21$)	Conventional ($n=29$)	p Value
Age (years)	69.8 ± 9.4	66.3 ± 8.8	NS
Male (%)	16 (76.2)	18 (62.0)	NS
BMI	21.5 ± 3.7	22.3 ± 3.4	NS
ASA score			
1	2 (9.5)	5 (17.2)	NS
2	17 (81.0)	18 (62.1)	NS
3	2 (9.5)	6 (20.7)	NS
Tumor localization (main side of the rectal wall)			
Anterior/lateral/posterior/circular	3/4/9/5	7/7/10/5	–
Clinical T factor[a]			
≤ 2 (M, SM, MP)	3 (14.3)	11 (38.0)	NS
3 (A)	16 (76.2)	17 (58.6)	NS
4 (AI)	2 (9.5)	1 (3.4)	NS
Clinical staging[a]			
Stage I	3 (14.3)	8 (27.6)	NS
Stage II	1 (4.8)	5 (17.2)	NS
Stage IIIA	2 (9.5)	5 (17.2)	NS
Stage IIIB	15 (71.4)	9 (31.0)	0.0048
Stage VI	0 (0.0)	2 (6.9)	NS
Neoadjuvant chemotherapy (%)	16 (76.2)	7 (24.1)	0.0003

BMI body mass index, *ASA* American Society of Anesthesiologists, *TpAPR* trans-perineal abdomino-perineal resection, *NS* not significant

[a]According to Japanese classification

two groups. Significantly higher proportions of patients were preoperatively diagnosed with clinical stage IIIB

according to the Japanese classification [29] and received neoadjuvant chemotherapy before surgery in the TpAPR than conventional group.

Intraoperative factors

All patients in both groups were placed in the supine position. Intraoperative factors, including the incidence of LLND, operation time, blood loss, and conversion to open surgery, are shown in Table 2. The incidence of LLND, the operation time, and the rate of conversion to open surgery were not significantly different between the two groups. However, blood loss was significantly lower in the TpAPR than conventional group. One case of conversion to open surgery was observed in the conventional group because of technical difficulties in intentional dissection of swelling of LNs in the para-aorta region during the laparoscopic transabdominal approach. In the TpAPR group, no conversion to open surgery occurred during either the laparoscopic transabdominal approach or TpMIS.

Oncological findings

The histopathological characteristics of the resected specimens are shown in Table 3. The tumor size was similar between the two groups. Histological findings and pathological staging were assessed based on the Japanese classification [29]. There were no significant differences in these oncological findings between the two groups. No significant difference was found in the incidence of a pathological tumor remnant on the surgical cut surface (i.e., positive radial margin according to the Japanese classification [29]) between the two groups [two patients (9.3%) in the TpAPR group and three patients (10.3%) in the conventional group]. The circumferential location of the positive margin was anterior in three of these five patients.

Table 2 Intraoperative factors

	TpAPR ($n=21$)	Conventional ($n=29$)	p value
Lateral lymph node dissection	10 (47.6)	8 (27.6)	NS
Bilateral	3 (14.3)	3 (10.3)	NS
Operation time (min)	549.4 ± 139.5	523.4 ± 152.5	NS
Blood loss (ml)	55 (10–600)	120 (20–1650)	0.0082
Conversion to open surgery	0 (0.0)	1 (3.4)	NS

TpAPR trans-perineal abdomino-perineal resection, *NS* not significant

Table 3 Histopathological characteristics of the resected specimens

	TpAPR ($n=21$)	Conventional ($n=29$)	p value
Tumor size (mm)	35 (0–60)	40 (0–70)	NS
Histological findings			
Tubular adenocarcinoma (tub1)	12 (57.1)	14 (48.3)	NS
Tubular adenocarcinoma (tub2)	7 (33.3)	13 (44.8)	NS
Papillary adenocarcinoma (pap)	1 (4.8)	1 (3.4)	NS
Poorly differenciated adenocarcinoma (por)	0 (0.0)	0 (0.0)	NS
Mucinous adenocarcinoma (muc)	1 (4.8)	1 (3.4)	NS
Pathological T factor			
≤ 2 (M, SM, MP)	8 (38.1)	12 (41.4)	NS
3 (A)	12 (57.1)	17 (58.6)	NS
4 (AI)	1 (4.8)	0 (0.0)	NS
Pathological staging[a]			
Stage 0 (pathological complete response)	1 (4.8)	0 (0.0)	NS
Stage I	6 (28.6)	11 (37.9)	NS
Stage II	6 (28.6)	8 (27.6)	NS
Stage IIIA	5 (23.8)	6 (20.7)	NS
Stage IIIB	3 (14.3)	1 (3.4)	NS
Stage IV	0 (0.0)	3 (10.3)	NS
Radial margin positive (RM1)	2 (9.5)	3 (10.3)	NS

TpAPR trans-perineal abdomino-perineal resection, *NS* not significant

[a]According to Japanese classification

Table 4 Postoperative courses

	TpAPR ($n = 21$)	Conventional ($n = 29$)	p Value
Postoperative complications			
Clavien–Dindo grade 2[a]			
Perineal wound infection	4 (19.0)	6 (20.9)	NS
Urinary retention	0 (0.0)	3 (10.3)	NS
Pelvic abscess	1 (4.8)	1 (3.4)	NS
Clavien–Dindo grade 3[a]			
Perineal wound infection	0 (0.0)	5 (17.2)	0.0499
Urinary retention	1 (4.8)	0 (0.0)	NS
Pelvic abscess	1 (4.8)	1 (3.4)	NS
Lymphocele infection	1 (4.8)	0 (0.0)	NS
Stoma necrosis	1 (4.8)	0 (0.0)	NS
Aspiration pneumonia	0 (0.0)	1 (3.4)	NS
Postoperative hospital stay (day)	14 (10–74)	23 (10–84)	0.0224
Mortality	0 (0.0)	1 (3.4)	NS

TpAPR trans-perineal abdomino-perineal resection, *NS* not significant

[a]According to the Clavien–Dindo classification

Postoperative course

Clavien–Dindo grade 2 or 3 [32] short-term postoperative complications (≤ 30 days after surgery), the postoperative hospital stay, and mortality are shown in Table 4. There was no significant difference in the number of grade 2 perineal wound infections between the two groups [four patients (19.0%) in the TpAPR group and six patients (20.9%) in the conventional group]. However, although no grade 3 perineal wound infections were observed in the TpAPR group, five patients (17.2%) had these infections in the conventional group. The conventional trans-perineal approach was significantly associated with a higher incidence of severe perineal wound infection ($p = 0.0499$).

There were no differences in other grade ≥ 2 postoperative complications (e.g., urinary retention, pelvic abscess, lymphocele infection, stoma necrosis, and aspiration pneumonia) between the two groups. The postoperative hospital stay was significantly shorter in the TpAPR than conventional group. No patients died in the TpAPR group, although one patient (3.4%) died in the conventional group. This patient had multiple comorbidities; after the development of aspiration pneumonia, the patient died of respiratory failure on postoperative day 84.

Discussion

Laparoscopic resection for rectal cancer is safe and feasible with reduced risks of postoperative morbidity and mortality [16, 34]. However, laparoscopic APR for locally advanced LRC involves the most difficult techniques in the field of colorectal surgery. The conventional trans-perineal approach requires a large skin incision to create an adequate surgical field, especially in patients with a narrow pelvis, bulky tumor, or obesity, even when the skin is spared from tumor invasion. Large skin incisions increase postoperative perineal complications such as perineal wound infection, dehiscence, and pelvic abscess formation. These perineal complications often result in prolonged wound care, a chronic perineal sinus, and a lower quality of life [35]. Perineal complications cause serious health care problems after APR. Therefore, a novel and useful technique for the trans-perineal approach during APR is urgently required to overcome these critical disadvantages.

In this study, we evaluated the safety and utility of TpMIS during laparoscopic APR in our institution. Intraoperative blood loss and severe perineal wound infection (Clavien–Dindo grade 3) were significantly lower in the TpAPR conventional group. Consequently, the postoperative hospital stay was shorter in the TpAPR group. TpMIS has at least two advantages for the trans-perineal approach during laparoscopic APR. First, this technique requires only a minimal skin incision for surgical procedures, and attachment of a single-port device enables this minimal incision. Second, even in patients with technically difficult LRC with a narrow pelvis, bulky tumor or obesity, TpMIS provides excellent vision and a sufficient surgical field, especially on the anterior side. We consider that a minimal skin incision reduces the incidence of postoperative perineal complications and that a magnified view via endoscopic vision can lead to more accurate dissection and less blood loss.

Although a perineal approach is possible through a small perineal wound, such an approach might lead to reduced exposure of the surgical field, especially for obese patients with a long or deep anal canal. This is especially true for

dissection on the anterior side, which is the major site of positive CRM during APR for advanced LRC or bulky tumors [28]. In contrast, TpMIS can provide an excellent surgical field with adequate magnified scope vision in all directions, including the anterior side. Therefore, TpMIS has a large advantage for adequate surgical procedures on the anterior side. Accordingly, we believe that TpAPR is an ideal to overcome a positive CRM.

Although TpMIS has various advantages as stated above, this procedure has some difficulties. The risk of urethral injury is greater in APR than in LAR or ISR. When dissecting the perineal body on the anterior side, no landmark is available to clearly distinguish rectal tissue from the urethra. A clear dissection line is difficult to find because of the complex anatomy around the perineal body or rectourethral muscle between the external anal sphincter and apex of the prostate. Several methods have been proposed for safe dissection in this area, such as the use of an infrared lighted urethral stent [36]. We believe that one solution is laparoscopic assistance for anatomical identification of the prostate. Even when an appropriate dissection plane cannot be identified in this area transanally, it is usually possible to reach the upper part of the prostate by a laparoscopic approach. Once the lateral side of the prostate has been identified transanally, even if it is just the upper part of the prostate, we can predict the contour of the prostate from below, which is helpful for anterior dissection [28]. Without this laparoscopic assistance in APR, we are likely to mistakenly dissect the tissue alongside the prostate without identifying its contour; this might lead to urethral injury, especially in high-risk patients [37].

As described above, anterior dissection may easily proceed toward the anterior-lateral side of the prostate. To avoid injury to the urethra or prostate, we used laparoscopic assistance via the trans-abdominal approach during TpMIS. Simultaneous performance of these procedures by two surgical teams is an important point for avoiding unexpected injury, although two surgical teams require at least four surgeons. In our study, we did not experience any unexpected injuries of irrelevant organs. Anatomical recognition and adequate dissection are provided by the approaches of the two teams from each side, even in patients with technically difficult LRC.

Specific regulations and ethical policies are crucial for institutional introduction of advanced surgeries. According to the international recommendation for the safe introduction of TaTME, step-by-step introduction including sufficient knowledge of this procedure, sufficient experience with laparoscopic TME, cadaver training, and mentorship is proposed [38]. Before introduction of TpAPR in our institution, we had experienced more than 500 cases of laparoscopic rectal cancer surgery, including APR (conventional perineal approach). During the initial period of TpAPR introduction in our institution, a prestigious laparoscopic surgeon who had experienced with > 50 cases of trans-anal TME provided technical guidance during TpAPR. A protracted learning curve (> 10 cases) was required even under excellent teaching by a well-experienced surgeon. Thus, we are concerned that thoughtless and rapid introduction of this unfamiliar technique may end in unexpected disasters.

In the present study, a tumor remnant on the surgical cut surface (i.e., positive radial margin) was observed in two patients (9.3%) in the TpAPR group and in three patients (10.3%) in the conventional group. Positive margins were detected at the cut surface of the anterior side in three patients, and thereafter, only one patient developed local recurrence in the TpAPR group. We consider that the surgical resection margin on the anterior side is important during laparoscopic APR for patients with locally advanced LRC.

A case report of trans-perineal single-port laparoscopy-assisted extra-levator abdominoperineal excision has been published [39]. The authors of this case report suggested that this procedure has intraoperative advantages of avoidance of postural changes and safe anesthesia. To the best of our knowledge, our study is the first clinical study to show that TpMIS is preferable to the conventional transperineal approach during laparoscopic APR in terms of the short-term outcomes. This study was designed as a retrospective study in a single institution. Potential limitations due to bias and a small sample size are inherent to this type of study.

In conclusion, the short-term outcomes of TpMIS during laparoscopic APR seemed to be reasonable for patients with LRC. Magnified visualization via endoscopy provides more accurate dissection and less intraoperative blood loss, and a minimal skin incision enables a reduction in postoperative perineal complications.

Author contributions D. Yasukawa collected the data, drew the schemas, and wrote the initial draft of the manuscript. T. Hori and D. Yasukawa revised further drafts. Y. Kadokawa, S. Kato, and Y. Aisu provided academic opinions and helped to assess important papers. S. Hasegawa supervised the study. All authors are in agreement with the content of the manuscript, and two corresponding authors.

Compliance with ethical standards

Disclosures Daiki Yasukawa, Tomohide Hori, Yoshio Kadokawa, Shigeru Kato, Yuki Aisu, and Suguru Hasegawa have no conflicts of interest or financial ties to disclose.

Ethical approval The study was approved by the Institutional Review Board of Tenri Hospital.

Informed consent The patients involved in this study provided written informed consent authorizing the use and disclosure of their protected health information.

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