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MINIREVIEWS

Extralevator abdominoperineal excision for advanced low rectal cancer: Where to go

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Abstract

Since its introduction, extralevator abdominoperineal excision (ELAPE) in the prone position has gained significant attention and recognition as an important surgical procedure for the treatment of advanced low rectal cancer. Most studies suggest that because of adequate resection and precise anatomy, ELAPE could decrease the rate of positive circumferential resection margins, intraoperative perforation, and may further decrease local recurrence rate and improve survival. Some studies show that extensive resection of pelvic floor tissue may increase the incidence of wound complications and urogenital dysfunction. Laparoscopic/robotic ELAPE and trans-perineal minimally invasive approach allow patients to be operated in the lithotomy position, which has advantages of excellent operative view, precise dissection and reduced postoperative complications. Pelvic floor reconstruction with biological mesh could significantly reduce wound complications and the duration of hospitalization. The proposal of individualized ELAPE could further reduce the occurrence of postoperative urogenital dysfunction and chronic perianal pain. The ELAPE procedure emphasizes precise anatomy and conforms to the principle of radical resection of tumors, which is a milestone operation for the treatment of advanced low rectal cancer.

Key words: Extralevator abdominoperineal excision; Advanced rectal cancer; Advantages; Complications; Pelvic reconstruction; Intraoperative position; Trans-perineal approach; Laparoscopic/robotic-extralevator abdominoperineal excision; Individual-extralevator abdominoperineal excision

Core tips: Since extralevator abdominoperineal excision procedure (ELAPE) was proposed, the surgical approach and technique have been gradually developed, and recognized by an increasing number of colorectal surgeons. This is a first review to report in detail the research progress and controversies of ELAPE in the last decade including advantages of procedure, incidence of postoperative complications,

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controversies about operative position, development of laparoscopic/robotic technologies and proposal of individualized treatment /trans-perineal approach.

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INTRODUCTION

Since resection of the rectum has been proposed as a treatment for rectal cancer, there has been significant innovation from pioneering surgeons in terms of surgical technique development to reduce recurrence and improve survival rate[1]. Sir Ernest Miles was the first surgeon to propose the concept of lymphatic spread and designed a new procedure, known as abdominoperineal resection (APR), which subsequently became the standard form of radical surgery for patients with advanced low rectal cancer[2,3]. APR significantly increased the chances of a radical cure for rectal cancer, but is associated with a higher risk for positive circumferential resection margins (CRM+), and intraoperative perforation (IOP), which can easily lead to local tumor recurrence[4,5]. Due to the complex anatomy around the rectum, and because the separation of the levator ani needs to be close to the anal canal, a narrow waist will be created at the level of the tumor-bearing segment; this is considered to be an important cause of postoperative local rectal cancer recurrence. Several studies have reported that the rates of IOP and CRM+ was as high as 28.2% and 49% for APR, respectively[6-8]. With the introduction total mesorectal excision, Holm *et al*[9] proposed the concept of cylindrical APR in 2007. This technique aimed to reduce the rates of CRM+ and IOP by expanding the area of resection, including resection of the anal canal, all of the levator ani muscle, and the lower mesorectum. West *et al*[10] provided support to this procedure by conducting pathological studies on specimens acquired from patients involving cylindrical APR. In 2010, the results of a European multicenter study further showed that with the use of cylindrical APR, the rate of CRM+ decreased from 49.6% to 20.3%, and that the incidence of IOP fell from 28.2% to 8.2%, and this study recommended adoption of extralevator abdominoperineal excision (ELAPE) instead of cylindrical APR[11].

The ELAPE procedure emphasizes the complete resection of the levator ani muscle that surrounds the mesorectum, and aims to reduce the incidence of CRM+, IOP, and the rate of postoperative local tumor recurrence[12]. As the number of clinical studies has increased over recent years, we have gained a deeper understanding of the efficacy and safety of ELAPE. Furthermore, there has been a significant improvement in the surgical methods and techniques during ELAPE. The objective of this article is to review the current literature relating to ELAPE and provide an update on research activity into this important procedure.

THERAPEUTIC EFFECT AND SURVIVAL

ELAPE removes more tissue from outside the muscularis propria and internal sphincter, thus avoiding the formation of a waist at the anorectal junction, and the quality of the resected specimens is greatly improved[12]. Han *et al*[13] compared therapeutic effects between patients undergoing conventional APR and ELAPE, and results showed that there were significantly fewer patients with a CRM+ in the ELAPE group compared with the APR group (5.7% *vs* 28.1%, $P = 0.013$), and that the local recurrence rate in the ELAPE group was significantly lower than the APR group (2.8% *vs* 18.8%, $P = 0.048$), without a significant increase in complications. Similarly, a retrospective study involving 206 patients with distal rectal cancers aimed to determine whether ELAPE procedure could improve oncological outcomes. The study showed that the rates of IOP (8.1% *vs* 21.1%, $P = 0.01$), and local tumor recurrence (6.7% *vs* 15.5%, $P = 0.013$) were significantly lower during a period in which ELAPE was used when compared with a period when ELAPE was not used, and recommended ELAPE for patients with locally advanced cT3-T4 rectal cancer with threatened margins[14]. In addition, Han *et al*[13] found that the mean overall survival and disease-free survival in patients treated by ELAPE were 45 and 44 mo,

respectively; there was no statistical difference compared with an APR group of patients. A multicenter study, conducted by Shen *et al*[15], further showed that patients who underwent ELAPE had significantly longer overall survival (median, 41.5 mo *vs* 29.8 mo, $P = 0.028$), disease-free survival (median, 38.5 mo *vs* 29.3 mo, $P = 0.027$), and local recurrence-free survival (3.80% *vs* 11.25%, $P = 0.027$), than those who underwent APR. A prospective study with a follow-up period of 5 years also reported that ELAPE could reduce the local recurrence rate and increase the five-year survival rate, and recommended for advanced low rectal cancer that cannot preserve the anus[16].

Over recent years, there has been some disagreement over whether ELAPE can improve the prognosis of patients with advanced low rectal cancer. A single-center study conducted by Asplund *et al*[17] showed that ELAPE did not significantly reduce the rates of CRM+, IOP, and local recurrence, instead it could increase the incidence of postoperative perineal wound infection (28% to 46%, $P < 0.05$) and perineal wound revision (8% to 22%, $P < 0.05$), which extend hospital stay. Carpelan *et al*[18] reported that the ELAPE procedure has no advantage in terms of reducing the rates of CRM+, IOP, and local recurrence, and compared with patients treated with APR, the overall survival and disease-free survival were not improved in patients treated with ELAPE. A national study from Danish Colorectal Cancer Group's prospective database also showed that CRM+ resections were more common after ELAPE than that after APR (16% *vs* 7%, $P = 0.006$), and that the ELAPE procedure was even a risk factor for CRM+[19]. While the aforementioned studies reflect the shortcomings of ELAPE, most meta-analyses showed that ELAPE was advantageous over the conventional APR in tumor treatment, which could significantly reduce the rate of IOP, local recurrence, and did not increase postoperative perineal wound complications[20,21].

At present, there is still debate as to whether ELAPE is superior to APR, and it is evident that different studies have arrived at different conclusions. We consider that ELAPE conceptually emphasizes the importance of resection along the lateral fascial plane of the external anal sphincter-levator ani muscle and the ischiorectal fossa fat was preserved as much as possible to reduce trauma, in line with the precise principle of radical tumor removal, and is therefore, more suitable for patients with low rectal cancer of cT3-T4[13] (Table 1).

INTRAOPERATIVE POSITION

The prone and lithotomy positions are two common positions during ELAPE surgery, although there is some debate as to which of these two positions is more favorable for patient prognosis. Previous studies, by Holm[22] and de Campos-Lobato *et al*[23], considered that surgical position does not affect perioperative morbidity or the oncologic outcomes of patients with low rectal cancer, and that the therapeutic effect of ELAPE depends on the experience and proficiency of the operator rather than the surgical position. Han *et al*[13] reported that when carried out in the prone jack-knife position, ELAPE conferred several advantages, including excellent exposure of the pelvic floor structures, simple procedure, and a reduced rate of local recurrence. Both Hunter[24], and Kim[25] considered that when carried out in the prone jack-knife position, ELAPE conferred some obvious advantages; for example, more precise perineal dissection, better operator comfort, and better exposure of the operative field. Complications arising from a change of position are rare, and can be avoided by an experienced team who are familiar with the procedure. Many surgeons prefer the prone position, including us, due to better exposure and because it also facilitates teaching.

However, Sabbagh *et al*[26] suggested that in the prone jack-knife position, the membranous portion of the urethra is more susceptible to injury, and that a change in position might increase operating time and the risks of cardiac arrest, or severe acute kidney failure. Therefore, it is not recommended to use the prone jack-knife position unless scientific data can demonstrate that the prone jack-knife position in ELAPE provides better exposure of the perineum and gives rise to a better prognosis[26]. In addition, laparoscopic or robotic ELAPE surgery can compensate for the inadequate exposure of the surgical field created by the lithotomy position. Zhang *et al*[27] performed laparoscopic ELAPE for low rectal cancer in 12 patients without a change of position; these authors reported that this strategy did not lead to any cases of bladder dysfunction, or sexual dysfunction, as a result of nerve damage. Another study, reported by Buchs *et al*[28], also reached a similar conclusion. The feasibility of robotic-assisted transabdominal levator transection in the lithotomy position during ELAPE was also proved by several studies[29-31].

We consider that the prone jack-knife position is important for ELAPE in open surgery for easier teaching and better visualization. Laparoscopic or robotic ELAPE

Table 1 Post-operative outcomes of extralevator abdominoperineal excision *vs* abdominoperineal excision

Refereces								Post-operative complications				
Authors	Year	Type	Group	*n*	CRM+(%)	IOP(%)	Local recurr-ence(%)	Perineal wound compli-cations (%)	Urinary retention (%)	Sexual dysfunc-tion (%)	Chronic perineal pain (%)	QoL scores
West *et al*[11]	2010	Retro case-control	ELAPE/APR	176/124	20.3/49.6, $P < 0.001$	8.2/28.3, $P < 0.001$	-	38/20, $P = 0.019$	46/17, $P = 0.579$	46/33, $P = 0.192$	-	-
Han *et al*[13]	2012	RCT	ELAPE/APR	35/32	5.7/28.1	5.7/15.6, $P = 0.246$	2.8/18.8, $P = 0.048$	37.1/31.3 $P = 0.612$	40/28.1, $P = 0.307$	74/60, $P = 0.306$	51.4/6.3, $P < 0.001$	-
Asplund *et al*[17]	2012	Retro case-control	ELAPE/APR	79/79	17/20, $P = 0.647$	13/10, $P > 0.05$	9/9, $P = 1$	46/28, $P < 0.05$	-	-	-	-
Vaughan-Shaw *et al*[58]	2012	Pro case-control	ELAPE/LAPR/OAPR	16/10/10	0/1/2, $P > 0.05$	0/0/1, $P > 0.05$	-	2/5/2, $P = 0.21$	3/2/2, $P = 0.99$	-	-	85.4/77.5/78.5, $P > 0.05$
Ortiz *et al*[66]	2014	Retro case-control	ELAPE/APR	457/457	13.6/13.1, $P > 0.846$	7.7/7,9, $P > 0.902$	5.6/2.7, $P > 0.664$	21.9/26, $P > 0.141$	-	-	-	-
Shen *et al*[55]	2015	Pro case-control	ELAPE/APR	36/33	4/12, $P = 0.297$	5.6/21.2, $P = 0.028$	0/15.2, $P < 034$	8.3/27.3, $P = 0.039$	11.1/3, $P = 0.359$	11.8/36.4, $P = 0.127$	-	$P > 0.05$
Wang *et al*[57]	2015	Retro case-control	ELAPE/APR	23/25	4.3/28, $P = 0.028$	0/20, $P = 0.023$	8.7/32, $P = 0.047$	39.1/24, $P = 0.259$	26.1/12, $P = 0.212$	60/37.5, $P = 0.210$	47.8/8, $P = 0.002$	$P > 0.05$
Klein *et al*[19]	2015	Retro case-control	ELAPE/APR	301/253	16/7, $P = 0.001$	2/3, $P = 0.373$	-	14/10, $P = 0.143$	-	-	-	-
Prytz *et al*[67]	2016	Pro case-control	ELAPE/APR	518/209	41.5/38.4, $P < 0.0001$	$P < 0.001$	$P < 0.001$	$P < 0.001$	-	-	-	-
Stelzner *et al*[16]	2016	Pro case-control	ELAPE/APR	36/36	2.9/2.8, $P = 1$	0/16.7, $P = 0.025$	5.9/18.2, $P = 0.153$	16.7/36.1, $P = 0.061$	-	-	-	-
Kamali *et al*[54]	2017	Pro case-control	ELAPE/APR	27/21	7.4/9.5, $P = 0.50$	-	3.7/4.7, $P = 1$	37/24, $P > 0.05$	-	-	-	77.3/65.3, $P = 0.27$
Habr-Gama *et al*[12]	2017	Retro case-control	ELAPE/APR	22/50	13.6/16.6, $P = 0.70$	0/8, $P = 0.30$	4.5/28.6, $P = 0.01$	22.7/46, $P = 0.007$	-	-	-	-
Carpelan *et al*[18]	2018	Retro case-control	ELAPE/APR	42/27	24/41, $P = 0.136$	10/22, $P = 0.134$	7/19, $P = 0.247$	45/30, $P = 195$	-	-	5/4, $P > 0.05$	-
Shen *et al*[15]	2019	Retro case-control	ELAPE/APR	106/88	4.2/6.5, $P > 0.05$	-	3.8/11.25, $P = 0.027$	17.0/14.8, $P = 0.699$	7.5/3.4, $P = 0.353$	-	-	-

ELAPE: Extralevator abdominoperineal excision; APR: Abdominoperineal excision; RCT: RANDOMISED Controlled Trial; CRM+: Positive circumferential resection margins; IOP: Intraoperative perforation; QoL: Quality of life; LAPR: Laparoscopic abdominoperineal excision; OAPR: Open abdominoperineal excision. Pro: Prospective. Retro: Retrospective.

provides a clear field of vision, and amplification; there might be no need to change position during surgery, although the procedure must be carried out by an experienced team.

RECONSTRUCTION OF THE PELVIC FLOOR

The ELAPE procedure improves the quality of resected specimens, but also leaves a large pelvic floor defect. Another challenge for colorectal surgeons, therefore, is to reconstruct the pelvic floor. Various methods have been developed to close pelvic defects after ELAPE[32]. Conventional primary closure is feasible following ELAPE, but because of the large defect, it is likely to result in a high rate of perineal hernia[11]. Wang *et al*[33] proposed the modified primary closure method, which focuses on the reconstruction of the pelvic peritoneum and the avoidance of adhesions between the small intestine and extraperitoneal tissues. Wang *et al*[33]'s study showed that the

reconstruction time was significantly longer (mean, 14.6 min *vs* 7.2 min, $P < 0.001$) in a modified primary closure group than in a biological mesh group; however, the post-operative hospital stay (mean, 8.1 d *vs*. 10.1 d, $P = 0.001$), and total cost (mean, 7279 *vs* 10 719US dollars, $P = 0.003$), were significantly lower. Myocutaneous flaps, which include gluteal rotation/advancement flaps, inferior gluteal artery myocutaneous island transposition flaps, transverse rectus/vertical rectus abdominis, and gracilis, are also widely used in pelvic floor reconstruction because they facilitate the healing process by good perfusion and oxygenation. However, the use of such flaps is associated with complicated surgeries, and increased patient trauma, and an increased risk of post-operative wound complications. Moreover, flaps can easily become necrotic, and patients required prolonged periods of immobilization after surgery[32,34-36].

Considering the disadvantages of such techniques, Han *et al*[37] attempted to use the human acellular dermal matrix to reconstruct the large pelvic defect in 12 patients after ELAPE; there was complete healing of the perineal wound in just two weeks after surgery in 11 of these patients, with no serious complications. Further study has shown that compared with primary closure, the biological mesh approach can significantly reduce the incidence of perineal wound infection (11.5% *vs* 22.2%, $P = 0.047$), perineal hernia (3.4% *vs* 13.0%, $P = 0.022$), wound dehiscence (0.6% *vs* 5.6%, $P = 0.042$), and total perineal wound complications (14.9% *vs* 35.2%, $P = 0.001$)[38]. Subsequent studies have also confirmed that biological mesh repair is an effective and safe method for pelvic reconstruction after ELAPE. In the BIOPEX-study, Musters *et al*[39] compared primary perineal closure and biological mesh closure after ELAPE. At the 12-mo follow-up visit, the authors found that the incidence of perineal hernia was significantly lower in the biological mesh group. Thomas *et al*[40] conducted long-term follow-up of 100 patients who underwent pelvic floor reconstruction after ELAPE with biological meshes and result showed that no mesh was infected and no mesh needed to be removed, eight patients had perineal hernias. In addition, a comparative review of biological mesh and gluteus maximus flaps for pelvic floor reconstruction showed that the two techniques were associated with similar postoperative complications, and that the biological mesh approach resulted in a significantly shorter hospital stay, and reduced hospital costs[41]. At present, randomized controlled trials with long-term follow-up are still needed to prove the efficacy and safety of biological patches and myocutaneous flaps during pelvic floor reconstruction after ELAPE[32,42].

Wounds after this form of surgery can be difficult to heal. There are a number of factors responsible for such poor wound healing, including excessive resection, the accumulation of fluids, and the effects of preoperative radiotherapy. Sumrien *et al*[43] reported that the application of a negative pressure system after ELAPE can significantly reduce perineal wound complications, and that this procedure did not make patients feel uncomfortable. We consider that human acellular dermal matrix, combined with negative pressure wound therapy, is effective for healing perianal wounds after ELAPE. We are currently conducting a clinical trial (NCT04033484) for pelvic floor reconstruction using biological mesh with negative pressure wound therapy following ELAPE to further analyze its therapeutic effect.

LAPAROSCOPIC AND ROBOTIC ELAPE

With the development of minimally invasive technology, an increasing number of centers have begun to develop laparoscopic and robotic ELAPE. Although operation time is longer than open surgery, laparoscopic ELAPE yields a lower incidence of postoperative complications and a shorter hospital stay, which is consistent with the concept of enhanced recovery after surgery[44]. Yang *et al*[45] used laparoscopic ELAPE to treat 33 patients with rectal cancers and reported satisfactory results. None of the patients required open surgery, the median operation time was 200 min, and the median intraoperative blood loss was 90 mL. Other studies have also confirmed that laparoscopic ELAPE is safe and feasible[46,47].

Robotic ELAPE has advantages of surgical exposure and dexterity in the deep pelvis without repositioning of the patient, and relevant reports are small sample studies[31,48]. Sieffert *et al*[29] reported six patients with rectal cancer who underwent robotic ELAPE; the mean total operation time was 417 ± 66 min (from incision to closure) and the mean blood loss was 314 ± 105 mL. There were no instances of IOP or CRM involvement, and all patients recovered well without recurrence after surgery. In addition, Kamali *et al*[49] compared the therapeutic effects of laparoscopic ELAPE and robotic ELAPE, and found that there were no significant differences in terms of operative outcome, postoperative complications, and the quality of life for patients

between the two groups. Furthermore, the robotic ELAPE procedure requires a shorter learning curve, and greater treatment costs than laparoscopic ELAPE.

The feasibility and safety of laparoscopic and robotic ELAPE are preliminary confirmed in current studies which involve small sample sizes, and the large sample perspective studies are needed to evaluate its oncological efficacy.

COMPLICATIONS AND QUALITY OF LIFE

Earlier studies showed that due to the wide excision required by ELAPE, the incidence of perineal wound complications, particularly wound infection and dehiscence, was significantly higher in patients undergoing ELAPE[11,13]. However, previous Meta-analyses[50,51] did not reveal a significant difference between ELAPE and APR procedures with regards to perineal wound complications. Habr-Gama *et al*[12] reported that wound dehiscence is less likely to occur after ELAPE, because the ELAPE procedure has a better field of view, and more precise homeostasis than APR. We considered that the occurrence of post-operative wound complications may be related to differences between patients, the choice of surgical methods (open or laparoscopic), different perineal operating positions, different ways of reconstructing the pelvic floor, and the inclusion of preoperative radiotherapy[52]. Perineal hernia is another common complication after ELAPE, with an incidence of up to 26% with primary closure after ELAPE[30]. The use of mesh might prevent the formation of perineal hernias[39].

Sexual function, and urinary function after ELAPE have also been a major concern. Han *et al*[53] reported that urinary retention after ELAPE occurs in up to 18.6% (19/102) of patients, and of the group of patients who had sex before surgery, the rate of sexual dysfunction was 40.5% (32/79) after ELAPE. Kamali *et al*[54] further reported that impotence was a very common adverse effect of ELAPE (with a mean symptom score of 89.7). Other studies suggested that there was no significant difference in terms of sexual dysfunction and urinary retention when compared between ELAPE and APR groups[51,55]. We consider that the rates of sexual dysfunction and urinary retention might be further reduced by increased familiarity with pelvic anatomy, precise surgical operation, laparoscopic or robotic applications, and individual treatment.

Chronic perineal pain is a common complication after ELAPE, although the vast majority of chronic pain cases will gradually resolve over time after surgery. Previous studies conducted by Han *et al*[13,53] showed that the incidence of postoperative chronic perineal pain reached up to 51.4%. During follow-up, we found that chronic perineal pain after ELAPE was significantly reduced 1 year after surgery, as was Visual Analogue Score. In another study, Welsch *et al*[56] retrospectively analyzed 30 cases of ELAPE, in which the coccyx was removed during surgery, and found that the incidence of postoperative chronic perineal pain was as high as 50%. Wang *et al*[57] further reported that the occurrence of chronic perineal pain in an ELAPE group was significantly higher than that in an APR group (47.8% *vs* 8%, $P = 0.002$), and that perineal pain may be related to coccygectomy. All patients felt a gradual reduction in pain 3 mo postoperatively. We consider that despite the high incidence of chronic perianal pain after ELAPE, most patients experience gradual pain relief over time. The main causes of chronic perianal pain appear to be related to coccyx resection, pudendal nerve injury, and the use of biological mesh.

At present, surgeons and patients are focusing more on the postoperative quality of life following ELAPE. A study conducted by Shen *et al*[55] showed that compared to patients in an APR group, patients in an ELAPE group showed a better general health status ($P = 0.038$); other items related to the quality of life did not show any significant difference when compared between the ELAPE group and the APR group. Kamali *et al*[54] used the QLQ-C30 and QLQ-CR29 questionnaires and found that there were no significant differences between ELAPE and APR patients in terms of long-term quality of life. Other studies relating to the quality of life after ELAPE have also reached the same conclusions[58,59].

Whether extensive resection of pelvic floor tissue increases the chance of injuring vital pelvic floor nerves has been a concern for surgeons. We consider that ELAPE procedure performed under the guidance of exact anatomy, and assisted by laparoscopy and robotics recently actually reduces surgical trauma and is beneficial to the recovery of patients (Table 1).

INDIVIDUALIZED TREATMENT

As mentioned above, compared with APR, ELAPE requires removal of more

perirectal tissue, and may increase the chance of injury to the pelvic and perineal nerves, which may increase the occurrence of postoperative complications such as sexual dysfunction, urinary retention and chronic perineal pain. Based on the study of pelvic anatomy and postoperative complications, Han *et al*[13,60] considered that it is not necessary to remove the entire levator ani muscle if a tumor is limited to one sidewall, or the tumor is staged as T3 (Figure 1). This requires the assurance of preoperative magnetic resonance imaging (MRI) evaluation and neoadjuvant therapy to accurately understand the preoperative staging of rectal cancer and the extent of tumor invasion to the rectal wall. The results of a primary study indicated that under the premise of ensuring radical resection, individualized ELAPE reduced surgical trauma, and the occurrence of chronic perineal pain, urinary retention, and sexual dysfunction[60].

The concept of individualized surgery has also been endorsed by other colorectal surgeons. Chi *et al*[46] considered that not all low rectal cancer patients undergoing ELAPE require the excision of all the levator muscles and coccyx bone, and that the extent of surgical resection should be determined on precise preoperative evaluation by MRI imaging. Park *et al*[61] further proposed a modified version of ELAPE, which emphasized perineal anatomy 1-2 cm from the pelvic sidewall, in order to realize a more extended surgical plane and effective wound closure. In addition, with the development and application of robotics, Pai *et al*[62] presented a robot-assisted modified ELAPE, which means extensive resection of the levator and ischiorectal fat on the tumor side, and conservative levator division and preservation of more fat on the opposite, while surgery could be completed without changing position.

Although current studies on individualized ELAPE involved a few cases and short follow-up time, the surgical results were satisfactory and the occurrence of postoperative complications was reduced without increasing the local recurrence rate. We consider that under the premise of ensuring radical tumor removal, individualized ELAPE might further reduce the postoperative urogenital complications and chronic pain. We also highlight the fact that this procedure is feasible and safe for patients with advanced low rectal cancer.

EXPLORATION OF TRANSPERINEAL OPERATION

Conventional ELAPE requires a change in surgical position during surgery, which undoubtedly increases the difficulty of dissection deep in the pelvis and risk of procedural complications. With the advancement of laparoscopic techniques and single-port access channels, several surgeons have explored the feasibility of trans-anal minimally invasive surgery-assisted ELAPE. Han *et al*[63] conducted the study of trans-perineal minimally invasive approach for ELAPE in a synchronous lithotomy position for locally advanced low rectal cancer (Figure 2), and the results showed that compared with the conventional ELAPE, the trans-perineal minimally invasive approach for ELAPE did not significantly increase the incidence of postoperative complications, and it is associated with shorter total operation time, less postoperative pain and shorter postoperative anus exhausting time. Buchs *et al*[28] considered that an endoscopically assisted distal to proximal approach provides better vision and easier perineal procedure than conventional approach for ELAPE. Three patients with advanced low rectal cancer were treated by this procedure and results showed that there were no CRM+, IOP and wound complications. In addition, other studies had also preliminarily confirmed the feasibility of trans-perineal minimally invasive approach for ELAPE[64,65].

At present, the sample size in the clinical studies on trans-perineal minimally invasive approach for ELAPE is small. Therefore, a large multicenter trial comparing this procedure with the conventional ELAPE is needed to confirm its feasibility. We consider that surgeons who perform this procedure should have advanced laparoscopic skills and experience of single-port surgery.

In addition, this procedure may be difficult to perform in severe obese patients or patients with a bulky tumor in a narrow pelvis.

CONCLUSION

Lots of studies have confirmed that ELAPE is associated with a lower local recurrence rate and better prognosis than APR. Although there are some controversies that still need to be resolved by further research, the ELAPE procedure has changed the landscape of surgical treatment for advanced low rectal cancer that does not preserve the anus and can be developed as an important surgical procedure for the treatment of advanced low rectal cancer.

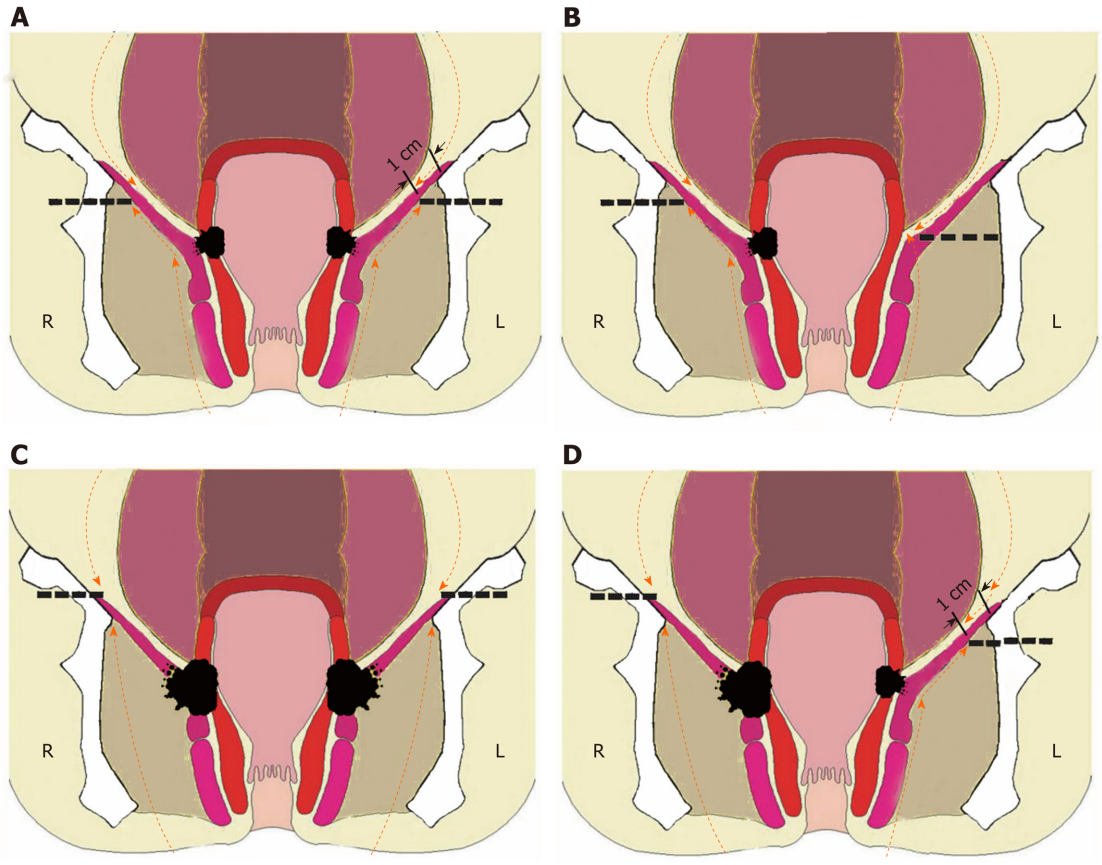

Figure 1 Individualized extralevator abdominoperineal excision procedure. A: Tumor not involving the ischioanal fat or levator ani muscle (T3), leave 1 cm of the levator ani muscles on the pelvic sidewall; B: Tumor located at one side (T3), levator ani muscle on the other side may be left; C: Tumor penetrating the levator ani muscle (T4) bilaterally, dissection should include the fat of the ischioanal fossa and the intact levator ani muscle bilaterally; D: Tumor penetrating the levator ani muscle (T4) unilaterally, part of the ischioanal fat and intact lavator ani muscle should be dissected unilaterally. This Figure is reprinted with authors'permission[13,60].

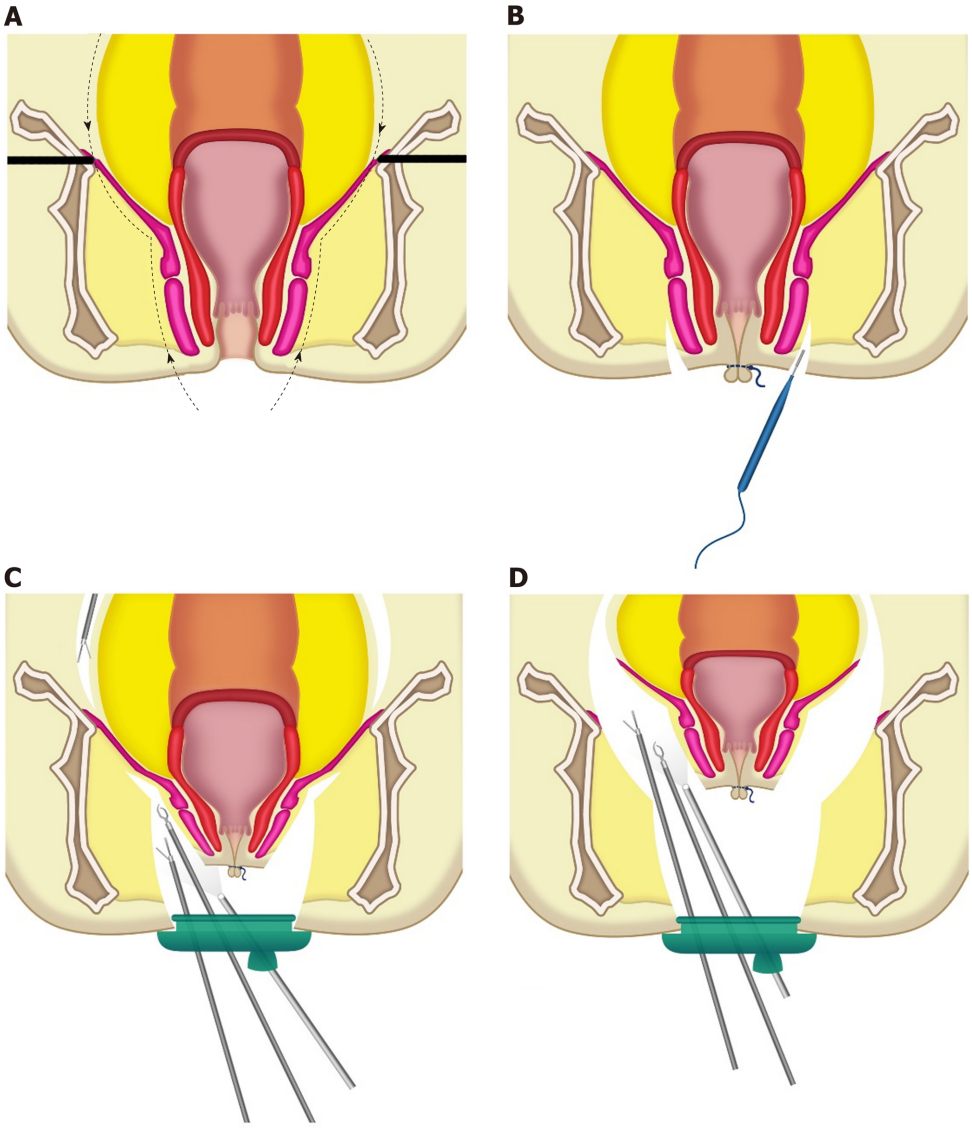

Figure 2 Trans-perineal minimally invasive approach for extralevator abdominoperineal excision procedure. A: The resection line of transperineal extralevator abdominoperineal excision; B: The anus was closed with a purse-string suture and an incision was made around the anus; C: The dissection was continued outside the external anal sphincter and levator muscle by using the trans-perineal trans-anal minimally invasive surgery (TAMIS) platform. The abdominal procedure was performed at the same time; D: The levator muscles were divided at the lateral most aspect by using the trans-perineal TAMIS platform. Reprinted with permission from the authors[63].

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