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

Yu Tao, Jia-Gang Han, Zhen-Jun Wang

ORCID number: Yu Tao (0000-0001-7201-8742); Jia-Gang Han (0000-0002-8112-9249); Zhen-Jun Wang (0000-0003-0176-6588).

Author contributions: Tao Y, Han JG, and Wang ZJ conceived and designed the research; Tao Y, Han JG and Wang ZJ performed the research; Tao Y, Han JG and Wang ZJ wrote the paper.

Conflict-of-interest statement: There is no conflict of interest associated with any of the senior author or other coauthors contributed their efforts in this manuscript.

Open-Access: This article is an open-access article that was selected by an in-house editor and fully peer-reviewed by external reviewers. It is distributed in accordance with the Creative Commons Attribution NonCommercial (CC BY-NC 4.0) license, which permits others to distribute, remix, adapt, build upon this work non-commercially, and license their derivative works on different terms, provided the original work is properly cited and the use is non-commercial. See: http://creativecommons.org/licenses/by-nc/4.0/

Manuscript source: Invited manuscript

Received: December 31, 2019
Peer-review started: December 31, 2019
First decision: February 19, 2020
Revised: March 27, 2020
Accepted: May 26, 2020
Article in press: May 26, 2020

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

©The Author(s) 2020. Published by Baishideng Publishing Group Inc. All rights reserved.

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,
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\(^6\,7\). 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[10], 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 29.5 mo, P = 0.027), and local recurrence-free survival (5.80% 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[11].

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[12] 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[13] 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+ progression. 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[10,12].

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-T4N0M0 (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[13] and de Campos-Lobato et al[14], 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[15] reported that when carried out in the prone jack-knife position, ELAPE conferred several advantages, including an excellent exposure of the pelvic floor structures, simple procedure, and a reduced rate of local recurrence. Both Hunter[16] and Kim[17] 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[18] 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[19]. 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[20] 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[21], 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[22-23].

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

| Authors             | Year | Type       | Group                  | n   | CRM+(%) | IOP(%) | Local recurrence(%) | Perineal wound complications (%) | Urinary retention (%) | Sexual dysfunction (%) | Sexual chronic perineal pain (%) | QoL scores |
|---------------------|------|------------|------------------------|-----|---------|--------|----------------------|---------------------------------|----------------------|------------------------|----------------------------------|------------|
| West et al[11]      | 2010 | Retro-case | ELAPE/A PR            | 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[23]       | 2012 | RCT        | ELAPE/A PR            | 35/32 | 5.7/28.1, P = 0.246 | 5.7/15.6, P = 0.048 | 37.1/31.3, P = 0.512       | 40/28.1, P = 0.307             | 74/60, P < 0.001              | -                      | -                    | -                               | -          |
| Asplund et al[33]   | 2012 | Retro-case | ELAPE/A PR            | 79/79 | 17/20, P = 0.647 | 13/10, P > 0.05        | 46/28, P < -                 | -                               | -                      | -                    | -                               | -          |
| Vaughan-Shaw et al[34] | 2012 | Pro-case  | ELAPE/L PR            | 16/10/10 | 0/1/2, P > 0.05 | 0/0/1, P > -         | 2/5/2, P = 0.21               | 3/2/2, P = -                   | -                      | -                    | -                               | 85.4/77.5/78.5, P > 0.05 |
| Ortiz et al[35]     | 2014 | Retro-case | ELAPE/A PR            | 457/457 | 13.6/13.1, P > 0.846 | 7.7/7.9, P > 0.902    | 21.9/26, P > 0.141          | -                               | -                      | -                    | -                               | -          |
| Shen et al[36]      | 2015 | Pro-case  | ELAPE/A PR            | 36/33 | 4/12, P = 0.297 | 5.6/21.2, P = 0.028   | 8.3/27.3, P = 0.039         | 11.1/3, P = 0.399               | 11.8/36.4, P = 0.127        | -                      | -                    | -                               | -          |
| Wang et al[37]      | 2015 | Retro-case | ELAPE/A PR            | 25/25 | 4.3/28, P = 0.028 | 0/20, P = 0.023        | 39.1/24, P = 0.259          | 26.1/12, P = 0.212             | 60/37.5, P = 0.002           | -                      | -                    | -                               | -          |
| Klein et al[38]     | 2015 | Retro-case | ELAPE/A PR            | 301/253 | 16/7, P = 0.001 | 2/3, P = 0.037        | 14/10, P = 0.014            | -                               | -                      | -                    | -                               | -          |
| Prytz et al[39]     | 2016 | Pro-case  | ELAPE/A PR            | 518/209 | 41.5/38.4, P = 0.001 | 5.8/21.2, P = 0.028   | 5.8/21.2, P = 0.039         | 11.1/3, P = 0.399               | 11.8/36.4, P = 0.127        | -                      | -                    | -                               | -          |
| Stelzner et al[40]  | 2016 | Pro-case  | ELAPE/A PR            | 36/36 | 2.9/28, P = 0.297 | 0/16.7, P = 0.135     | 5.8/18.2, P = 0.571         | 16.7/36.1, P = 0.061           | -                      | -                    | -                               | -          |
| Kamali et al[41]    | 2017 | Pro-case  | ELAPE/A PR            | 27/21 | 7.4/9.5, P = 0.5 | 0/8, P = 0.023        | 3.7/4.7, P = 1              | 37.2/4, P = 0.05               | -                      | -                    | -                               | 77.3/65.3, P = 0.27 |
| Habr-Gama et al[42] | 2017 | Retro-case | ELAPE/A PR            | 22/50 | 13.6/16.6, P = 0.70 | 0/8, P = 0.134         | 4.5/28.6, P = 0.01           | 22.7/46, P = -                | -                      | -                    | -                               | -          |
| Carpelan et al[43]  | 2018 | Retro-case | ELAPE/A PR            | 42/27 | 24/41, P = 0.136 | 10/22, P = 0.134      | 7/19, P = 0.247             | 45/30, P = -                   | -                      | -                    | -                               | 5/4, P > -         |
| Shen et al[44]      | 2019 | Retro-case | ELAPE/A PR            | 106/88 | 4.2/6.5, P > 0.05 | 3.8/11.25, P = 0.027   | 17.0/14.8, P = 0.009         | 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[46]. Conventional primary closure is feasible following ELAPE, but because of the large defect, it is likely to result in a high rate of perineal hernial[47]. Wang et al[48] 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[48]’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 compounded 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\(^{[29-34,36]}\).

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\(^{[42-45]}\).

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 postoperative radiotherapy. Sumrien et al\(^{[46]}\) 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\(^{[47]}\). Yang et al\(^{[48]}\) 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\(^{[49-51]}\).

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\(^{[52-54]}\). Siefert et al\(^{[55]}\) 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\(^{[56]}\) 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.
As mentioned above, compared with APR, ELAPE requires removal of more INDIVIDUALIZED TREATMENT.

Laparoscopy and robotics recently actually reduces surgical trauma and is beneficial to procedure performed under the guidance of exact anatomy, and assisted by vital pelvic floor nerves has been a concern for surgeons. We consider that ELAPE reached the same conclusions [58,59].

Other studies relating to the quality of life after ELAPE have also 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 suggested that there was no significant difference in terms of sexual dysfunction and urinary retention when compared between ELAPE and APR groups [54,55]. 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. [53,54] and Welsch et al. [53,54] 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. [53] 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. [54] 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 perineal 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. [50] 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. [50] 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.

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).

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 [30,31] did not reveal a significant difference between ELAPE and APR procedures with regards to perineal wound complications. Habr-Gama et al. [55] 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 [33]. Perineal hernia is another common complication after ELAPE, with an incidence of up to 26% with primary closure after ELAPE [54]. The use of mesh might prevent the formation of perineal hernias [50].

Sexual function, and urinary function after ELAPE have also been a major concern. Han et al. [50] 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. [55] 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 [54,55]. 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. Perineal hernia is another common complication after ELAPE, with an incidence of up to 26% with primary closure after ELAPE [54]. The use of mesh might prevent the formation of perineal hernias [50].

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.

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.\cite{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\cite{60}.

The concept of individualized surgery has also been endorsed by other colorectal surgeons. Chi et al.\cite{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.\cite{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.\cite{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.\cite{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.\cite{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\cite{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 levator ani muscle should be dissected unilaterally. This Figure is reprinted with authors' permission.

[Reference URL]
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].

REFERENCES

1. Graney MJ, Graney CM. Colorectal surgery from antiquity to the modern era. *Dis Colon Rectum* 1980; 23: 432-441 [PMID: 6980687 DOI: 10.1007/bf02586797]

2. Miles WE. A method of performing abdomino-perineal excision for carcinoma of the rectum and of the terminal portion of the pelvic colon (1908). *CA Cancer J Clin* 1971; 21: 361-364 [PMID: 5001853 DOI: 10.3322/canjclin.21.6.361]

3. Campos FG, Hah-Gama A, Nahas SC, Perez RO. Abdominoperineal excision: evolution of a centenary operation. *Dis Colon Rectum* 2012; 55: 844-853 [PMID: 22910469 DOI: 10.1097/DCR.0b013e31825ab0f7]

4. Wibe A, Syse A, Andersen E, Trelit S, Myrvold HE, Søreide O; Norwegian Rectal Cancer Group. Oncological outcomes after total mesorectal excision for cure for cancer of the lower rectum: anterior vs. abdominoperineal resection. *Dis Colon Rectum* 2004; 47: 48-58 [PMID: 14719151 DOI: 10.1007/s10350-003-0012-y]

5. Marr R, Birbeck K, Garvican J, Macklin CP, Tiffin NJ, Parsons WJ, Mapstone NP, Sebag-Montefiore D, Scott N, Johnston D, Sagar P, Finan P, Quirke P. The modern abdominoperineal excision: the next challenge after total mesorectal excision. *Ann Surg* 2005; 242: 74-82 [PMID: 15973104 DOI: 10.1097/01.sla.0000167926.60908.15]

6. Salerno G, Daniels IR, Brown G. Magnetic resonance imaging of the low rectum: defining the radiological anatomy. *Colorectal Dis* 2006; 8 Suppl 3: 10-13 [PMID: 16813585 DOI: 10.1111/j.1463-1318.2006.01063.x]

7. Morson BC, Vaughan EG, Bussey HJ. Pelvic Recurrence after Excision of Rectum for Carcinoma. *Br
Wang YL, Zhang X, Mao JJ, Zhang WQ, Dong H, Zhang FP, Dong SH, Zhang WJ, Dai Y. Application of Colorectal Dis 2018; 25: 351-352 [PMID: 18541901 DOI: 10.1209/22007.14.5961]

10 West NP, Finan PJ, Anderin C, Lindholm J, Holm T, Quirke P. Evidence of the oncologic superiority of cylindrical abdominoperineal excision for low rectal cancer. J Clin Oncol 2008; 26: 3517-3522 [PMID: 18541901 DOI: 10.1209/22007.14.5961]

11 West NP, Anderin C, Smith KJ, Holm T, Quirke P. European Extralevator Abdominoperineal Excision Study Group. Multicentre experience with extralevator abdominoperineal excision for low rectal cancer. Br J Surg 2010; 97: 588-599 [PMID: 20166891 DOI: 10.1002/bjs.6916]

12 Habr-Gama A, Saito J, Macartney F, de Campos-Lobato LF, Alemán E, Valaitis B, Gama-Rodrigues J, Perez R. Extralevator Abdominal Perineal Excision Versus Standard Abdominal Perineal Excision: Impact on Quality of the Resected Specimen and Postoperative Morbidity. World J Surg 2017; 41: 2160-2167 [PMID: 28265736 DOI: 10.1007/s00268-017-3963-1]

13 Han JG, Wang ZJ, Wei GH, Gao ZG, Yang Y, Zhao BC. Randomized clinical trial of conventional versus cylindrical abdominoperineal resection for locally advanced lower rectal cancer. Am J Surg 2012; 204: 274-282 [PMID: 22920402 DOI: 10.1016/j.amjsurg.2012.05.001]

14 Lehtonen T, Räsänen M, Carpelan-Holmström M, Leppistö A. Oncological outcomes before and after the extralevator abdominoperineal excision era in rectal cancer patients treated with abdominoperineal excision in a single centre, high volume unit. Colorectal Dis 2019; 21: 183-190 [PMID: 30414461 DOI: 10.1111/cad.14465]

15 Shen Z, Bu Z, Li A, Lu J, Zhu L, Chong CS, Gao Z, Jiang K, Wang S, Li F, Xiao Y, Ji J, Ye Y. Multicenter study of surgical and oncological outcomes of extra-levator versus conventional abdominoperineal excision for lower rectal cancer. Eur J Surg Oncol 2020; 46: 115-122 [PMID: 31471089 DOI: 10.1016/j.ejso.2019.08.017]

16 Stelzer S, Hellmich G, Sims A, Kitten T, Puffer E, Zimmer J, Bleyl D, Witzigmann H. Long-term outcome of extralevator abdominoperineal excision (ELAPE) for low rectal cancer. Int J Colorectal Dis 2016; 31: 1729-1737 [PMID: 27631643 DOI: 10.1007/s00384-016-2637-z]

17 Asplund D, Haglind E, Angenete E. Outcome of extralevator abdominoperineal excision compared with standard surgery: results from a single centre. Colorectal Dis 2012; 14: 1191-1196 [PMID: 22221401 DOI: 10.1111/j.1463-1318.2012.02930.x]

18 Carpelan A, Karvonen J, Varpe P, Rantalai A, Kaljonen A, Grünnroos J, Huhlinen H. Extralevator versus standard abdominoperineal excision in locally advanced rectal cancer: a retrospective study with long-term follow-up. Int J Colorectal Dis 2018; 33: 375-381 [PMID: 29445870 DOI: 10.1007/s00384-018-2977-y]

19 Klein M, Fischer A, Rosenberg J, Gigeran J, Danish Colorectal Cancer Group. Extralevator abdominoperineal excision (ELAPE) does not result in reduced rate of tumor perforation or rate of positive circumferential resection margin: a nationwide database study. Ann Surg 2015; 261: 933-938 [PMID: 25211268 DOI: 10.1097/SLA.0b013e318221eb10]

20 Zhang Y, Wang D, Zhu L, Wang B, Ma X, Shi B, Yan Y, Zhou C. Standard versus extralevator abdominoperineal excision and oncologic outcomes for patients with distal rectal cancer: A meta-analysis. Medicine (Baltimore) 2017; 96: e9150 [PMID: 29384902 DOI: 10.1097/MD.0000000000001910]

21 Qi XY, Cui M, Liu MX, Xu K, Tan F, Yao ZD, Zhang N, Yang H, Zhang CH, Xing JD, Su XQ. Extralevator abdominoperineal excision versus abdominoperineal excision for low rectal cancer: a meta-analysis. Chin Med J (Engl) 2019; 132: 2446-2456 [PMID: 31651517 DOI: 10.1097/CMJ.0000000000005485]

22 Holm T. Abdominoperineal resection revisited: is positioning an important issue? Dis Colon Rectum 2011; 54: 921-922 [PMID: 21730778 DOI: 10.1009/dcr.0.013e318221eb680]

23 de Campos-Lobato LF, Stochli L, Dietz DW, Lavery IC, Fazio VW, Kalady MF. Prophylactic ileostomy positioning during an abdominoperineal resection for rectal cancer results in comparable oncologic outcomes. Dis Colon Rectum 2011; 54: 939-946 [PMID: 21730781 DOI: 10.1009/dcr.0.013e318221eb664]

24 Hunter A. The Prone Position for Abdominoperineal Excision: Why Not? Dis Colon Rectum 2016; 59: 357-358 [PMID: 26953996 DOI: 10.1009/dcr.0.013e318221eb534]

25 Kim YJ. Extralevator Abdominoperineal Resection in the Prone Position. Ann ColonRectal Surg 2016; 32: 1-2 [PMID: 26962527 DOI: 10.3393/ac.2016.32.1.1]

26 Sambagh M, Fumery M, Mauvais F, Regimbeau JM. The Prone Position for Performing Perineal Dissection During Extralevator Abdominoperineal Resection: A Necessary Waste of Time? Dis Colon Rectum 2016; 59: 353-356 [PMID: 26953995 DOI: 10.1009/dcr.0.013e318221eb535]

27 Zhang X, Wang Z, Liang J, Zhou Z. Transabdominal extralevator abdominoperineal excision (eELAPE) performed by laparoscopic approach with no position change. J Laparoendosc Adv Surg Techn A 2015; 25: 202-206 [PMID: 25658808 DOI: 10.1089/lap.2014.0413]

28 Buchs NC, Kraus R, Mortensen NJ, Cunningham C, George B, Jones O, Guy R, Asplund D, Bangalore S, Lindsey I, Hompes R. Endoscopically assisted extralevator abdominoperineal excision. Colorectal Dis 2015; 17: 0277-0280 [PMID: 26452256 DOI: 10.1111/cod.12344]

29 Sieffert M, Ouellette J, Johnson M, Hicks T, Hallman M. Novel technique of robotic extralevator abdominoperineal resection with gracilis flap closure. Int J Med Robot 2017; 13: e1764 [PMID: 27436066 DOI: 10.1002/rcs.1764]

30 Sayers AE, Patel RK, Hunter IA. Perineal hernia formation following extralevator abdominoperineal excision. Colorectal Dis 2015; 17: 351-355 [PMID: 25413255 DOI: 10.1111/cod.12345]

31 Eftaiha SM, Pai A, Sulo S, Park JH, Prasad LM, Marecsek SJ. Robot-Assisted Abdominoperineal Resection: Clinical, Pathologic, and Oncologic Outcomes. Dis Colon Rectum 2016; 59: 607-614 [PMID: 27270512 DOI: 10.1009/dcr.0.013e318221eb610]

32 Foster JD, Tou S, Curtis NJ, Smith NJ, Achenes A, Maxwell-Armstrong C, Watts A, Singh B, Francis NK. Closure of the perineal defect after abdominoperineal excision for rectal adenocarcinoma - ACPGBI Position Statement. Colorectal Dis 2018; 20 Suppl 5: 5-23 [PMID: 30182511 DOI: 10.1111/cod.14348]

33 Wang YL, Zhang X, Mao JJ, Zhang WQ, Dong H, Zhang FP, Dong SH, Zhang WJ, Dai Y. Application of modified primary closure of the pelvic floor in laparoscopic extralevator abdominoperineal excision for low rectal cancer. World J Gastroenterol 2018; 24: 3440-3447 [PMID: 30122882 DOI: 10.3748/wjg.v24.i30.3440]
Chasapi M, Maher M, Mitchell P, Dalal M. The Perineal Turnover Perforator Flap: A New and Simple Technique for Perineal Reconstruction After Extravesical Abdominoperineal Excision. *Ann Plast Surg* 2018; 80: 395-399 [PMID: 29166213 DOI: 10.1097/SAP.0000000000001267]

Hellinga J, Khoe PC, van Etten B, Hemmer PH, Havenga K, Sterenborg MW, Eltaher Y. Fasciocutaneous Lotus Petal Flap for Perineal Wound Reconstruction after Extravesical Abdominoperineal Excision: Application for Reconstruction of the Pelvic Floor and Creation of a Neovagina. *Ann Surg Oncol* 2016; 23: 4073-4079 [PMID: 27338743 DOI: 10.1245/s10434-016-5332-y]

Anderlini C, Martiing A, Lagergren J, Ljung A, Holm T. Short-term outcome after gluteus maximus myocutaneous flap reconstruction of the pelvic floor following extravesical abdominoperineal excision of the rectum. *Colorectal Dis* 2012; 14: 1060-1064 [PMID: 21981319 DOI: 10.1111/j.1463-1318.2011.02848.x]

Han JG, Wang ZJ, Gao ZG, Xu HM, Yang ZH, Jin ML. Pelvic floor reconstruction using human acellular dermal matrix after cylindrical abdominoperineal resection. *Dis Colon Rectum* 2010; 53: 219-223 [PMID: 19867998 DOI: 10.1007/DCR.0b013e3181715585]

Han JG, Wang ZJ, Gao ZG, Wei GH, Yang Y, Zhai ZW, Zhao BC, Yi BQ. Perineal Wound Complications After Extravesical Abdominoperineal Excision for Low Rectal Cancer. *Dis Colon Rectum* 2019; 62: 1477-1484 [PMID: 31567926 DOI: 10.1097/DCR.0000000000001497]

Masters GD, Klaver CEL, Boekel RJ, Burger JW, van Deijvendijk P, van Etten B, van Geloven AW, de Graaf EJR, Hoff C, Leijten JWA, Rutten HJT, Singh B, Vuyksteke RCLJM, de Wilt JHW, Dijkgraaf MGW, Bemelman WA, Tanis PJ. Biological Mesh Closure of the Pelvic Floor After Extravesical Abdominoperineal Resection for Rectal Cancer: A Multicenter Randomized Controlled Trial (the BIOPENX-Study). *Ann Surg* 2017; 365: 1074-1081 [PMID: 27768621 DOI: 10.1097/SLA.0000000000002202]

Thomas PW, Blackwell JEM, Herrod PJJ, Peacock O, Singh R, Williams JP, Hurst NG, Speake WJ, Bhatta A, Lund J. Long-term outcomes of biological mesh repair following extravesical abdominoperineal excision of the rectum: an observational study of 100 patients. *Tech Coloproctol* 2019; 23: 761-767 [PMID: 31392530 DOI: 10.1007/s10155-019-02056-0]

Marshall MJ, Smart NJ, Daniels IR. Biologic meshes in perineal reconstruction following extravesical abdominoperineal excision (elAPE). *Colorectal Dis* 2012; 14 Suppl 3: 12-18 [PMID: 23136819 DOI: 10.1111/codi.12044]

Rutegárd M, Rutegárd J, Haapamäki MM. Multicentre, randomised trial comparing acellular porcine collagen implant versus glutes maximus myocutaneous flap for reconstruction of the pelvic floor after extended abdominoperineal excision of rectum: study protocol for the Extended Abdominoperineal Excision (NEAPEX) study. *BMJ Open* 2019; 9: e027255 [PMID: 31147361 DOI: 10.1136/bmjopen-2018-027255]

Sumrrien H, Newman P, Burt C, McCarthy K, Dixon A, Pallyblank A, Lyons A. The use of a negative pressure wound management system in perineal wound closure after extravesical abdominoperineal excision (ELAPE) for low rectal cancer. *Tech Coloproctol* 2016; 20: 627-631 [PMID: 27380256 DOI: 10.1007/s10155-016-1495-6]

Kipling SL, Young K, Foster JD, Smart NJ, Hunter AE, Cooper E, Francis NK. Laparoscopic extravesical abdominoperineal excision of the rectum: short-term outcomes of a prospective case series. *Tech Coloproctol* 2014; 18: 445-451 [PMID: 24981545 DOI: 10.1007/10155-013-1701-2]

Yang X, Jin C, Deng X, Wang M, Zhang Y, Wei M, Meng W, Wang Z. Laparoscopic Extravesical Abdominoperineal Resection of the Rectum with Primary Suturing: Short-Term Outcomes from Single-Institution Study. *J Laparoendosc Adv Surg Tech A* 2016; 26: 40-46 [PMID: 26779723 DOI: 10.1089/laa.2015.0325]

Chi P, Chen ZF, Lin HM, Lu XR, Huang Y. Laparoscopic extravesical abdominoperineal resection for rectal carcinoma with transabdominal levator transection. *Ann Surg Oncol* 2013; 20: 1560-1566 [PMID: 23054115 DOI: 10.1245/s10434-012-2675-x]

Baird DLH, Simillics C, Kontouvakis C, Sheng Q, Nikolou C, Law WL, Rasheed S, Tekkis PP. A systematic review of transabdominal levator division during abdominoperineal excision (APER). *Ann Surg Oncol* 2013; 20: 2997-3006 [PMID: 25904132 DOI: 10.1111/codi.12921]

De Nardi P, Summo V, Vignali A, Capretti G. Standard versus extravesical abdominoperineal low rectal cancer excision outcomes: a systematic review and meta-analysis. *Ann Surg Oncol* 2015; 22: 2997-3006 [PMID: 26500518 DOI: 10.1245/s10434-015-4366-8]

Masters GD, Buskens CJ, Bemelman WA, Tanis PJ. Perineal wound healing after abdominoperineal resection for rectal cancer: a systematic review and meta-analysis. *Dis Colon Rectum* 2014; 57: 1129-1139 [PMID: 25101610 DOI: 10.1097/DCR.0000000000000182]

Han JG, Wang ZJ, Qian Q, Dai Y, Zhang QZ, Yang JS, Li F, Xi XB. A prospective multicenter clinical study of extravesical abdominoperineal resection for locally advanced low rectal cancer. *Dis Colon Rectum* 2014; 57: 1333-1340 [PMID: 25379997 DOI: 10.1097/DCR.0b013e318277d8c2]

Kamali D, Sharpe A, Mishaba A, Reddy A. Oncological and quality of life outcomes following extravesical abdominoperineal resection for rectal cancer. *Ann R Coll Surg Engl* 2014; 96: 402-409 [PMID: 23842642 DOI: 10.1016/j.annrcs.2017.0038]

Shen Z, Ye Y, Zhang X, Xie Q, Yin M, Yang X, Jiang K, Liang B, Wang S. Prospective controlled study of the safety and oncological outcomes of ELAPE procure with definitive anatomic landmarks versus conventional APE for lower rectal cancer. *Eur J Surg Oncol* 2015; 41: 472-477 [PMID: 25699773 DOI: 10.1016/j.ejso.2015.01.017]

Welsch T, Mateagakis V, Conti P, Kulu Y, Büchler MW, Ulrich A. Results of extravesical abdominoperineal resection for low rectal cancer including quality of life and long-term wound complications. *Int J Colorectal Dis* 2013; 28: 503-510 [PMID: 23178992 DOI: 10.1007/s00384-012-1611-7]
Wang YL, Dai Y, Jiang JB, Yuan HY, Hu SY. Application of laparoscopic extralevator abdominoperineal excision in locally advanced low rectal cancer. Chin Med J (Engl) 2015; 128: 1340-1345 [PMID: 25963355 DOI: 10.4103/0366-6999.156779]

Vaughan-Shaw PG, Cheung T, Knight JS, Nichols PH, Pilkington SA, Mirnezami AH. A prospective case-control study of extralevator abdominoperineal excision (ELAPE) of the rectum versus conventional laparoscopic and open abdominoperineal excision: comparative analysis of short-term outcomes and quality of life. Tech Coloproctol 2012; 16: 355-362 [PMID: 22777690 DOI: 10.1007/s10151-012-0851-4]

Vaughan-Shaw PG, King AT, Cheung T, Beck NE, Knight JS, Nichols PH, Nugent KP, Pilkington SA, Smallwood JA, Mirnezami AH. Early experience with laparoscopic extralevator abdominoperineal excision within an enhanced recovery setting: analysis of short-term outcomes and quality of life. Ann R Coll Surg Engl 2011; 93: 451-459 [PMID: 21929915 DOI: 10.1308/003588411X588621]

Zheng Y, Han JG, Wang ZJ, Gao ZG, Wei GH, Zhai ZW, Zhao BC. Preliminary Outcome of Individualized Abdominoperineal Excision for Locally Advanced Low Rectal Cancer. Chin Med J (Engl) 2018; 131: 1268-1274 [PMID: 29786037 DOI: 10.4103/0366-6999.232810]

Park EJ, Baik SH, Kang J, Hur H, Min BS, Lee KY, Kim NK, Sohn SK. Short-term outcomes of the modified extralevator abdominoperineal resection for low rectal cancer (with videos). Surg Endosc 2016; 30: 1672-1682 [PMID: 26183956 DOI: 10.1007/s00464-015-4400-x]

Pai A, Eftaiha SM, Melich G, Park JJ, Lin PK, Prasad LM, Marecik SJ. Robotic Site Adjusted Levator Transection for Carcinoma of the Rectum: A Modification of the Existing Cylindrical Abdominoperineal Resection for Eccentrically Located Tumors. World J Surg 2017; 41: 590-595 [PMID: 27778072 DOI: 10.1007/s00268-016-3735-3]

Han JG, Wang ZJ, Wei GH, Zhai ZW, Zhai BC. Trans-perineal minimally invasive approach during extralevator abdominoperineal excision for advanced low rectal cancer: A retrospective cohort study. Asian J Surg 2020 [PMID: 31982269 DOI: 10.1016/j.asjsur.2019.11.004]

Farag A. Postanal minimally invasive surgery "PAMIS" assisted extra-levator abdominoperineal excision "ELAPE" for cancer: A novel approach in supine position. Arab J Gastroenterol 2019; 20: 53-55 [PMID: 30702621 DOI: 10.1016/j.ajg.2019.02.001]

Hasegawa S, Okada T, Hida K, Kawada K, Sakai Y. Transperineal minimally invasive approach for extralevator abdominoperineal excision. Surg Endosc 2016; 30: 4620-4621 [PMID: 26718358 DOI: 10.1007/s00464-015-4736-2]

Ortiz H, Ciga MA, Armendariz P, Kreisler E, Codina-Cazador A, Gomez-Barbadillo J, Garcia-Granero E, Rong JV, Biondo S; Spanish Rectal Cancer Project. Multicentre propensity score-matched analysis of conventional versus extended abdominoperineal excision for low rectal cancer. Br J Surg 2014; 101: 874-882 [PMID: 24817654 DOI: 10.1002/bjs.9522]

Prytz M, Angenete E, Bock D, Haglund E. Extralevator Abdominoperineal Excision for Low Rectal Cancer–Extensive Surgery to be Used With Discretion Based on 3-Year Local Recurrence Results: A Registry-based, Observational National Cohort Study. Ann Surg 2016; 263: 516-521 [PMID: 25906414 DOI: 10.1097/SLA.0000000000001237]
