

World Journal of *Gastroenterology*

World J Gastroenterol 2020 June 14; 26(22): 2889-3117



**OPINION REVIEW**

- 2889** Circulating exosomal miRNAs as potential biomarkers for Barrett's esophagus and esophageal adenocarcinoma
Lv J, Zhao HP, Dai K, Cheng Y, Zhang J, Guo L

REVIEW

- 2902** Ever-increasing diversity of drug-induced pancreatitis
Weissman S, Aziz M, Perumpail RB, Mehta TI, Patel R, Tabibian JH
- 2916** Nutrition in alcohol-related liver disease: Physiopathology and management
Kamran U, Towey J, Khanna A, Chauhan A, Rajoriya N, Holt A
- 2931** Liver-related effects of chronic hepatitis C antiviral treatment
Laursen TL, Sandahl TD, Kazankov K, George J, Grønbaek H
- 2948** Regenerative medicine of pancreatic islets
Arutyunyan IV, Fatkhudinov TK, Makarov AV, Elchaninov AV, Sukhikh GT
- 2967** Benign gallbladder diseases: Imaging techniques and tips for differentiating with malignant gallbladder diseases
Yu MH, Kim YJ, Park HS, Jung SI

MINIREVIEWS

- 2987** COVID-19 pandemic: Its impact on liver disease and liver transplantation
Sahin TT, Akbulut S, Yilmaz S
- 3000** Diagnostic challenges in non-cirrhotic portal hypertension - porto sinusoidal vascular disease
Nicoară-Farcău O, Rusu I, Ștefănescu H, Tanțău M, Badea RI, Procopeț B
- 3012** Extralevator abdominoperineal excision for advanced low rectal cancer: Where to go
Tao Y, Han JG, Wang ZJ

ORIGINAL ARTICLE**Basic Study**

- 3024** High plasma levels of COL10A1 are associated with advanced tumor stage in gastric cancer patients
Necula L, Matei L, Dragu D, Pitica I, Neagu AI, Bleotu C, Dima S, Popescu I, Diaconu CC, Chivu-Economescu M

- 3034** Hsa_circRNA_102610 upregulation in Crohn's disease promotes transforming growth factor- β 1-induced epithelial-mesenchymal transition *via* sponging of hsa-miR-130a-3p
Yin J, Ye YL, Hu T, Xu LJ, Zhang LP, Ji RN, Li P, Chen Q, Zhu JY, Pang Z

- 3056** Optimal dosing time of Dachengqi decoction for protection of extrapancreatic organs in rats with experimental acute pancreatitis
Yao JQ, Zhu L, Miao YF, Zhu L, Chen H, Yuan L, Hu J, Yi XL, Wu QT, Yang XJ, Wan MH, Tang WF

Case Control Study

- 3076** Single-nucleotide polymorphisms based genetic risk score in the prediction of pancreatic cancer risk
Wang XY, Chen HT, Na R, Jiang DK, Lin XL, Yang F, Jin C, Fu DL, Xu JF

Retrospective Study

- 3087** Infection recurrence following minimally invasive treatment in patients with infectious pancreatic necrosis
Gao CC, Li J, Cao F, Wang XH, Li A, Wang Z, Li F

Observational Study

- 3098** Intestinal dysbiosis in pediatric Crohn's disease patients with *IL10RA* mutations
Xue AJ, Miao SJ, Sun H, Qiu XX, Wang SN, Wang L, Ye ZQ, Zheng CF, Huang ZH, Wang YH, Huang Y

CASE REPORT

- 3110** Giant splenic artery aneurysm presenting with massive upper gastrointestinal bleeding: A case report and review of literature
Panzer F, Inchingolo R, Rizzi M, Biscaglia A, Schievenin MG, Tallarico E, Pacifico G, Di Venere B

ABOUT COVER

Editorial Board Member of *World Journal of Gastroenterology*, Michele Barone, MD, PhD, Adjunct Professor, Research Associate, Section of Gastroenterology, Department of Emergency and Organ Transplantation, University of Bari, Bari 70124, Italy

AIMS AND SCOPE

The primary aim of *World Journal of Gastroenterology* (WJG, *World J Gastroenterol*) is to provide scholars and readers from various fields of gastroenterology and hepatology with a platform to publish high-quality basic and clinical research articles and communicate their research findings online.

WJG mainly publishes articles reporting research results and findings obtained in the field of gastroenterology and hepatology and covering a wide range of topics including gastroenterology, hepatology, gastrointestinal endoscopy, gastrointestinal surgery, gastrointestinal oncology, and pediatric gastroenterology.

INDEXING/ABSTRACTING

The WJG is now indexed in Current Contents®/Clinical Medicine, Science Citation Index Expanded (also known as SciSearch®), Journal Citation Reports®, Index Medicus, MEDLINE, PubMed, PubMed Central, and Scopus. The 2019 edition of Journal Citation Report® cites the 2018 impact factor for WJG as 3.411 (5-year impact factor: 3.579), ranking WJG as 35th among 84 journals in gastroenterology and hepatology (quartile in category Q2). CiteScore (2018): 3.43.

RESPONSIBLE EDITORS FOR THIS ISSUE

Responsible Electronic Editor: *Yan-Liang Zhang*

Proofing Production Department Director: *Yun-Xiaojuan Wu*

Responsible Editorial Office Director: *Ze-Mao Gong*

NAME OF JOURNAL

World Journal of Gastroenterology

ISSN

ISSN 1007-9327 (print) ISSN 2219-2840 (online)

LAUNCH DATE

October 1, 1995

FREQUENCY

Weekly

EDITORS-IN-CHIEF

Subrata Ghosh, Andrzej S Tarnawski

EDITORIAL BOARD MEMBERS

<http://www.wjgnet.com/1007-9327/editorialboard.htm>

PUBLICATION DATE

June 14, 2020

COPYRIGHT

© 2020 Baishideng Publishing Group Inc

INSTRUCTIONS TO AUTHORS

<https://www.wjgnet.com/bpg/gerinfo/204>

GUIDELINES FOR ETHICS DOCUMENTS

<https://www.wjgnet.com/bpg/GerInfo/287>

GUIDELINES FOR NON-NATIVE SPEAKERS OF ENGLISH

<https://www.wjgnet.com/bpg/gerinfo/240>

PUBLICATION ETHICS

<https://www.wjgnet.com/bpg/GerInfo/288>

PUBLICATION MISCONDUCT

<https://www.wjgnet.com/bpg/gerinfo/208>

ARTICLE PROCESSING CHARGE

<https://www.wjgnet.com/bpg/gerinfo/242>

STEPS FOR SUBMITTING MANUSCRIPTS

<https://www.wjgnet.com/bpg/GerInfo/239>

ONLINE SUBMISSION

<https://www.f6publishing.com>



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

Yu Tao, Jia-Gang Han, Zhen-Jun Wang, Department of General Surgery, Beijing Chaoyang Hospital, Capital Medical University, Beijing 100020, China

Corresponding author: Jia-Gang Han, MD, Professor, Department of General Surgery, Beijing Chaoyang Hospital, Capital Medical University, No. 8 Gongtinan Road, Chaoyang District, Beijing 100020, China. hjg211@163.com

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,

Published online: June 14, 2020**P-Reviewer:** Anand A, Espín-Basany E, Rutegard J**S-Editor:** Wang JL**L-Editor:** MedE-Ma JY**E-Editor:** Zhang YL

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

Citation: Tao Y, Han JG, Wang ZJ. Extralevator abdominoperineal excision for advanced low rectal cancer: Where to go. *World J Gastroenterol* 2020; 26(22): 3012-3023

URL: <https://www.wjgnet.com/1007-9327/full/v26/i22/3012.htm>

DOI: <https://dx.doi.org/10.3748/wjg.v26.i22.3012>

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	<i>n</i>	CRM+(%)	IOP(%)	Local recurr- ence(%)	Perineal wound compl- ications (%)	Urinary retention (%)	Sexual dysfunc- tion (%)	Chronic perineal pain (%)	QoL scores
West <i>et al</i> ^[11]	2010	Retro case- control	ELAPE/A PR	176/124	20.3/49.6, <i>P</i> < 0.001	8.2/28.3, <i>P</i> < 0.001	-	38/20, <i>P</i> = 0.019	46/17, <i>P</i> = 0.579	46/33, <i>P</i> = 0.192	-	-
Han <i>et al</i> ^[13]	2012	RCT	ELAPE/A PR	35/32	5.7/28.1	5.7/15.6, <i>P</i> = 0.246	2.8/18.8, <i>P</i> = 0.048	37.1/31.3 <i>P</i> = 0.612	40/28.1, <i>P</i> = 0.307	74/60, <i>P</i> = 0.306	51.4/6.3, <i>P</i> < 0.001	-
Asplund <i>et al</i> ^[17]	2012	Retro case- control	ELAPE/A PR	79/79	17/20, <i>P</i> = 0.647	13/10, <i>P</i> > 0.05	9/9, <i>P</i> = 1	46/28, <i>P</i> < 0.05	-	-	-	-
Vaughan -Shaw <i>et al</i> ^[58]	2012	Pro case- control	ELAPE/L APR/OA PR	16/10/10	0/1/2, <i>P</i> > 0.05	0/0/1, <i>P</i> > 0.05	-	2/5/2, <i>P</i> = 0.21	3/2/2, <i>P</i> = 0.99	-	-	85.4/77.5/ 78.5, <i>P</i> > 0.05
Ortiz <i>et al</i> ^[66]	2014	Retro case- control	ELAPE/A PR	457/457	13.6/13.1, <i>P</i> > 0.846	7.7/7.9, <i>P</i> > 0.902	5.6/2.7, <i>P</i> > 0.664	21.9/26, <i>P</i> > 0.141	-	-	-	-
Shen <i>et al</i> ^[55]	2015	Pro case- control	ELAPE/A PR	36/33	4/12, <i>P</i> = 0.297	5.6/21.2, <i>P</i> = 0.028	0/15.2, <i>P</i> < 0.034	8.3/27.3, <i>P</i> = 0.039	11.1/3, <i>P</i> = 0.359	11.8/36.4, <i>P</i> = 0.127	-	<i>P</i> > 0.05
Wang <i>et al</i> ^[57]	2015	Retro case- control	ELAPE/A PR	23/25	4.3/28, <i>P</i> = 0.028	0/20, <i>P</i> = 0.023	8.7/32, <i>P</i> = 0.047	39.1/24, <i>P</i> = 0.259	26.1/12, <i>P</i> = 0.212	60/37.5, <i>P</i> = 0.210	47.8/8, <i>P</i> = 0.002	<i>P</i> > 0.05
Klein <i>et al</i> ^[19]	2015	Retro case- control	ELAPE/A PR	301/253	16/7, <i>P</i> = 0.001	2/3, <i>P</i> = 0.373	-	14/10, <i>P</i> = 0.143	-	-	-	-
Prytz <i>et al</i> ^[67]	2016	Pro case- control	ELAPE/A PR	518/209	41.5/38.4, <i>P</i> < 0.0001	<i>P</i> < 0.001	<i>P</i> < 0.001	<i>P</i> < 0.001	-	-	-	-
Stelzner <i>et al</i> ^[16]	2016	Pro case- control	ELAPE/A PR	36/36	2.9/2.8, <i>P</i> = 1	0/16.7, <i>P</i> = 0.025	5.9/18.2, <i>P</i> = 0.153	16.7/36.1, <i>P</i> = 0.061	-	-	-	-
Kamali <i>et al</i> ^[54]	2017	Pro case- control	ELAPE/A PR	27/21	7.4/9.5, <i>P</i> = 0.50	-	3.7/4.7, <i>P</i> = 1	37/24, <i>P</i> > 0.05	-	-	-	77.3/65.3, <i>P</i> = 0.27
Habr- Gama <i>et al</i> ^[12]	2017	Retro case- control	ELAPE/A PR	22/50	13.6/16.6, <i>P</i> = 0.70	0/8, <i>P</i> = 0.30	4.5/28.6, <i>P</i> = 0.01	22.7/46, <i>P</i> = 0.007	-	-	-	-
Carpelan <i>et al</i> ^[18]	2018	Retro case- control	ELAPE/A PR	42/27	24/41, <i>P</i> = 0.136	10/22, <i>P</i> = 0.134	7/19, <i>P</i> = 0.247	45/30, <i>P</i> = 0.195	-	-	5/4, <i>P</i> > 0.05	-
Shen <i>et al</i> ^[15]	2019	Retro case- control	ELAPE/A PR	106/88	4.2/6.5, <i>P</i> > 0.05	-	3.8/11.25, <i>P</i> = 0.027	17.0/14.8, <i>P</i> = 0.699	7.5/3.4, <i>P</i> = 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* 10 719 US 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*^[58] 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 ischioanal 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.

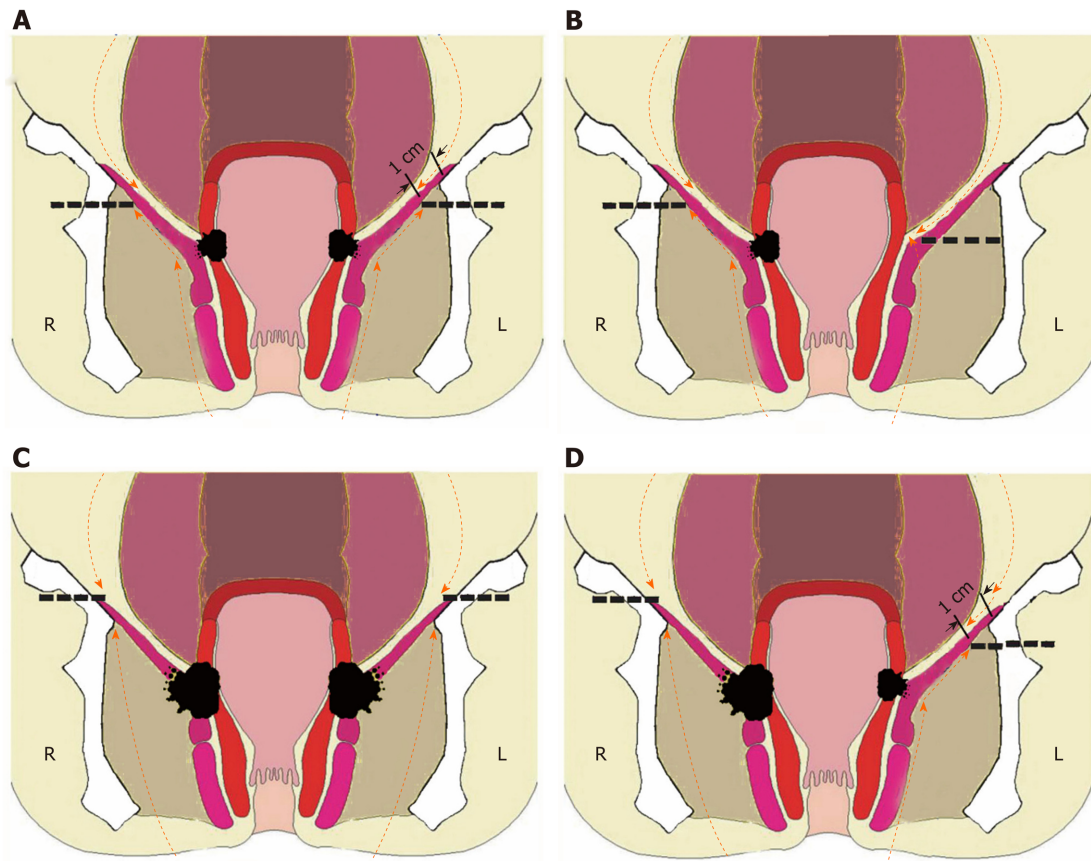


Figure 1 Individualized extralevator abdominoperineal excision procedure. A: Tumor not involving the ischioanal fat or levator ani muscle (T3), leave 1 cm of the levator ani muscles on the pelvic sidewall; B: Tumor located at one side (T3), levator ani muscle on the other side may be left; C: Tumor penetrating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

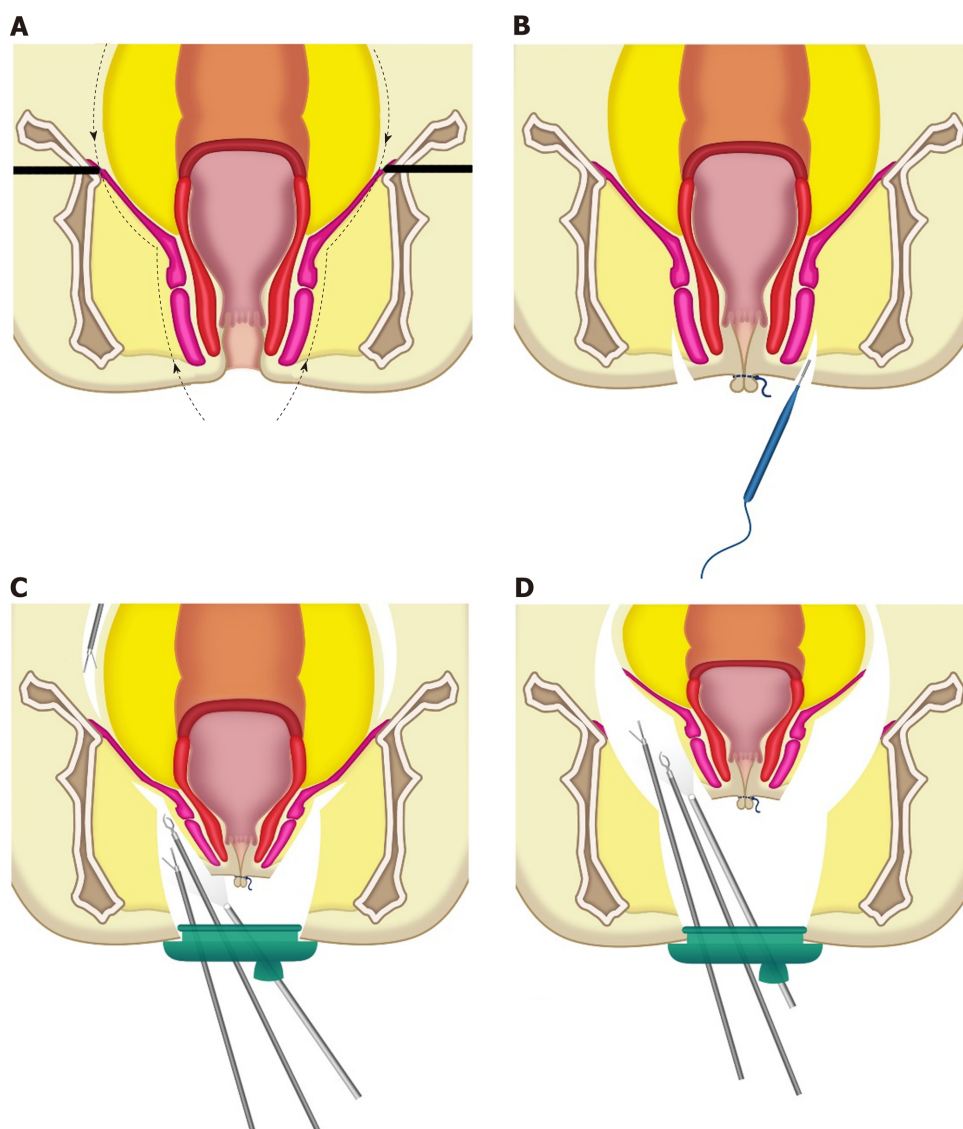


Figure 2 Trans-perineal minimally invasive approach for extralevator abdominoperineal excision procedure. A: The resection line of transperineal extralevator abdominoperineal excision; B: The anus was closed with a purse-string suture and an incision was made around the anus; C: The dissection was continued 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].

REFERENCES

- 1 Graney MJ, Graney CM. Colorectal surgery from antiquity to the modern era. *Dis Colon Rectum* 1980; **23**: 432-441 [PMID: 6998687 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, Habr-Gama A, Nahas SC, Perez RO. Abdominoperineal excision: evolution of a centenary operation. *Dis Colon Rectum* 2012; **55**: 844-853 [PMID: 22810469 DOI: 10.1097/DCR.0b013e31825ab0f7]
- 4 Wibe A, Syse A, Andersen E, Tretli 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, Dixon MF, 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*

- Med J* 1963; **2**: 13-18 [PMID: 20789881 DOI: 10.1136/bmj.2.5348.13]
- 8 **Salerno G**, Chandler I, Wotherspoon A, Thomas K, Moran B, Brown G. Sites of surgical wasting in the abdominoperineal specimen. *Br J Surg* 2008; **95**: 1147-1154 [PMID: 18690619 DOI: 10.1002/bjs.6231]
- 9 **Holm T**, Ljung A, Häggmark T, Jurell G, Lagergren J. Extended abdominoperineal resection with gluteus maximus flap reconstruction of the pelvic floor for rectal cancer. *Br J Surg* 2007; **94**: 232-238 [PMID: 17143848 DOI: 10.1002/bjs.5489]
- 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: 10.1200/JCO.2007.14.5961]
- 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: 20186891 DOI: 10.1002/bjs.6916]
- 12 **Habr-Gama A**, São Julião GP, Mattacheo A, de Campos-Lobato LF, Aleman E, Vailati BB, Gama-Rodrigues J, Perez RO. 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, Lepistö 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: 30411461 DOI: 10.1111/codi.14468]
- 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 oncologic 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 **Stelzner S**, Hellmich G, Sims A, Kittner 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, Rantala A, Kaljonen A, Grönroos J, Huhtinen 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, Gögenur I; Danish Colorectal Cancer Group (DCCG). 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.0000000000000910]
- 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.00000000000009150]
- 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/CM9.0000000000000485]
- 22 **Holm T**. Abdominoperineal resection revisited: is positioning an important issue? *Dis Colon Rectum* 2011; **54**: 921-922 [PMID: 21730778 DOI: 10.1097/DCR.0b013e318221eb80]
- 23 **de Campos-Lobato LF**, Stocchi L, Dietz DW, Lavery IC, Fazio VW, Kalady MF. Prone or lithotomy positioning during an abdominoperineal resection for rectal cancer results in comparable oncologic outcomes. *Dis Colon Rectum* 2011; **54**: 939-946 [PMID: 21730781 DOI: 10.1097/DCR.0b013e318221eb64]
- 24 **Hunter A**. The Prone Position for Abdominoperineal Excision: Why Not? *Dis Colon Rectum* 2016; **59**: 357-358 [PMID: 26953996 DOI: 10.1097/DCR.0000000000000534]
- 25 **Kim YJ**. Extralevator Abdominoperineal Resection in the Prone Position. *Ann Coloproctol* 2016; **32**: 1-2 [PMID: 26962527 DOI: 10.3393/ac.2016.32.1.1]
- 26 **Sabbagh C**, 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: 10.1097/DCR.0000000000000535]
- 27 **Zhang X**, Wang Z, Liang J, Zhou Z. Transabdominal extralevator abdominoperineal excision (eLAPE) performed by laparoscopic approach with no position change. *J Laparoendosc Adv Surg Tech 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, Ashraf S, Lindsey I, Hompes R. Endoscopically assisted extralevator abdominoperineal excision. *Colorectal Dis* 2015; **17**: O277-O280 [PMID: 26454256 DOI: 10.1111/codi.13144]
- 29 **Sieffert M**, Ouellette J, Johnson M, Hicks T, Hellan 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/codi.12843]
- 31 **Eftaiha SM**, Pai A, Sulo S, Park JJ, Prasad LM, Marecik SJ. Robot-Assisted Abdominoperineal Resection: Clinical, Pathologic, and Oncologic Outcomes. *Dis Colon Rectum* 2016; **59**: 607-614 [PMID: 27270512 DOI: 10.1097/DCR.0000000000000610]
- 32 **Foster JD**, Tou S, Curtis NJ, Smart NJ, Acheson 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/codi.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 abdominal perineal excision for low rectal cancer. *World J Gastroenterol* 2018; **24**: 3440-3447 [PMID: 30122882 DOI: 10.3748/wjg.v24.i30.3440]

- 34 **Chasapi M**, Maher M, Mitchell P, Dalal M. The Perineal Turnover Perforator Flap: A New and Simple Technique for Perineal Reconstruction After Extralevator Abdominoperineal Excision. *Ann Plast Surg* 2018; **80**: 395-399 [PMID: [29166313](#) DOI: [10.1097/SAP.0000000000001267](#)]
- 35 **Hellinga J**, Khoe PC, van Etten B, Hemmer PH, Havenga K, Stenekes MW, Eltahir Y. Fasciocutaneous Lotus Petal Flap for Perineal Wound Reconstruction after Extralevator 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](#)]
- 36 **Anderin C**, Martling A, Lagergren J, Ljung A, Holm T. Short-term outcome after gluteus maximus myocutaneous flap reconstruction of the pelvic floor following extra-levator abdominoperineal excision of the rectum. *Colorectal Dis* 2012; **14**: 1060-1064 [PMID: [21981319](#) DOI: [10.1111/j.1463-1318.2011.02848.x](#)]
- 37 **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: [20087098](#) DOI: [10.1007/DCR.0b013e3181b715b5](#)]
- 38 **Han JG**, Wang ZJ, Gao ZG, Wei GH, Yang Y, Zhai ZW, Zhao BC, Yi BQ. Perineal Wound Complications After Extralevator Abdominoperineal Excision for Low Rectal Cancer. *Dis Colon Rectum* 2019; **62**: 1477-1484 [PMID: [31567926](#) DOI: [10.1097/DCR.0000000000001495](#)]
- 39 **Musters GD**, Klaver CEL, Bosker RJI, Burger JWA, van Etten B, van Geloven AAW, de Graaf EJ, Hoff C, Leijtens JWA, Rutten HJT, Singh B, Vuylsteke RJCLM, de Wilt JHW, Dijkgraaf MGW, Bemelman WA, Tanis PJ. Biological Mesh Closure of the Pelvic Floor After Extralevator Abdominoperineal Resection for Rectal Cancer: A Multicenter Randomized Controlled Trial (the BIOPEX-study). *Ann Surg* 2017; **265**: 1074-1081 [PMID: [27768621](#) DOI: [10.1097/SLA.0000000000002020](#)]
- 40 **Thomas PW**, Blackwell JEM, Herrod PJJ, Peacock O, Singh R, Williams JP, Hurst NG, Speake WJ, Bhalla A, Lund JN. Long-term outcomes of biological mesh repair following extra levator abdominoperineal excision of the rectum: an observational study of 100 patients. *Tech Coloproctol* 2019; **23**: 761-767 [PMID: [31392530](#) DOI: [10.1007/s10151-019-02056-0](#)]
- 41 **Marshall MJ**, Smart NJ, Daniels IR. Biologic meshes in perineal reconstruction following extra-levator abdominoperineal excision (eLAPE). *Colorectal Dis* 2012; **14** Suppl 3: 12-18 [PMID: [23136819](#) DOI: [10.1111/codi.12044](#)]
- 42 **Rutegård M**, Rutegård J, Haapamäki MM. Multicentre, randomised trial comparing acellular porcine collagen implant versus gluteus maximus myocutaneous flap for reconstruction of the pelvic floor after extended abdominoperineal excision of rectum: study protocol for the Nordic Extended Abdominoperineal Excision (NEAPE) study. *BMJ Open* 2019; **9**: e027255 [PMID: [31147361](#) DOI: [10.1136/bmjopen-2018-027255](#)]
- 43 **Sumrien H**, Newman P, Burt C, McCarthy K, Dixon A, Pullyblank A, Lyons A. The use of a negative pressure wound management system in perineal wound closure after extralevator abdominoperineal excision (ELAPE) for low rectal cancer. *Tech Coloproctol* 2016; **20**: 627-631 [PMID: [27380256](#) DOI: [10.1007/s10151-016-1495-6](#)]
- 44 **Kipling SL**, Young K, Foster JD, Smart NJ, Hunter AE, Cooper E, Francis NK. Laparoscopic extralevator abdominoperineal excision of the rectum: short-term outcomes of a prospective case series. *Tech Coloproctol* 2014; **18**: 445-451 [PMID: [24081545](#) DOI: [10.1007/s10151-013-1071-2](#)]
- 45 **Yang X**, Jin C, Deng X, Wang M, Zhang Y, Wei M, Meng W, Wang Z. Laparoscopic Extralevator Abdominoperineal Excision 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/lap.2015.0325](#)]
- 46 **Chi P**, Chen ZF, Lin HM, Lu XR, Huang Y. Laparoscopic extralevator 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](#)]
- 47 **Baird DLH**, Simillis C, Kontovounisios C, Sheng Q, Nikolaou S, Law WL, Rasheed S, Tekkis PP. A systematic review of transabdominal levator division during abdominoperineal excision of the rectum (APER). *Tech Coloproctol* 2017; **21**: 701-707 [PMID: [28891039](#) DOI: [10.1007/s10151-017-1682-0](#)]
- 48 **Marecik SJ**, Zawadzki M, Desouza AL, Park JJ, Abcarian H, Prasad LM. Robotic cylindrical abdominoperineal resection with transabdominal levator transection. *Dis Colon Rectum* 2011; **54**: 1320-1325 [PMID: [21904149](#) DOI: [10.1097/DCR.0b013e31822720a2](#)]
- 49 **Kamali D**, Reddy A, Imam S, Omar K, Jha A, Jha M. Short-term surgical outcomes and patient quality of life between robotic and laparoscopic extralevator abdominoperineal excision for adenocarcinoma of the rectum. *Ann R Coll Surg Engl* 2017; **99**: 607-613 [PMID: [29022779](#) DOI: [10.1308/rcsann.2017.0093](#)]
- 50 **Zhou X**, Sun T, Xie H, Zhang Y, Zeng H, Fu W. Extralevator abdominoperineal excision for low rectal cancer: a systematic review and meta-analysis of the short-term outcome. *Colorectal Dis* 2015; **17**: 474-481 [PMID: [25704132](#) DOI: [10.1111/codi.12921](#)]
- 51 **De Nardi P**, Summo V, Vignali A, Capretti G. Standard versus extralevator abdominoperineal low rectal cancer excision outcomes: a systematic review and meta-analysis. *Ann Surg Oncol* 2015; **22**: 2997-3006 [PMID: [25605518](#) DOI: [10.1245/s10434-015-4368-8](#)]
- 52 **Musters 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](#)]
- 53 **Han JG**, Wang ZJ, Qian Q, Dai Y, Zhang ZQ, Yang JS, Li F, Li XB. A prospective multicenter clinical study of extralevator abdominoperineal resection for locally advanced low rectal cancer. *Dis Colon Rectum* 2014; **57**: 1333-1340 [PMID: [25379997](#) DOI: [10.1097/DCR.0000000000000235](#)]
- 54 **Kamali D**, Sharpe A, Musbahi A, Reddy A. Oncological and quality of life outcomes following extralevator versus standard abdominoperineal excision for rectal cancer. *Ann R Coll Surg Engl* 2017; **99**: 402-409 [PMID: [28462642](#) DOI: [10.1308/rcsann.2017.0038](#)]
- 55 **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: [25659773](#) DOI: [10.1016/j.ejso.2015.01.017](#)]
- 56 **Welsch T**, Mategakis V, Contin P, Kulu Y, Büchler MW, Ulrich A. Results of extralevator 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](#)]

- 57 **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]
- 58 **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]
- 59 **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]
- 60 **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]
- 61 **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]
- 62 **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]
- 63 **Han JG**, Wang ZJ, Wei GH, Zhai ZW, Zhao 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]
- 64 **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: 30770261 DOI: 10.1016/j.ajg.2019.02.001]
- 65 **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]
- 66 **Ortiz H**, Ciga MA, Armendariz P, Kreisler E, Codina-Cazador A, Gomez-Barbadillo J, Garcia-Granero E, Roig 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]
- 67 **Prytz M**, Angenete E, Bock D, Haglind 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]



Published by Baishideng Publishing Group Inc
7041 Koll Center Parkway, Suite 160, Pleasanton, CA 94566, USA
Telephone: +1-925-3991568
E-mail: bpgoffice@wjgnet.com
Help Desk: <http://www.f6publishing.com/helpdesk>
<http://www.wjgnet.com>

