Surgical Endoscopy (2022) 36:1657–1665
https://doi.org/10.1007/s00464-021-08683-9

DYNAMIC MANUSCRIPT

Distinctive features of small vessels on the mesorectal and parietal pelvic fascia as important landmarks in guiding precise inter-fascial dissection for low rectal cancer

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Received: 9 January 2021 / Accepted: 7 August 2021 / Published online: 16 August 2021

Abstract

Background The confinement of the pelvis and the complexity of pelvic fascial anatomy still pose difficulties in achieving good quality surgery for rectal cancer. We aimed to introduce small vessels on the mesorectal fascia and the parietal pelvic fascia as novel landmarks to aid in the identification of the inter-fascial dissection plane. Besides, the perioperative, survival, and functional outcomes of this surgical technique were reported.

Methods We first described that small vessels running on the mesorectal fascia and the parietal pelvic fascia showed distinctive features, which included (1) small vessels on the parietal fascia took the same orientation as the ureter or the sympathetic and parasympathetic nerve; (2) small vessels on the mesorectal fascia were coursing cranially and medially on the anterolateral aspect, and medially and caudally on the posterolateral aspect; (3) small vessels on the mesorectal fascia became invisible at the interface between the pelvic wall and the mesorectal fascia. These features could be applied in fascial identification and separation. Then, we reported the outcomes of low rectal cancer surgery with small vessels-guided technique.

Results From 2013 to 2016, a consecutive series of 310 patients with low rectal cancer underwent laparoscopic total mesorectal excision with small vessels-guided technique. The positive rate of circumferential resection margin was 3.2%, and complete mesorectal excision was achieved in 97.8% (303/310) patients. The 3-year overall survival, disease-free survival, and local recurrence rates were 89.4%, 79.7%, and 2.6%, respectively. The urinary function was considered normal in 96.8% of patients, with a moderate dysfunction in 3.2% of patients. Besides, 29.5% of male patients occurred sexual function injury.

Conclusion Distinctive features of small vessels on the parietal pelvic fascia and the mesorectal fascia can serve as novel and additive landmarks in guiding precise inter-fascial dissection for low rectal cancer.

Keywords Low rectal cancer · Small vessels · Mesorectal fascia

The implementation of total mesorectal excision (TME) worldwide has improved both functional and survival outcomes dramatically [1, 2]. In addition, the optimal quality of TME surgery has also been implied to justify the avoidance of preoperative chemoradiotherapy in stage II/III rectal cancer with intermediate-risk factors [3, 4]. TME entails sharp dissection between the visceral mesorectal/mesocolic fascia and the parietal fascia to remove the entire ontogenetic mesorectal package [5]. However, the close adherence of the mesorectum, on its anterolateral aspect, to the inferior hypogastric plexus (IHP) and the neurovascular bundle of Walsh (NVB), makes a great surgical challenge. A shiny fascial covering in this area on the specimen cannot always be achieved. Heald dubbed this part of the dissection "mesorectal fat surface dissection," as no actual loose areolar tissue exists. Histological studies have also suggested that the mesorectal fascia (MRF) not only fuses with the prehypogastric nerve fascia and ventral continuation of the parietal presacral fascia at a point medial to the IHP [6] but also thins out distally or is even absent in some areas [7]. The difficulty in dissecting this area is especially real for laparoscopic surgery in obese patients due to the suboptimal retraction and lack of landmarks in differentiating adipose tissue within

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the package of MRF or NVB. The main objective of this study was to introduce small vessels (SVs) on the MRF and on the parietal pelvic fascia as novel landmarks to aid in the identification of the inter-fascial dissection plane. Besides, the perioperative, survival, and functional outcomes of this surgical technique for patients with low rectal cancer were reported.

Patients and methods

This study has been approved by the Ethics Committee of West China Hospital. The description of patterns and courses of SVs on visceral and parietal fascia came mainly from surgical observation and partly from cadaver anatomy. Low rectal cancer surgery was performed by guiding with the features of SVs since 2013. All procedures were performed by a single team of surgeons. Clinical characteristics, pathological data, survival outcomes, and functional outcomes were retrieved from our prospective colorectal cancer database. The neoadjuvant treatment and the follow-up schedule of the patients were described in great detail in our recent study [8]. The last patient follow-up was completed in January 2020.

The functional outcomes included defecation, urinary, and male sexual functions, which were collected at 6–12 months after surgery. The defecation function was assessed by the low anterior resection syndrome (LARS) score system for patients who underwent sphincter-preserving resection [9, 10]. The urinary function was assessed with the International Prostate Symptom Score (IPSS) system for all patients [11] and recording delayed removal of urinary catheter (more than seven days after surgery). The male sexual function was assessed using the International Index of Erectile Function-5 scoring system (IIEF-5) for male patients who were less than 60 years old at the time of surgery [12].

The anatomy of the direction of SVs is shown in Fig. 1.

Features of SVs on MRF and their surgical implication

After incision of the peritoneal reflection, on the anterolateral aspect of the mesorectum, SVs could be observed running in a cranial and slightly medial direction (Fig. 2A, B). On the posterolateral aspect of the mesorectum, SVs on MRF coursed medially or caudally toward the anus (Fig. 2C, D). These SVs shared several common features: (1) The cranially coursing SVs were visible only when the anterior dissection stayed in the correct plane; otherwise, in case of straying into the mesorectum, SVs would have been in the direction of the anus or toward the rectal muscular tube, with no cranially tapering ends visible. (2) The proximal parts of SVs became invisible at the interface between the pelvic wall (anterior and sidewall) and the mesorectum. Their more proximal trajectory outside of the parietal fascia was embedded within the sheath of connective tissue wrapping NVB or IHP (Fig. 2E), and when exposed, there was no tapering end (Fig. 2F). More caudally, SVs originated from or drained into vessels within NVB.

To further investigate these features of SVs, four fresh male hemi-pelvises infused with a mixture of red-colored gelatin and seven formalin-fixed male cadaveric hemi-pelvises were dissected in the Department of Human Anatomy, Sichuan University. The informed consent was obtained from their family. On the anterolateral aspect, about 4–10 SVs were observed passing through the Denonvilliers' fascia (DVF) onto the surface of the mesorectum on each side (Fig. 3A). On the lateral, SVs, varying from several to teens, passed through the pelvic plexus and entered the mesorectum at its posterolateral aspect (Fig. 3B). These SVs could originate from the inferior vesicle artery including its urethral and prostatic branches, the middle rectal artery, or the accessory middle rectal artery. A very thin layer of connective tissue was observed wrapping these SVs (Fig. 3C, D).

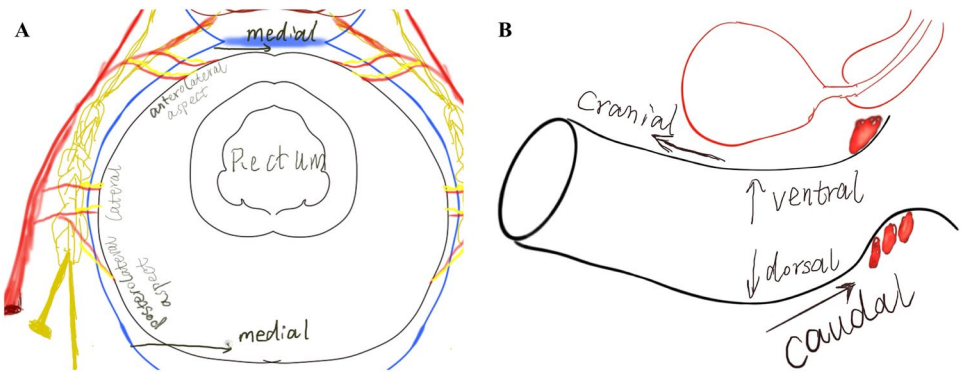

Fig. 1 The anatomy of the direction of small vessels (Color figure online)

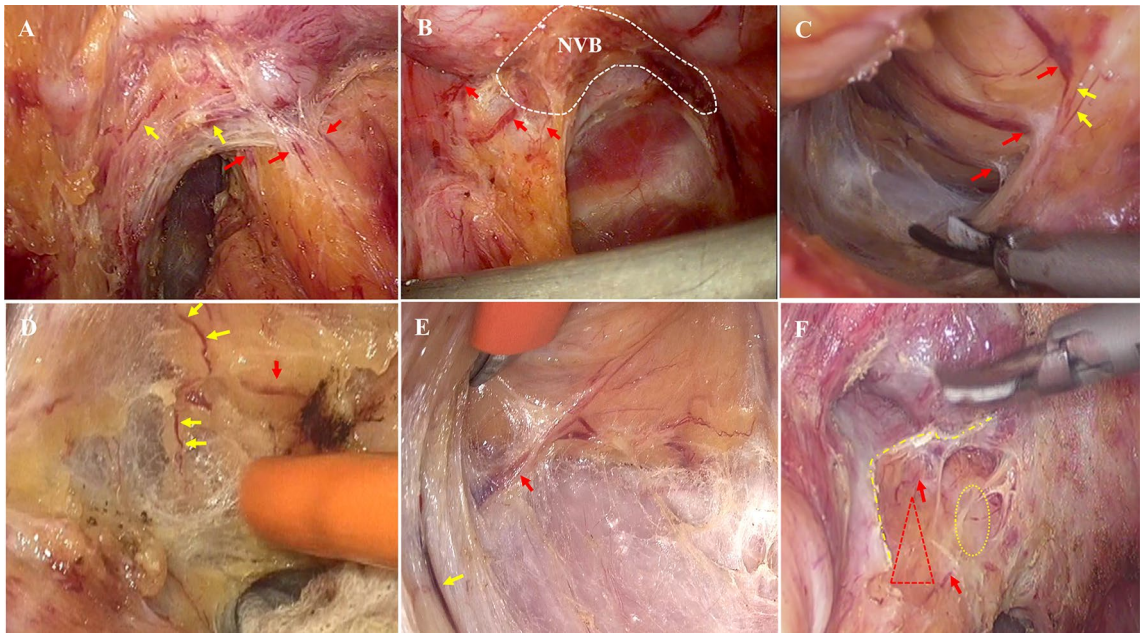

Fig. 2 Features of small vessels on mesorectal fascia and prehypogastric nerve fascia below peritoneal reflection. Red arrows indicate small vessels on the mesorectal fascia. Yellow arrows indicate small vessels on parietal fascia. Dotted line indicates the anterior leaf of Denonvilliers' fascia. Red triangle indicates the mesorectum (Color figure online)

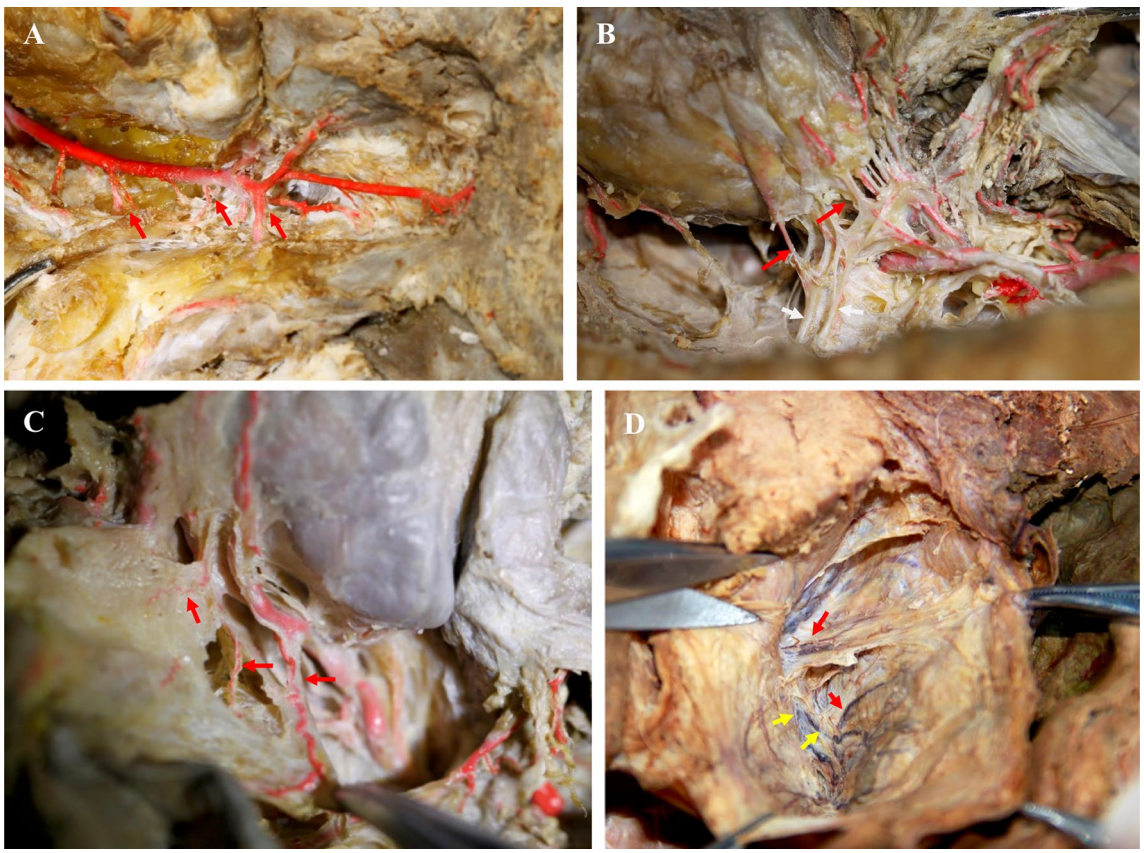

Fig. 3 Cadaveric observation of small vessels to the mesorectum on the visceral and parietal fascia. Red arrows indicate small vessels on the mesorectal fascia. White arrows indicate inferior hypogastric plexus. Yellow arrows indicate small vessels on parietal fascia (Color figure online)

Features of SVs on the parietal pelvic fascia

SVs on retroperitoneal or subperitoneal fascia did not demonstrate special and distinctive patterns as compared to those lining under visceral peritoneum. However, SVs on the parietal pelvic fascia (prehypogastric nerve fascia) and retroperitoneal fascia covering the ureter and gonadal vessels were always in the same orientation as the ureter, vessels, or auto-nerve fibers that lied beneath the correspondent fascia (Fig. 4A, D). Distal to the peritoneal reflection, anterolaterally, the obliquely craniolateral to caudomedial coursing SVs differed greatly from those cranially and medially running vessels on MRF, which were helpful to set up the pre-rectal space and identify the location of auto-nerve fiber on the pelvic sidewall and within NVB. Above the retroperitoneal reflection, the oblique trajectory of SVs on prehypogastric nerve fascia or fascia over the ureter and gonadal vessels could also help avoid entering behind these critical structures (Fig. 4F).

Another important feature of SVs on parietal fascia above the peritoneal reflection was that they stayed on the surface of the corresponding fascia and rarely crossed onto the adjacent visceral fascia, except for those near the origin of inferior mesenteric vessels (Fig. 4E). Even different parietal fasciae, such as Toldt's fascia and Gerota fascia, had respective SVs, with vascular communicating at limited points. These vascular features provided an alternative way of tracing the thin and delicate parietal facia, helping to maintain the intactness of the parietal fascia. The inter-fascial retrorectal and retrocolic dissection required more use of blunt dissection to reveal the trajectory of SVs as well as the intermittent sharp division of inter-fascial fibrous connections.

SVs guided inter-fascial dissection

Technical points of applying these vascular features are detailed in Supplementary Video 1 and 2. Briefly, above the peritoneal reflection, the pursuit of the obliquely coursing SVs and their branches on parietal fascia was practiced. The division of SVs on the parietal fascia should largely be avoided. Visualization of SVs crossing from parietal fascia to visceral one prompted re-checking the dissection plane. Below the peritoneal reflection, any SVs coursing in a caudal or dorsal–ventral direction should be pushed laterally or ventrally. Observation of SVs tapering cranially ensured the correct dissection plane. Then, blunt dissection, including pushing-back, splitting, or sliding along the cleft between two fasciae, was applied to expand the tissue plane and reveal more SVs. Most distally, efforts were made to expose the point where SVs drained into veins in NVB. The point to divide these SVs should be 1–2 mm away from their base.

Statistical analysis

The categorical variables or ranked data were described as frequency (percentage). The continuous variables were described as mean (range) or median (range). The survival curves were analyzed using the Kaplan–Meier method. Data

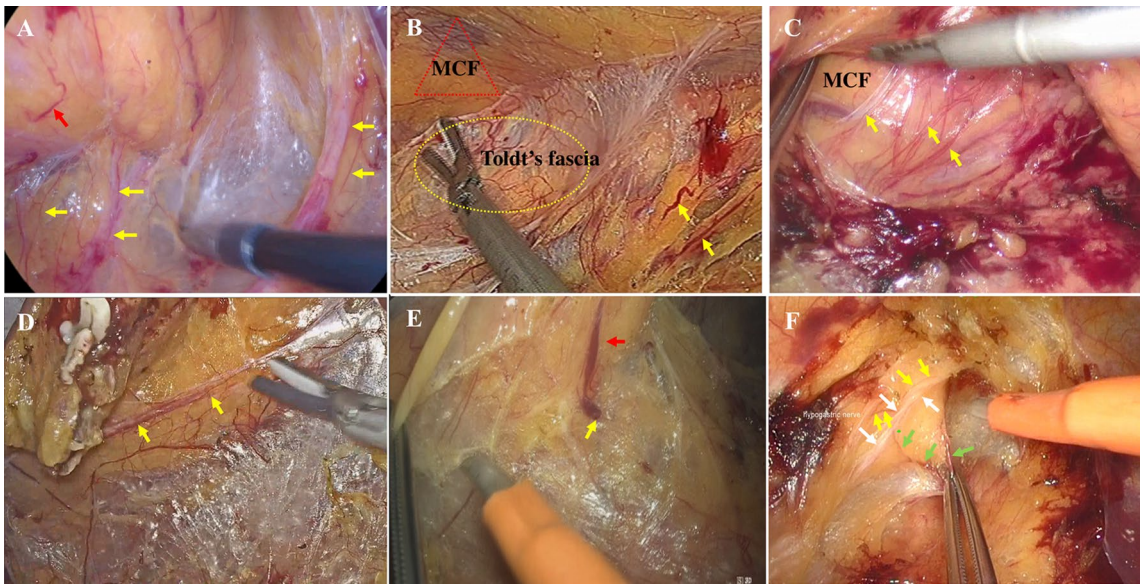

Fig. 4 Features of small vessels on prehypogastric nerve fascia and the other parietal fascia. Red arrows indicate small vessels on the mesorectal fascia. Yellow arrows indicate small vessels on parietal fascia. Red triangle indicates the mesocolic fascia. Yellow circle indicates the Toldt's fascia. White arrows indicate inferior hypogastric plexus. Green arrows indicate a small vessel crossing from the parietal side to the mesorectal side suggesting the wrong dissection plane (Color figure online)

analyses were carried out using SPSS software (version 22.0, SPSS Inc., Chicago, IL, USA).

Results

From 2013 to 2016, a consecutive series of 310 patients with low rectal cancer underwent laparoscopic TME with SVs-guided technique. Patient characteristics and outcomes are listed in Table 1. A total of 115 patients (37.1%) received neoadjuvant therapy (short-course radiotherapy: 83 and long-course chemoradiotherapy: 32). The median operative time was 175 (range 80–470) min. Eighty-eight patients (28.4%) had postoperative complications. The anastomotic leak occurred in 10 patients (3.2%). The major complication rate was 3.9%. No patient died within 30 days after surgery. Negative circumferential resection margin (CRM) was achieved in 96.8% (300/310) patients, and complete mesorectal excision was achieved in 97.8% (303/310) patients. The median follow-up period was 54 months (range 2–84). The 3-year overall survival, disease-free survival, and local recurrence rates were 89.4%, 79.7%, and 2.6%, respectively (Fig. 5).

Out of the 214 patients who underwent low anterior resection, 199 filled out the LARS questionnaire (93.0%). The rate of patients with no or minor LARS was 64.8%. Besides, 284 of the 310 patients (91.6%) completed the IPSS questionnaire. The urinary function was considered normal in 96.8% of patients, with a moderate dysfunction in 3.2% of patients. Among 94 male patients younger than 60 years old at the time of surgery, pre- and post-operative male sexual function data were obtained in 80 patients (85.1%). Fifty-eight patients were sexually active after surgery and 48 patients had mild or no erectile dysfunction (ED). Among 22 patients who were sexually inactive after surgery, 13 patients with sexual activity before surgery became impotent after surgery, while 7 patients claimed to have no erectile dysfunction, but practiced abstinence due to personal concerns. Hence, among 78 patients who claimed sexually active before surgery, 55 (70.5%) remained sexually functional, while 23 (29.5%) occurred sexual function injury.

Discussion

SVs on visceral and parietal fascia within the abdominal cavity have been mentioned previously [13]. Its value in surgery, however, has never been fully appreciated. Here, we described distinctive patterns and courses of SVs on parietal fascia and MRF and detailed the value of these features in performing inter-fascial dissection for low anterior resection and providing novel landmarks for fascia recognition.

The distal part of the rectum (also the mesorectum) and other pelvic organs shared similar embryonic origins from the cloaca and similar vascular supply from internal iliac vessels. The rectum and the prostate were reported to receive blood supply at a very high frequency from the same arterial trunk, which makes up the arterial vessels within NVB [14]. This study indicated that dozens of SVs, instead of a single middle rectal artery, pass through IHP and DVF or emerge from NVB to supply the mesorectum. In this way, these SVs contribute to the adhesion or fixation of the mesorectum to the pelvic wall. It is assumable that these SVs along with pelvic nerve fibers supplying the distal rectum provide the major mechanisms for the adhesion of the mesorectum. The division of these vessels one by one facilitates the detachment of the mesorectum with blunt dissection. Furthermore, due to the denser package of connective tissue within IHP and NVB, the proximal portion of these SVs becomes "invisible" in the surgical field. The root of these vessels stands for the interface between MRF and the IHP/NVB. This is especially of value during distal mesorectal mobilization on its anterolateral aspect, where excessive retraction at a certain point, instead of planar retraction provided by flat retractor in open surgery, are more likely to cause the bulging-out or angulation of NVB and IHP. When dense adhesion is encountered, straying into the mesorectum or NVB/IHP may not be a rare occurrence. In this case, the orientation and revealing of SVs on MRF and parietal fascial make important landmarks in addition to the contour of the mesorectum and the white-to-yellow interface. The whitish interface does not always show up due to the lack of good retraction or in the case of dense adhesion.

Another debate issue concerning TME is whether the dissection should be in front of or behind the DVF. Though histology studies have proven the existence of MRF behind DVF, partial resection of DVF will protect the thin MRF from being breached at a proximal level. The key issue concerning the level to divide DVF is the difficulty to define the inner edge of NVB, which is nearly impossible to observe with certainty during open surgery. Because these SVs repeatedly piercing through DVF, we suggest always taking the root (1–2 mm away) of these SVs as the level to divide DVF as shown in the video.

The key tricks to reveal and trace these SVs include blunt dissection and avoidance of continuous use of coagulatory instruments. Blunt dissection is usually applied either by pushing-back on the SVs indicated fascia or on the parietal side, or by sliding the blade of the instrument along the cleft between two fasciae. These blunt dissection tips were extremely for the revealing of SVs, the heat of energy instrument will certainly obliterate these vessels. Guided by SVs, 97.8% of patients achieved a complete mesorectal excision, and the positive rate of CRM was only 3.2%, which

Table 1 Patient characteristics and the perioperative, survival, and functional outcomes

	No. patients ($n=310$)
Male sex	182 (58.7%)
Age, years, median (range)	61 (24–91)
Body mass index, kg/m^2, median (range)	23.4 (13.1–33.9)
ASA	
I + II	229 (73.9%)
III	81 (26.1%)
Tumor location, cm, median (range)	5 (0–6)
cT stage	
T1 + T2	66 (21.3%)
T3 + T4	244 (78.7%)
cN stage	
N0	192 (61.9%)
N1	100 (32.3%)
N2	18 (5.8%)
Mesoretal fascia	
Positive	35 (11.3%)
Negative	242 (78.1%)
Not available	33 (10.6%)
Neo-adjuvant therapy	
None	195 (62.9%)
Short-course radiotherapy	83 (26.8%)
Chemoradiotherapy	32 (10.3%)
Procedures	
Low anterior resection	214 (69.1%)
Abdominoperineal resection	85 (27.4%)
Hartmann	11 (3.5%)
Operative time, min, median (range)	175 (80–470)
Estimated blood loss, ml, median (range)	40 (5–450)
Postoperative complications	88 (28.4%)
Anastomotic leakage	10 (3.2%)
Anastomotic bleeding	6 (1.9%)
Incisional infection	8 (2.6%)
Ileus	9 (2.9%)
Urinary retention	13 (4.2%)
Delayed removal of catheter	1 (0.3%)
Major complications	12 (3.9%)
Tumor size, cm, median (range)	3 (0–8)
pTNM stage	
I	124 (40.0%)
II	87 (28.1%)
III	89 (28.7%)
Pathologic complete response	10 (3.2%)
Circumferential resection margin*	
Positive (≤ 1 mm)	10 (3.2%)
Negative (> 1 mm)	300 (96.8%)
Total mesorectal excision[&]	
Complete	303 (97.8%)
Nearly complete	6 (1.9%)
Incomplete	1 (0.3%)
Adjuvant therapy	
Chemo-radiotherapy	23 (7.4%)

Table 1 (continued)

	No. patients ($n=310$)
Chemotherapy	131 (42.3%)
None	156 (50.3%)
Local recurrence	9 (2.9%)
Distant metastasis	64 (20.8%)
Death	60 (19.4%)
3-year overall survival rate	89.4%
3-year disease-free survival rate	79.7%
3-year local recurrence rate	2.6%
LARS score	199
No LARS (0–20 scores)	77 (38.7%)
Minor LARS (21–29 scores)	52 (26.1%)
Major LARS (30–42 scores)	70 (35.2%)
International Prostate Symptom Score	284
Mildly symptomatic (0–7 scores)	275 (96.8%)
Moderately symptomatic (8–19 scores)	9 (3.2%)
Severely symptomatic (20–35 scores)	0 (0.0%)
Male sexual function	80
Sexually active after surgery, IIEF-5	58
Sever ED (5–7 scores)	1 (1.7%)
Moderate ED (8–11 scores)	9 (15.5%)
Mild ED (12–21 scores)	25 (43.1%)
Without ED (≥22 scores)	23 (39.7%)
Sexually inactive after surgery, IIEF-5	22
Sexually active before surgery and severe ED after surgery	13 (59.1%)
Sexually active before surgery and without ED after surgery	7 (31.8%)
Sexually inactive before and after surgery	2 (9.1%)

LARS low anterior resection syndrome, *IIEF* international index of erectile function, *ED* erectile dysfunction

*Positive circumferential resection margin is defined as the shortest distance of 1 mm or less from tumor to resection margin (*Lancet*. 1994;344(8924):707–711)

&The quality of total mesorectal excision specimen is graded according to Dutch Colorectal Cancer Group criteria (*J Clin Oncol*. 2002;20(7):1729–1734)

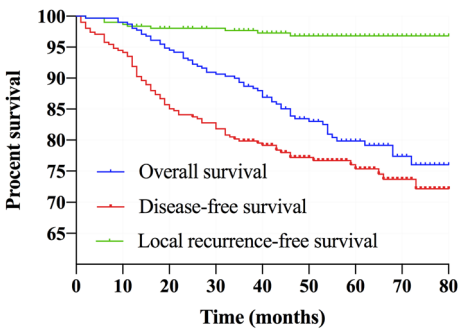

Fig. 5 Kaplan–Meier curve of overall, disease-free, and local recurrence-free survival for low rectal cancer patients

demonstrated the great values of SVs in guiding inter-fascial dissection for low rectal cancer.

Previous literature reported that the prevalence of major LARS after low anterior resection ranged from 19 to 56% [15–19]. In this study, the major LARS rate was 35.2%, which was similar to those studies. However, a very good result of the urinary function was observed in this series. Although thirteen patients (4.2%) occurred urinary retention after surgery, only one patient left the hospital with a urethral catheter. During follow-up, no patient presented severe symptoms, while only 3.2% of patients presented moderate symptoms, and 96.8% of patients presented mild symptoms or no symptoms, which seems to be better than literature (mild 83–94%, moderate/severe 6–17%) [20, 21]. Division of SVs on the posterolateral aspect of the mesorectum provides an easier way to expose the ridge of IHP, as shown in Supplementary Video 1 and Fig. 6, which may lead to better urinary function preservation. As for sexual function, we only included male patient who were no more than 60 years old at the time of surgery because a majority of the old Chinese population are sexually inactive. Thus, 94 male patients were enrolled and only 80 (85.1%)

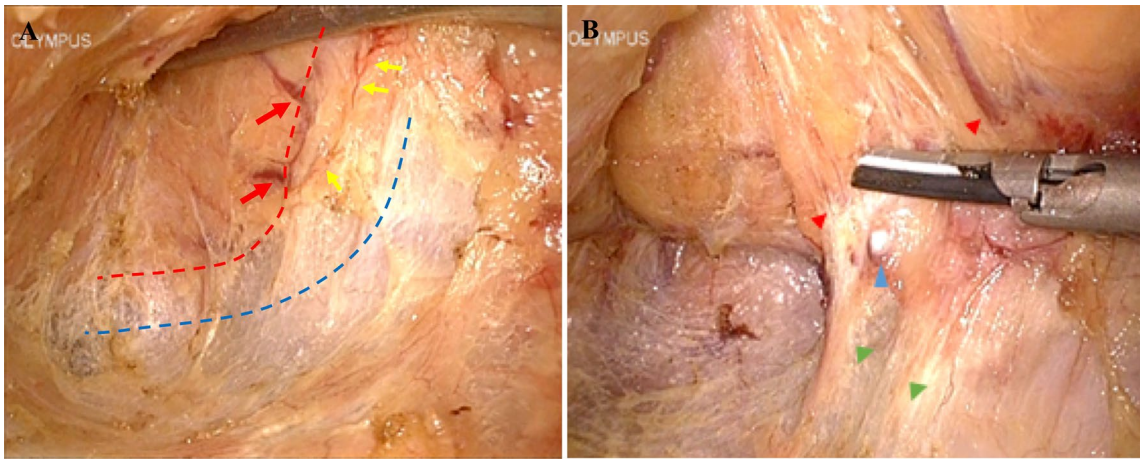

Fig. 6 Small vessels on posterolateral mesorectum help exposure of ridge of inferior hypogastric plexus. **A** before division of SVs. **B** after division of SVs. Red arrows indicate small vessels on the mesorectal fascia. Yellow arrows indicate small vessels on prehypogastric nerve fascia. Green arrow heads indicate the ridge of inferior hypogastric plexus (Color figure online)

patients responded to the questionnaires. For patients with sexual activities before surgery, 29.5% presented moderate/sever ED, which is comparable to literature (22–75%) [20, 22–29]. Due to the close proximity of NVB to the distal mesorectum, injuries to the auto-nerve fiber might arise from either direct division of it or thermal injury. The visualization of NVB might not lead straight-forwardly to better preservation of sexual function, or cause more thermal damage. The impact of this SVs-guided technique on urinary and sexual function awaits further prospective cohort studies by surgeons who learn to use this technique in their practice. As this anatomical understanding matures gradually, the authors in this study were not able to design a comparative study to test the real value of this technique in functional outcomes.

In conclusion, SVs on both MRF and parietal (pelvic) fascia show distinctive features in orientation and trajectories. These features may be taken as additive landmarks for the identification of both parietal and visceral fascia for rectal surgery.

Supplementary Information The online version contains supplementary material available at https://doi.org/10.1007/s00464-021-08683-9.

Funding This work was supported by Ministry of Science and Technology of the People's Republic of China (No. 2017YFC0908204), Department of Science and Technology of Sichuan Province (No. 2021YFS0025), 1.3.5 project for disciplines of excellence, West China Hospital, Sichuan University (No. 20HXJS003), 1·3·5 project for disciplines of excellence-Clinical Research Incubation Project, West China Hospital, Sichuan University (No. 2019HXFH031), and Post-Doctor Research Project, West China Hospital, Sichuan University (No. 2019HXBH041).

Declarations

Disclosures Drs. Qingbin Wu, Mingtian Wei, Xubing Zhang, Xiangbing Deng, and Ziqiang Wang have no conflicts of interest or financial ties to disclose.

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