Review Article

The anatomical study and clinical application of the lateral ligaments of the rectum

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Contributions: (I) Conception and design: J Wu, C Zhang; (II) Administrative support: ZC Kuo, C Zhang; (III) Provision of study material or patients: J Wu, C Zhang; (IV) Collection and assembly of data: J Wu, ZC Kuo; (V) Data analysis and interpretation: All authors; (VI) Manuscript writing: All authors; (VII) Final approval of manuscript: All authors.

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Abstract: The anatomical location and contents of the lateral ligaments of the rectum (LLR) should be identified in the procedure of total mesorectal excision, as well as its relationship with the middle rectal artery and pelvic plexus. However, discovering this relationship is plaguing the existence and composition of the lateral rectal ligament with confusion and misconceptions. The application of laparoscopy in rectal cancer excision is helpful in identifying the existence of the lateral ligament of the rectum. According to the anatomical study and our clinical observations, the traditional anatomical structures of the lateral ligament of the rectum do exist. It is essential for general surgeons to understand the anatomical location, contents and the technique of dissection of the lateral rectal ligament and doing so is helpful in improving the quality of life of post-operative patients.

Keywords: Lateral ligaments of the rectum (LLR); rectal cancer; total mesorectal excision; abdominoperineal anatomy

Received: 23 November 2018; Accepted: 28 January 2019; Published: 13 February 2019.

doi: 10.21037/dmr.2019.01.02

View this article at: http://dx.doi.org/10.21037/dmr.2019.01.02

Introduction

The anatomical locations and structures of the lateral ligaments of the rectum (LLR) have been the topic of many discussions since its discovery. Many researchers have very diversified understandings from their observations through surgical operations and autopsies, while some researchers mull over the existence of individual differences of it. With the widespread usage of laparoscopic total mesorectal excision of mid-low rectal cancer in China, the location and anatomical structures of the LLR are simpler to observe and identify through an enhanced plane of observation provided by the laparoscope, including the middle rectal artery and the pelvic plexus. With laparoscopy, we can thoroughly excise the tumor, minimizing the rate of recurrence, and preserving the autonomous nervous functions of the pelvis. Thus, research into the anatomical location and structures of the LLR, and its best plane of dissection proves to be of paramount significance in rectal cancer surgeries.

Anatomical location of LLR

Miles (1) proposed the concept of LLR during an abdominal-perineal resection back in 1908. It is the dense connective tissues connecting rectum to the lateral walls of the pelvis and the base of the bladder by the ureterovesical junction. In 1984, Goligher *et al.* (2) redefined it as a triangular-shaped structure originating laterally from the pelvic fascia, connecting to the rectum bilaterally. The 1995 38th edition of Gray's Anatomy (3) defined LLR as the fascia originating from the S3 level posterior pelvic wall, enveloping the middle rectal artery, and extending to the rectum. Since its anatomical location and structures are still widely debated, surgical methods used to deal with it are varied as well. Miles believes that the mobilization of the

lateral section of rectum requires the complete excision of the LLR down to the surface of levator ani. Heald (4) did not mention the existence of LLR in his surgery in 1982, when he proposed to use sharp dissection for mesorectum in total mesorectal excision; thus, preventing local recurrence of carcinoma due to remnants of mesorectum left behind via blunt dissection. Murray *et al.* (5) believes that the last step in mobilization of the lateral rectum requires blunt dissection under direct vision, hooking the LLR on a finger before clamping, ligating and cutting it. In 2000, Bissett *et al.* (6), though did not ligate the LLR after exposing it anteriorly and posteriorly and subsequently resecting it in an extrafascial excision of the rectum, they did emphasize on not overstressing the LLR during the surgery to prevent inferior hypogastric plexus damage.

To confirm its contents, Jones *et al.* (7), dissecting a total of 28 formalin-treated cadavers in 1999, found "very insubstantial connective tissue strands" between the rectum and pelvic wall in only 18 of them, with 15 of them presenting with unilateral middle rectal arteries. Finally, he concluded in his report that there are no LLR in the mesorectal plane. However, more recent studies of autopsy specimens and surgical observations report nearly 100% of them having LLR. In 2006, Academician Zhang *et al.* (8) found LLR formed by the rectal branch of inferior hypogastric plexus and middle rectal artery on the mesorectum laterally in 20 male cadaver autopsies. In 2013, Runkel (9) described the LLR as bundles of nerves and blood vessels at the S4 level during his laparoscopic Nerve-Oriented Mesorectal Excision. Another researcher in 2015, Huang *et al.* (10) of SYSU 3rd affiliated hospital dissected five male cadavers and observed 62 cases of laparoscopic surgery of mid-low rectal cancer, echoing the idea that the dense connective tissues they observed at the spinal level S3-5 are the LLR. In a laparoscopic total mesorectal excision, the rectum was pulled forward, allowing the exposure and dissection of the peritoneum and the proper fascia of the rectum down to the level of the pelvic floor. Then the anterior rectum was freed by cutting the reflected peritoneum of the rectovesical pouch, exposing the Denonvillier's pouch. In it, between the Denonvillier's fascia and proper rectal fascia at the 10 and 2 o'clock direction of the rectum, at the level of the prostate gland and base of seminal vesicles, lie the LLR, atop the levator ani, connecting to the fascia of the perineal diaphragm. Thus, we believe that the LLR exist, and the key to its dissection is locating the correct dissection plane between Denonvillier's fascia and proper fascia of rectum; that the LLR is located laterally anteriorly on the rectum instead of laterally; that when freeing the lateral and posterior portion of the rectum, one should care not to damage the presacral plexus and the autonomous nerves next to the middle rectal artery. Handling the LLR without proper knowledge of its anatomical locations could bring harm to the pelvic autonomous nerve plexuses.

Middle rectal artery and lateral ligaments of rectum

Structures of LLR and its relationship with the middle rectal artery is the 2nd question to resolve in the anatomical research of the LLR. Based on Mile's description of the LLR that describes its inclusion of the middle rectal artery, surgeons of his time thought that the LLR contained the middle rectal artery, nerve bundles, lymphatic ducts, and other structures, thus, in an effort to prevent bleeding, procedures such as clamping, dissection and ligation is necessary during an abdominoperineal excision. However, many autopsy-based research since then had various findings in regard to the existence of the middle rectal artery in LLR. A 42-sample autopsy conducted by Ayoub (11) had concluded that the rate of appearance of middle rectal artery in LLR to be 12%, while Lin *et al.* (12) reported 28.1%, and DiDio *et al.* (13) reported a 56.7% chance of finding a middle rectal artery in LLR. Boxall *et al.* (14) reported a more consistent rate of 95.3%, using red emulsion infusion method. There are 2 opinions regarding these findings: one thinks of the middle rectal artery as an inconsistent structure of the LLR, sometimes supplying the rectum via other routes; the other believes that due to the variations in the diameter of the middle rectal artery, it is difficult to discover an artery of around 0.5 mm in diameter during dissection (15). However, Boxall *et al.* (14), using a red emulsion to infuse the arteries, and Nano *et al.* (16), using imageology and other assistive methods, have consistently (>90%) found the middle rectal artery within the LLR. A constant anatomical relationship between the two can be found during excisions of low-level rectal cancer; especially when dissecting the lateral rectum during total mesorectal excision, the middle rectal arteries with larger diameters cannot be cut without ligation. Although the smaller middle rectal artery has little clinical significance, it is advised to use ultrasonic knives instead of electric knives to prevent damaging the nerves accompanying the middle rectal artery via heat; it might affect post-surgical recovery of autonomous nervous functions (9).

Pelvic nerve plexus and lateral ligaments of rectum

There are varying degrees of sexual and urinary dysfunction following a traditional abdominoperineal excision. While the application of laparoscopy and autonomic nerve-preserving principles can lower the risk, most post-surgical patients still developed Low Anterior Resection Syndrome (LARS), mainly manifesting as incontinence, frequency, urgency, or feelings of incomplete emptying, tenesmus, and constipation. Risk factors of LARS include neoadjuvant treatment, total mesorectal excision, anastomotic fistula, patients of age 64 or younger, and female patients (17), with total mesorectal excision patients having a higher risk of LARS than partial mesorectal excision. The mechanisms of LARS include damage to the reflex pathway of the internal sphincter of the anal canal. Theoretically, innervating the inner sphincter of the anal canal is done by sympathetic nerves, and with the pelvic nervous plexus closely related to the LLR, methods of its resection will damage the nerves and thus affecting the functions of the internal sphincter, causing LARS.

By understanding the anatomical relationships of LLR and the pelvic nerve plexus, we may better protect the nerves during surgery. Sato (18) separates the LLR into lateral and medial sections, with the pelvic splanchnic nerves located posteriorly and inferiorly to the lateral portion of LLR. The majority of the pelvic splanchnic plexus is the inferior hypogastric plexus, which consists of the hypogastric nerve, pelvic splanchnic nerve, and sacral splanchnic nerve (8). The branches of pelvic splanchnic plexus innervate the urogenital organs and rectum, whereby the rectum branch of it travels from the pelvic wall to the anterior lateral mesorectum, via the LLR. This branch is a stable structure in LLR, forming a T-shaped structure between the pelvic splanchnic plexus on the lateral pelvic wall and the LLR. The anatomical level of dissection of the lateral side of the rectum during total mesorectal excision is between the mesorectum and the pelvic splanchnic plexus. The mobilization of the lateral rectum should be completed after dissecting the T-shaped structure formed by the pelvic splanchnic plexus and LLR. This procedure should be done under direct vision, preventing excessive traction on the LLR or the T-shaped structure. If the structural anatomy of the site is fuzzy, refrain from resecting the LLR too close to the pelvic wall to avoid damaging the pelvic splanchnic plexus.

Conclusions

As described above, the lateral ligament of the rectum is a real anatomical structure. It mainly consists of dense connective tissue, including the middle rectal artery and a rectal branch of the inferior hypogastric plexus. It is the pathway in which blood vessels and nerves access the lower rectum, and it is bordered laterally by the pelvic splanchnic plexus. Understanding the anatomical location and structures within the LLR during total mesorectal excision has important clinical significance. The anatomic plane of LLR is different from those of the traditional textbooks. When mobilizing the lateral mesorectum one must dissect tissues carefully to recognize the structures of LLR. When resecting the LLR, avoid overstraining the rectum, or clamping or cauterizing large sections of tissues in order to avoid damaging the pelvic autonomous nervous plexuses, so that the patient may recover his or her urinary functions after the surgery.

Acknowledgments

Funding: None.

Footnote

Conflicts of Interest: All authors have completed the ICMJE uniform disclosure form (available at http://dx.doi.org/10.21037/dmr.2019.01.02). CZ serves as an unpaid Associate Editor-in-Chief of *Digestive Medicine Research*. The other authors have no conflicts of interest to declare.

Ethical Statement: The authors are accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

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doi: 10.21037/dmr.2019.01.02
Cite this article as: Wu J, Kuo ZC, Zhang C. The anatomical study and clinical application of the lateral ligaments of the rectum. Dig Med Res 2019;2:2.