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Complete mesocolic excision: Lessons from anatomy translating to better oncologic outcome

Min-Hua Zheng, Sen Zhang, Bo Feng

Min-Hua Zheng, Sen Zhang, Bo Feng, Shanghai Minimally Invasive Surgery Center, Ruijin Hospital, Shanghai Jiao Tong University School of Medicine, Shanghai 200025, China

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Correspondence to: Bo Feng, MD, PhD, Shanghai Minimally Invasive Surgery Center, Ruijin Hospital, Shanghai Jiao Tong University School of Medicine, No. 197, Ruijin Er Road, Shanghai 200025, China. fengbo2022@163.com
Telephone: +86-21-63846590
Fax: +86-21-63846590

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Abstract

Since the introduction of complete mesocolic excision (CME) for colon cancer, the oncologic outcome of patients has been greatly improved, which has led to a longer survival

and a lower recurrence, just like the total mesorectum excision for rectal cancer. Despite the fact that the exact anatomy of the organ is one of the most vital things for surgeons to conduct surgery, no team has really studied the exact structure of the mesocolon and related attachments for CME, until the mesocolonic anatomy was first formally characterized in 2012. Therefore, this article mainly focuses on the anatomy development of the mesocolon and the achievement in this field. Meanwhile, we introduce the latest progress in laparoscopic surgery for colon cancer achieved by our team.

Key words: Colorectal cancer; "Page-turning" approach; Laparoscopic surgery; Complete mesocolic excision; Toldt's fascia

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Core tip: Despite that complete mesocolic excision (CME) has been conducted for many years, leading to a better outcome in colon cancer patients, there are limited studies on the structure of the mesocolon or related attachments, which is of great importance for surgeons to carry out surgery, until K. Culligan first formally characterized the mesocolonic anatomy, explaining the reason why CME would have a better oncologic outcome. Meanwhile, based on the exact anatomy of mesocolon, we introduce the latest progress in laparoscopic surgery for colon cancer achieved by our team, such as "page-turning" approach, and we also list the most important structure related to the CME.

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INTRODUCTION

In the past, patients with rectal cancer survived less than those with colon cancer. However, since Heald *et al.*^[1] first proposed total mesorectum excision (TME) for rectal cancer, the TME has standardized the surgical management of rectal cancer, which is based on the theory that mesorectum is composed of visceral and parietal planes covering rectum-supplying vessels and its lymphatic drainage like envelopes, leading to a lower recurrence rate as well as better 5-year cancer-related survival, which is even higher than that of colon cancer^[2-4] given that the surgery for colon cancer had not changed so much. In 2009, on the basis of the TME, Hohenberger *et al.*^[5] put forward the concept of complete mesocolic excision (CME). He stated that the mesocolon is covered by visceral and parietal planes by an envelope-style just like the mesorectum, and the "holy plane"^[6] extends to the mesocolon from the mesorectum. In his study, the patients who underwent CME had lower local recurrence and better survival, from 6.5% to 3.5% and 82.1% to 89.1% respectively. Since then, more and more studies have proven that superiority^[7,8].

Surgeons are meant to be ones who cure the disease through surgery with excellent knowledge about the organs, therefore, it is essential to stress the importance of accurately understanding mesocolic anatomy for surgeons to conduct CME. Although there have been studies on CME for years, no team really studied the exact structure of the mesocolon and related attachments, until K. Culligan *et al.*^[9] first formally characterized the mesocolonic anatomy in 2012. They made many undocumented and important discoveries, which could explain and confirm the feasibility and superiority of CME. Besides presenting the promising oncological outcome, this article mainly focuses on the anatomy of mesocolon and laparoscopic approach of CME to help peers comprehend CME better, and such improvement in anatomy-related understanding may explain why CME is a potential standardized procedure for colon cancer.

RESERACH

A systematic literature search was conducted using Pubmed and EMBASE with the terms of "complete mesocolic excision", "CME", "anatomy of CME", "laparoscopic CME" as well as "colon surgery". Many related studies were found and we summarized and presented the findings with our clinical experience.

The anatomy development of mesocolon

One of the earliest and most famous description of mesocolon was made by Sir Treves^[10] in 1885. He dissected and studied the anatomy of intestinal canal, peritoneum and mesentery with 100 cadavers and reported that mesocolon is discontinuous and fragmental. About half of the cadavers had neither an ascending nor a descending mesocolon, and 14 cadavers had them

both. The existence of mesocolon was always described as abnormal, even as "a cleft palate"^[11]. Indeed, before Sir Frederick Treves, Carl Toldt in 1879^[12], whose findings apparently differed from the above ones, studied the development of human mesentery, and noted the permanent existence of mesocolon in human being as well as a distinct fascial plane between the mesocolon and the underlying retroperitoneum. Known as Toldt's fascia, it was formed by the fusion of the visceral peritoneum of the mesocolon with the parietal peritoneum of the retroperitoneum. From today's point of view, Toldt's finding was almost true while Treves' not, but it did not work well at that time. Treves' discovery was so profound and foundational that it was spreaded and accepted extensively into surgery and teaching, even to recent days, it was still accepted widely as Rishabh Sehgal^[13,14] mentioned.

There has been no research really studying the exact structure of mesocolon for decades, until Culligan *et al.*^[9] first formally characterized the mesocolonic anatomy in detail. They chose 109 patients to undergo total abdominal colectomy, observed and recorded the anatomy of mesocolon, the related attachments and specimens, and finally noted many undocumented and meaningful findings: (1) mesocolon is continuous from the ileocaecal to rectosigmoid level; (2) Toldt's fascia is identified in the place where mesocolon is apposed to the retroperitoneum, such as ascending, descending mesocolon and non-mobile portion of mesosigmoid, while it does not show up in the transverse mesocolon and the mobile component of the mesosigmoid; and (3) the proximal rectum originates from the confluence of the mesorectum and mesosigmoid; and so on. What's more admirable, besides the important macroscopic discoveries above, Culligan's team first investigated the microscopic structures of mesocolon, Toldt's fascia and retroperitoneum before and after the colonic mobilization^[15,16]. They obtained samples from 24 cadavers, stained them with hematoxylin and eosin, Masson trichrome, and by immunohistochemistry to identify lymphatic vessels. Some samples were directly observed by scanning electron microscopy. Just like the macroscopic findings, they found consistent microscopic structures of mesocolon and associated fascia from the ileocecal to mesorectal level; in the place where mesocolon is apposed to the retroperitoneum, a connective tissue could be identified between them (*i.e.*, Toldt's fascia). Nowadays, we appreciate the excellent work done by Culligan's team. It was incredible and profound. For the first time, they described the exact anatomy of mesocolon, confirmed the continuity and surgical plane, and provided convincing proof for surgeons to conduct CME from the anatomical and histological aspects. Later, Gao *et al.*^[17] finished a similar study, also proving the continuity of mesocolon and the existence of visceral fascia. In his study he also thought the fascia to be able to block the tumor migration. Gao and Culligan used different terminologies to refer to the same thing, for example, Gao named it "visceral fascia" while Culligan called it "Toldt's fascia"^[18]. Such phenomenon is very normal, and there is also no

standardized nomenclature for CME, for instance, “right hemi-colectomy”, “enlarged right hemi-colectomy”, “Gerot’s fascia”, or “visceral fascia” and “parietal fascia”. Not being accurate and definite^[19,20] may confuse the new learners regarding explanations of the surgical procedures, which may have a bad impact on such improvement. Even though there is no “gold standard” for colon cancer, it is essential and necessary to have a unified terminology.

The laparoscopic approach of CME

Unexpectedly, despite the misconception in the textbook for centuries, surgeons have always seen mesocolon as a whole and conducted surgery based on the surgical plane between mesocolon and retroperitoneum^[19]. Back to 100 years ago, Jamieson (Jamieson and Dobson, 1909) suggested that surgery for colon cancer should resect the lesion, clean the regional lymph nodes to the vascular roots, and dissect lymph nodes of the interperitoneal colon, mesocolon and vascular roots, which was similar to the technique strategies of CME proposed by Hohenberger^[5]. Hohenberger demanded sharp separation of visceral and parietal fascia based on embryonic anatomy, ligation at the root of central supply vessels, and more radical lymph node dissection. The feasibility and promising outcome of CME have been confirmed in open surgery.

The improvement of laparoscopic techniques and further definition of equipment make it possible for surgeons to conduct colon cancer surgery. Taking the right-hemi colon cancer as an example, it is relatively more complicated and has more vessel variations. Feng *et al.*^[20] from our team first confirmed the feasibility and technical strategies of laparoscopic CME with medial access, following the dissection starting at the ileocolic vessel, proceeding along the superior mesenteric vein, and exposing the inborn surgical plane composed of Toldt’s and prerenal fascia to uncover the head of the pancreas and to mobilize the duodenum. The exposing range begins from the origin of transverse colon mesentery to the peritoneal reflection, and ligation at the origin of the central vessels to dissect the entire mesocolon was performed as a whole. Compared to the lateral access, the medial access complies more with the “no-touch” principle, since the lateral access starts with mobilizing the colon and then dissecting and ligating the central vessel. Not only is the pathological result comparable to the open surgery, but also the long-term outcome works well too^[2,4,21,22]. Based on the surgical experience through extensive surgeries, Feng *et al.*^[23] then exploited and distinguished two approaches for media access: Completely medial and hybrid medial approach (CMA and HMA). The major difference between them is the approach to dissect the inferior edge of the pancreas. The CMA uses a “bottom-to-top” fashion while the HMA uses a blending of “top-to-bottom and bottom-to-top” fashion. Compared to the HMA, the surgery time and ligation time of central vessel were significantly shorter, while the HMA induced more

vessel-related complications. Besides, our team recently found an improved surgical access based on CMA, which we named “page-turning” approach (CMA_{PA}). It is conducted in a “bottom-to-top” and “inside-to-outside” direction, which adopted the strategy of “point-to-line” and “line-to-plane” [point: Taking the ileocolic vessels as a dissection trigger; line: Dissecting the vessels along the superior mesenteric vessel (SMV); plane: Extending the surgical plane by the “page-turning” approach, which was formed by Toldt’s fascia]. We suppose that this approach is technically feasible and complies more with the principle of tumor radical surgery.

However, CMA and HMA both emphasize the accurate recognition of the anatomical plane, especially the transverse retrocolic space which can extend to inter-mesenteric space and right retrocolic space to completely mobilize the right colon. Consequently, without a better understanding of the exact mesocolon, no surgeons can conduct perfect CME.

CONCLUSION

Just as the TME for rectal cancer, the CME follows the principle of embryology and anatomy by sharply dissecting the surgical plane between the visceral and parietal fascia to get an integrated mesocolon, ligation at the root of the central vessel and clearance of more lymph nodes, which can lead to a better survival. However, there is not an efficient evaluation system for CME except the grading system by West *et al.*^[24]: Muscularis propria plane (poor plane) if little mesocolon is excised with incision down to the muscularis propria; intramesocolic plane (moderate plane) if partial mesocolon is excised with an irregular shape but not down to the muscularis propria; mesocolic plane (good plane) if intact mesocolon is excised without defections on it and high ligation of the supply vessels. He further demonstrated a 15% increase of overall survival in the “mesocolic plane” group compared to “non-comparable” group. Even though the surgeons bear the concept in mind, there still have not been a global consensus about the accurate configuration of the mesocolon with related attachments. In addition, various words and terminologies are used in the CME, which makes people confused, especially the young. Besides, the reason why we describe CME as a better approach instead of a successful one, or why we think it has the potential to be the standard procedure for colon cancer, is that it has not been accepted universally, and there are still some debates. Some studies showed that extensive lymphadenectomy by CME failed to increase the survival^[25-28], although CME emphasizes the necessity to remove more lymph nodes, which can lead to a better survival. Besides, the operation time for CME is longer as the procedure is technically more challenging and complex, which may lead to more complications, such as bleeding, genitourinary dysfunction, or chyle leakage^[29,30]. What’s more, Culligan *et al.*^[18] first discovered abundant lymphatic vessels within Toldt’s fascia as well as mesocolon. This

means that it is possible that there are communications between them, which may cause tumor cell spread, and if that happens, there is little need to conduct CME. Further studies are needed to clarify this issue.

The majority of data we got were from single-center, retrospective studies, and not convincing enough for surgeons to accept CME as a standard procedure for colon cancer. So it is the time and it is essential for us to standardize the procedure of CME and conduct completely randomized and multi-center prospective studies to provide more proofs. At that time we will have great confidence to decide whether CME could be the standard procedure for colon cancer or not.

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