

World Journal of *Gastrointestinal Surgery*

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WJGS mainly publishes articles reporting research results and findings obtained in the field of gastrointestinal surgery and covering a wide range of topics including biliary tract surgical procedures, biliopancreatic diversion, colectomy, esophagectomy, esophagostomy, pancreas transplantation, and pancreatectomy, etc.

INDEXING/ABSTRACTING

The WJGS is now abstracted and indexed in Science Citation Index Expanded (SCIE, also known as SciSearch®), Current Contents/Clinical Medicine, Journal Citation Reports/Science Edition, PubMed, and PubMed Central. The 2021 edition of Journal Citation Reports® cites the 2020 impact factor (IF) for WJGS as 2.582; IF without journal self cites: 2.564; 5-year IF: 3.378; Journal Citation Indicator: 0.53; Ranking: 97 among 212 journals in surgery; Quartile category: Q2; Ranking: 73 among 92 journals in gastroenterology and hepatology; and Quartile category: Q4.

RESPONSIBLE EDITORS FOR THIS ISSUE

Production Editor: Rui-Rui Wu, Production Department Director: Xiang Li, Editorial Office Director: Ya-Juan Ma.

NAME OF JOURNAL

World Journal of Gastrointestinal Surgery

ISSN

ISSN 1948-9366 (online)

LAUNCH DATE

November 30, 2009

FREQUENCY

Monthly

EDITORS-IN-CHIEF

Peter Schemmer

EDITORIAL BOARD MEMBERS

<https://www.wjgnet.com/1948-9366/editorialboard.htm>

PUBLICATION DATE

March 27, 2022

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INSTRUCTIONS TO AUTHORS

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

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<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>



Case Control Study

Does cranial-medial mixed dominant approach have a unique advantage for laparoscopic right hemicolectomy with complete mesocolic excision?

Li Lin, Si-Bo Yuan, Huan Guo

Specialty type: Gastroenterology and hepatology

Provenance and peer review:

Unsolicited article; Externally peer reviewed.

Peer-review model: Single blind

Peer-review report's scientific quality classification

Grade A (Excellent): 0
Grade B (Very good): B, B
Grade C (Good): C
Grade D (Fair): 0
Grade E (Poor): 0

P-Reviewer: El-Nakeep S, Egypt;
Hegazy AA, Egypt

Received: September 1, 2021

Peer-review started: September 1, 2021

First decision: November 7, 2021

Revised: November 14, 2021

Accepted: March 5, 2022

Article in press: March 5, 2022

Published online: March 27, 2022



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Abstract

BACKGROUND

Complete mesocolic excision (CME) with central vascular ligation (CVL) was proposed by Hohenberger in 2009. The CME principle has gradually become the technical standard for colon cancer surgery. How to achieve CME with CVL in laparoscopic right hemicolectomy (LRH) is controversial, and a unified standard approach is not yet available. In recent years, the authors' team has integrated the theory of membrane anatomy, tried to combine the cephalic approach with the classic medial approach (MA) for technical optimization, and proposed a cranial-medial mixed dominant approach (CMA).

AIM

To explore the feasibility of operational approaches for LRH with CME.

METHODS

In this retrospective cohort study, the clinical data of 57 patients with right-sided colon cancer (TNM stage I, II, or III) who underwent LRH with CME from January 2016 to June 2020 were collected and summarized. There were 31 patients in the traditional MA group and 26 in the CMA group.

RESULTS

There were no significant differences in baseline data between the two groups. The operation was shorter and the number of lymph nodes dissected was higher in the CMA group than in the MA group, but there was no significant difference in the number of positive lymph nodes, intraoperative blood loss, postoperative exhaust time, feeding time, postoperative hospital stay or postoperative complication incidence.

CONCLUSION

Our study shows that the CMA is a safe and feasible procedure for LRH with CME and has a unique advantage.

Key Words: Right hemicolectomy; Laparoscopic surgery; Complete mesocolic excision; Mesocolon; Embryology; Colon cancer

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Core Tip: This work presents the combination of the cranial approach and the classic medial approach and optimization of the combined approach to propose a cranial-medial mixed dominant approach (CMA) based on embryonic development and membrane anatomy. Our study shows that the CMA is a safe and feasible procedure for laparoscopic right hemicolectomy with complete mesocolic excision and has a unique advantage.

Citation: Lin L, Yuan SB, Guo H. Does cranial-medial mixed dominant approach have a unique advantage for laparoscopic right hemicolectomy with complete mesocolic excision? *World J Gastrointest Surg* 2022; 14(3): 221-235

URL: <https://www.wjgnet.com/1948-9366/full/v14/i3/221.htm>

DOI: <https://dx.doi.org/10.4240/wjgs.v14.i3.221>

INTRODUCTION

Since Heald[1] proposed the total mesorectal excision (TME) principle in 1982, TME has become the international gold standard for rectal cancer[2]. In 1991, Jacobs *et al*[3] first reported laparoscopic colorectal cancer resection. A similar concept of complete mesocolic excision (CME) with central vascular ligation (CVL) was proposed by Hohenberger *et al*[4] in 2009 based on the concepts of TME. The CME principle has gradually become the technical standard for colon cancer surgery[5,6]. The National Comprehensive Cancer Network (NCCN) guidelines for colon cancer recommended laparoscopic surgery for patients with curable colon cancer[7] for years, but it is generally considered that laparoscopic right hemicolectomy (LRH) is relatively complex and difficult[8]. How to achieve CME with CVL in LRH has been controversial, and a unified standard approach is not yet available. Before this procedure can be generally recommended, a consensus is needed on how the operation can be carried out optimally. However, quite a few approaches have been proposed[9-11]. In recent years, the authors' team has integrated the theory of embryonic development and membrane anatomy, combined the cranial approach with the classic medial approach (MA) and optimized the combined approach to propose a cranial-medial mixed dominant approach (CMA). This approach allows better control of surgical risks, is more compliant with CME requirements, and is more standardized and reproducible.

MATERIALS AND METHODS

Materials

All the patients, both those in the CMA group and those in the MA group, were admitted to the Department of Gastrointestinal Surgery of Zhongshan Hospital of Xiamen University and underwent LRH with CME and CVL, which was performed by Professor Sibo Yuan. Between January 2016 and December 2020, adult patients who had a confirmed diagnosis of renal cell carcinoma (RCC), who underwent contrast-enhanced CT of the chest, abdomen, and pelvis for clinical staging (cTNM), and who underwent radical colectomy were selected from the database. The selection criteria were as follows: (1) Patients were 15 years of age or older, with no limitation on sex; (2) Patients had a confirmed diagnosis of clinical stage I, II, or III adenocarcinoma through biopsy of the right colon on colonoscopy, including the caecum, ascending colon, hepatic flexure, and proximal transverse colon; and (3) Patients underwent laparoscopic surgery at a scheduled time rather than emergency surgery due to severe obstruction or perforation. During 2016-2018, 36 patients underwent LRH with the traditional MA. From 2018 to 2020, 33 patients underwent treatment with the CMA. Twelve of the 69 patients were excluded from this study due to resection of local metastases of the organ (stomach, uterus, annex, *etc.*) and simultaneous resection of liver metastases and intestinal polyps, for which we could not assess the operative duration, postoperative recovery or other factors. Professor Yuan primarily used the MA before 2018 and proposed and primarily used the CMA after 2018 to complete LRH. Twenty-six patients

were included in the CMA group, and 31 patients were included in the MA group after exclusion (Figure 1). Postoperative clinical tumour staging was based on the Union for International Cancer Control (UICC) cancer staging manual (version 6). Preoperative blood and albumin (ALB) transfusions were performed in cases of anaemia and hypoproteinaemia, respectively. The basic condition of the patients and the outcome data are shown in Table 1.

Surgical approaches

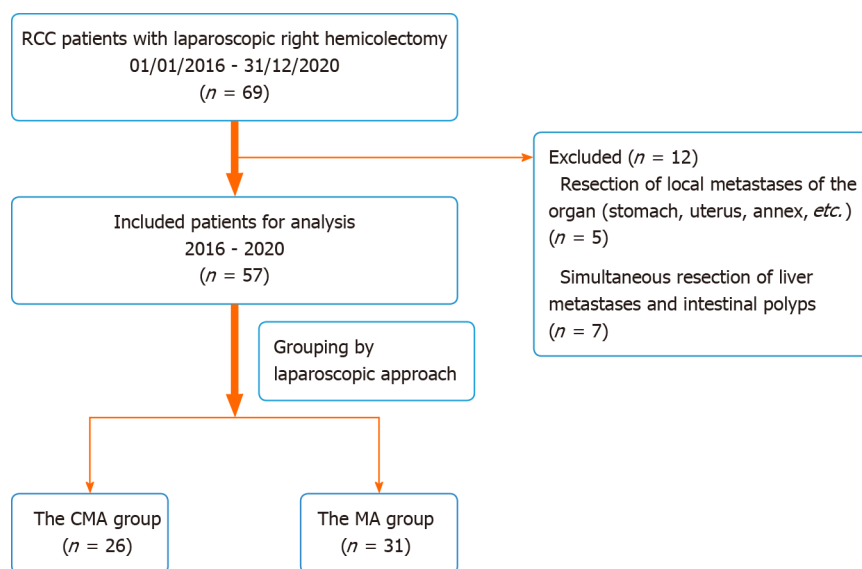
Dissociation of the right colon under laparoscopy was completed in both groups of patients (CMA and MA). Then, the surgeon made a small incision of approximately 4 cm on the right side of the abdomen to complete the anastomosis (routine end-side anastomosis), finally rearranging the bowel.

CMA: (1) Establishment of a laparoscopic system and intraperitoneal exploration: All patients were placed in the lithotomy position after the administration of general anaesthesia, with the left leg lowered as much as possible to avoid affecting the operation of the surgeon. Throughout the procedure, the surgeon stood on the left side of the patient, whereas the first assistant stood on the right side, and the second assistant held a mirror and stood between the legs of the patient. Five trocars were used (three 5 mm, one 12 mm, one 10 mm), with one observation and four operation ports. Among these, one observation port with a 10-mm trocar was located 2 cm lower than the umbilicus. One operation port with a 5-mm trocar was placed at Maxwell's point. The second operation port with a 12-mm trocar was placed near the anti-Maxwell point. The third and fourth operation ports with 5-mm trocars were located approximately 2 cm lower than the edge of the rib arch across the left and right clavicular midline intersections (Figure 2). Laparoscopic exploration of the liver lobe, peritoneum, omentum, spleen, stomach, colon, pelvis, and small intestine was performed; the tumour location and size were evaluated to assess the extent of tumour invasion into the surrounding tissue and determine the scope of surgical resection. Then, the projection of the surgical trunk, the superior mesenteric artery (SMA) on the mesocolon and the root of the middle colic vessels were explored; (2) The greater omentum was split with an ultrasonic knife to the left of the superior edge of the transverse colon, the omental bursa was entered, and the greater omentum outside the gastric omental vascular arch (tumour of the ascending colon or ileocaecum) or inside the vascular arch (tumour of the hepatic curvature or right half of the transverse colon) was longitudinally cut off, revealing the right mesenteric fusion region of the transverse mesocolon, the mesogastrium and the underlying visceral duodenal-pancreatic peritoneum (also called the fusion fascia of Fredet)[12,13]; (3) Cephalic-approach procedure (CAP): The first assistant lifted the gastric body and pulled the mesogastrium upwards laterally, and the surgeon used the right hand to pull the transverse mesocolon downwards, which formed an antagonistic force and satisfactorily exposed the right fusion fascia area of the transverse mesocolon and the mesogastrium. The surgeon first dissected the fusion fascia in the innermost area adjacent to the gastric antrum (Figure 3A), entered the dorsal side of the fusion fascia of Fredet (Figure 3B), and then gently expanded the surgical plane between the fusion fascia of Fredet and the visceral duodenal-pancreatic peritoneum in a medial-to-lateral direction. After cleavage of the lateral "white line of Toldt" around the hepatic flexure, the fusion fascia was incised between the hepatic curvature of the colon and the second part of the duodenum and expanded downwards and slightly laterally, and the plane between the fusion fascia of Toldt and the subperitoneal deep fascia (Gerota fascia) near the lateral side of the second part of the duodenum was entered. Using the projection of the superior right colic vein (SRCV) on the fusion fascia of Fredet as a landmark, the surgical plane was expanded medially to expose the gastroduodenal trunk of Henle (GCTH), and the nonvascularized mesocolic area was expanded on the left side of the root of the middle colonic vessels, completing the dissection of the surgical area of the GCTH[14,15] (SAGCTH), defined as the area of the superior mesenteric vein (SMV) located at the head of the pancreas and including the venous confluence of the right gastroepiploic vein (RGEV), anterosuperior pancreaticoduodenal vein (ASPV), and SRCV. Then, exposure was continue downwards to the second part of the duodenum, the head of the pancreas and the cranial root of the middle colic vessel; a piece of gauze was placed transversely at the lower edge as a landmark. In this procedure, the most important thing was to maintain the surgical plane between the fusion fascia of Fredet and the visceral duodenal-pancreatic peritoneum and to completely resect the fusion fascia of Fredet (Figure 3C); (4) Medial-approach procedure (MAP): The first assistant pulled up the mesocolon of the middle colic vascular area with the left hand, pulled the mesocolon of the ileocolic vascular area with the right hand, and exposed the projection of the surgical trunk[14,17] on the mesocolon. The surgeon incised the mesentery junction (the fusion point of the mesocolon, the visceral peritoneum, and the intestinal mesentery, approximately 3 cm below the projection of the ileocolic vessels to the confluence of the SMV) with an ultrasonic scalpel (Figure 3D and E), utilized the vapourization effect of the ultrasonic scalpel, sought the fusion fascia of Toldt and then entered the surgical plane between the fusion fascia of Toldt and subperitoneal deep fascia (Figure 3F); then, the surgeon slightly expanded the plane laterally to the white line of Toldt, down to the peritoneal reflexion area of the ileocaecum, and up to the lower margin of duodenum and cut off the right fusion fascia of Toldt at the third portion of the duodenum, where the fusion fascia of Toldt divided into the posterior pancreatic fascia of Treitz and the fusion fascia of Fredet. The dorsal side of the fusion fascia of Fredet was entered to reach a rendezvous of the surgical plane with that of the CAP (Figure 3G and H). The ileocolic artery (ICA) was used as a landmark, revealing the surgical

Table 1 Basic patient preoperative characteristics

Item	CMA group (n = 26)	MA group (n = 31)	P value
Age (yr)	63.12 ± 13.65	61.35 ± 12.27	0.61
Sex			0.794
Male	14	18	
Female	12	13	
BMI (kg/m ²)	21.42 ± 3.15	22.54 ± 3.43	0.209
Tumour size (cm)	5.18 ± 1.80	4.84 ± 2.06	0.52
Previous abdominal surgery			0.488
Yes	3	6	
No	23	25	
Tumour location			0.644
Ileocecal junction	7	6	
Ascending colon	11	12	
Flexura hepatica coli	8	13	
Histological grade			0.185
Well	0	1	
Moderate	18	26	
Poor	8	4	

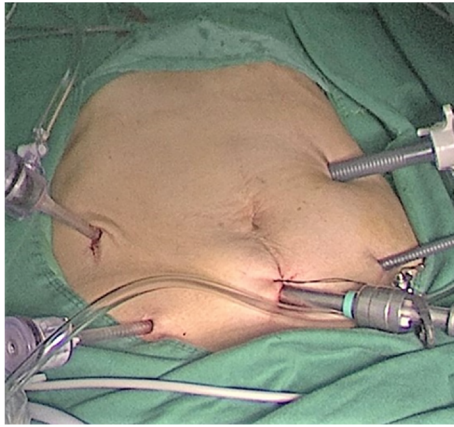
CMA: Cranial-medial mixed dominant approach; MA: Medial approach.



DOI: 10.4240/wjgs.v14.i3.221 Copyright The Author(s) 2022.

Figure 1 Flow chart of clinical data selection.

trunk; the mesenteric radix was sharply dissected from the caudal side (small intestinal venous branch of the SMV) to the cranial side (the left root of the middle colic artery (MCA), with the projection of the gauze used as a landmark), and the roots of the vessels (ileocolic vessels, right colic artery, etc.) were ligated simultaneously; (5) Rendezvous of the surgical plane after the CAP and MAP. The rendezvous zone: (a) The nonvascularized mesocolic area on the left side of the root of the MCA was dissected to enter the ventral plane of the pancreas; and (b) The connecting line from the right side of the middle colic vessel to the GCTH was opened up, which connected the dorsal side of the fusion fascias of Fredet



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Figure 2 The position of the five trocars.

and Toldt. The root of the right branch of the MCA was ligated simultaneously; and (6) Cleavage of the lateral white line of Toldt was performed around the caecum (Figure 3L), along the ascending colon and around the hepatic flexure, connecting the posterior plane of the expanded fusion fascia of Toldt to complete the overall mobilization of the right colon (Figure 3M). The specimen from the operation was in Figure 4.

MA: First, we found the anatomic projection of the ileocolic vessel pedicle. We anatomized the SMV from the caudal side to the cranial side and ligated the roots of the vessels [ileocolic vein (ICV), ileocolic artery (ICA), RCV, right colic artery (RCA), *etc.*]. Then, we followed the fusion space of the hepatic flexure of the colon and completely dissected the colonic hepatic flexure (as mentioned above). Finally, we mobilized the right colon along with the expanded fusion fascia of Toldt.

Observational indexes

Intraoperative data were obtained regarding the operative duration (duration of the total operation and the laparoscopic procedure), blood loss, specimen length, and number of resected and positive lymph nodes. Postoperative data, including exhaust time, liquid intake time, postoperative hospitalization (days), and postoperative complications, were recorded. Complications were graded according to the Clavien-Dindo classification[18]. Mortality and short-term postoperative complications within the first 30 postoperative days (or during the entire hospital stay if longer than 30 d) were recorded. Postoperative ileus was defined as no tolerance for solid food and no defecation by postoperative day 6 [19]. Postoperative bleeding was defined as bleeding requiring at least one transfusion of packed red cells during surgery or in the subsequent 48 h.

Statistical analysis

All calculations and analyses were performed by SPSS software, version 22.0 (SPSS, Chicago, IL). Quantitative data are expressed as the mean \pm SD. Student's *t* test was used to compare the differences between the two groups; $P < 0.05$ was considered statistically significant.

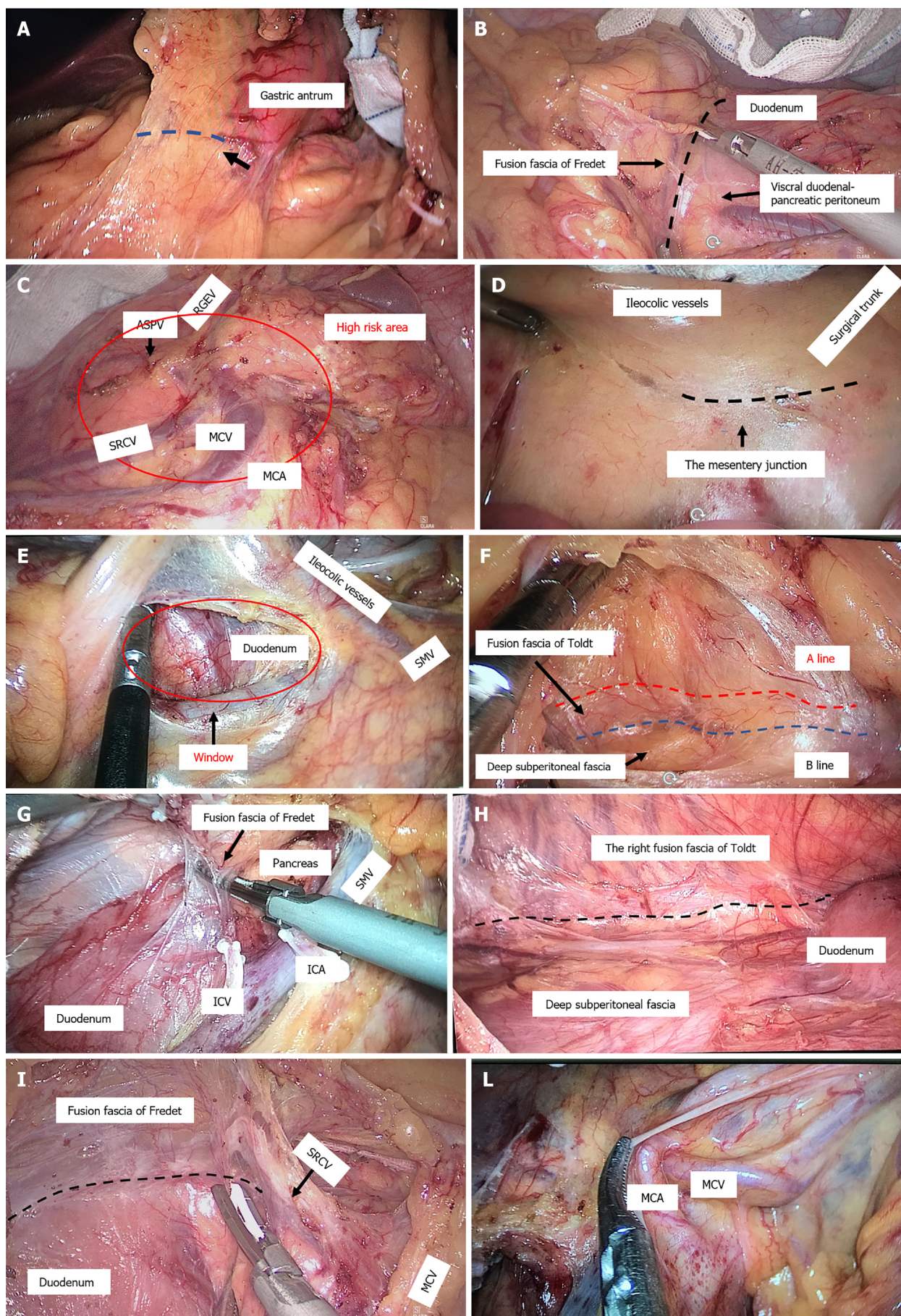
RESULTS

General information

Twenty-six and 31 patients were assigned to the MA and CMA groups, respectively (Table 1). There was no significant difference between the groups in sex, tumour location, tumour classification, laboratory results [carcinoembryonic antigen (CEA) level, haemoglobin (HB) level, white blood cell (WBC) count, ALB level, *etc.*] or body mass index.

Comparison of intraoperative and postoperative conditions

The mean resection sample length in the MA group was 26.95 ± 6.18 cm, which was not different from that in the CMA group (27.926 ± 7.52 cm) ($P = 0.598$). The number of lymph nodes collected in the CMA group was 30.50 ± 15.31 , which was significantly greater than that in the MA group (23.81 ± 9.06). The number of positive lymph nodes was similar in both groups. In the CMA group, the operative duration was 135.12 ± 17.47 min, and the laparoscopic procedure time was 69.73 ± 15.13 min, which were significantly lower ($P < 0.05$) than those in the MA group (150.61 ± 26.01 min and 84.81 ± 21.48 min,



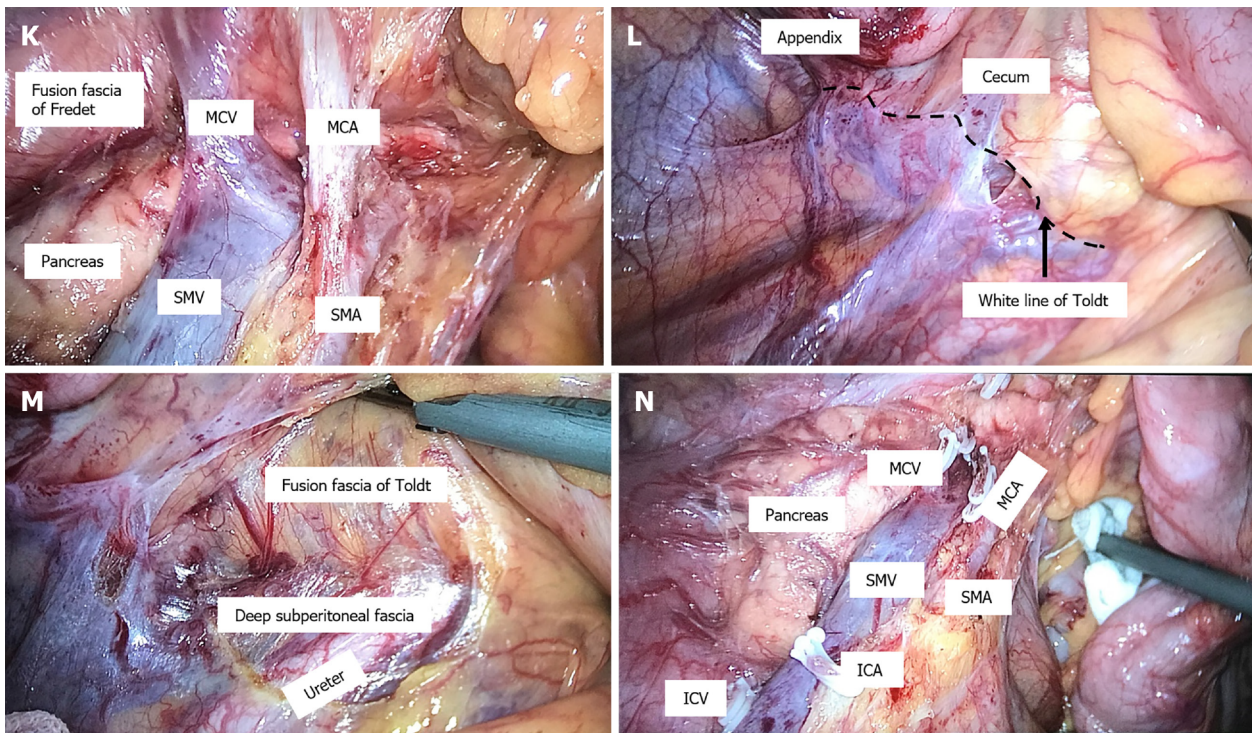


Figure 3 The cranial-medial mixed dominant approach. A: The right fusion fascia area of the transverse mesocolon and the mesogastrium. The black arrow indicates the position of the first cut with dissection along the dotted line; B: Expanded surgical plane between the fusion fascia of Fredet and the visceral duodenal-pancreatic peritoneum; C: High-risk area using the superior right colic vein as a landmark included the gastrocolic trunk of Henle, middle colic vein (MCV), and middle colic artery (MCA); D: The mesentery junction fusion point of the mesocolon and the intestinal mesentery, approximately 3 cm below the projection of ileocolic vessels to the confluence of the superior mesenteric vein (SMV); E: The mesocolic window was opened to enter the right retrocolic space; F: Expanded surgical plane of the right retrocolic space between the ventral side of the fusion fascia of Toldt and deep subperitoneal fascia. A line: Red dotted line, B line: Blue dotted line, as indicated by Shinohara[15]; G: Fusion fascia of Fredet; H: Right retrocolic space after resection between the fusion fascia of Toldt and deep subperitoneal fascia; I: Rendezvous view of the surgical plane after the cephalic-approach procedure and medial-approach procedure, cut along the black dotted line on the fusion fascia of Fredet; J: Complex three-dimensional anatomical structure of the root of medial colic vessels; K: Three-dimensional dissection of the mesocolon around the root of the MCVs; L: Lateral white line of Toldt around the ileocaecum; M: Cleavage of the lateral white line of Toldt around the caecum connected to the posterior plane of the expanded fusion fascia of Toldt; N: SMV after lymph node dissection. RGEV: Right gastroepiploic vein; ASPV: Anterosuperior pancreaticoduodenal vein; SRCV: Superior right colic vein; ICA: ileocolic artery; ICV: ileocolic vein; SMA: Superior mesenteric artery.

respectively). There was no significant difference in the intraoperative blood loss, feeding fluid time, exhaust time, length of hospital stay or postoperative laboratory results (seven days after the operation) between the two groups ($P > 0.05$) (Table 2).

Operational complications

The incidence of complications in the CMA group was 23%, while that in the CA group was 13%, but the difference was not significant ($P = 0.486$). The 30 d mortality rate was 0 in both groups. However, there were 3 cases of lymphatic fistula in the CMA group, all of which were cured by conservative treatment (Table 3).

DISCUSSION

Multiple cohort studies have confirmed the oncological effectiveness and surgical safety of CME with CVL[20-22], in which the embryologic tissue planes are resected along the entire enveloped mesocolon. There is a multicentre, prospective, randomized trial comparing conventional (laparoscopic) right hemicolectomy with robotic CME for patients with right-sided colon cancer at 4 centres in the UK currently underway, and we are very much looking forwards to its results[23]. Although there are still some doubts[8], laparoscopic CME has gradually become the technical standard for colon cancer[5]. However, there is no consensus on which standard surgical approach should be used to perform LRH with CME.

The representative approaches of LRH with CME include the MA, cephalic approach, caudal approach and other mixed approaches. European randomized controlled trials (RCTs) have suggested that[24] the MA has advantages in LRH and is both widely used in clinical practice and representative. However, Liang *et al*[9] suggested that the MA is difficult and commonly leads to bleeding due to

Table 2 Comparison of intraoperative and postoperative conditions between the two groups

Item	CMA group (n = 26)	MA group (n = 31)	P value
Sample length (cm)	26.95 ± 6.18	27.926 ± 7.52	0.598
No. of lymph nodes collected	30.50 ± 15.31	23.81 ± 9.06	0.046
No. of positive lymph nodes	2.15 ± 2.99	1.45 ± 2.32	0.323
Nerve invasion			0.524
Yes	20	26	
No	6	5	
Vessel carcinoma embolus			0.432
Yes	14	20	
No	12	11	
Invasive depth			0.021
T1	2	1	
T2	0	1	
T3	8	1	
T4	16	28	
Lymph node metastasis			0.658
N0	13	19	
N1	9	9	
N2	4	3	
pTNM			
0	0	1	0.339
I	1	0	
II	12	16	
III	11	14	
IV	2	0	
Total operation time (min)	135.12 ± 17.47	150.61 ± 26.01	0.01
Laparoscopic procedure time (min)	69.73 ± 15.13	84.81 ± 21.48	0.003
Intraoperative blood loss (mL)	48.46 ± 30.07	67.10 ± 87.88	0.309
Exhaust time (d)	3.81 ± 1.92	4.45 ± 1.15	0.123
Liquid intake time (d)	5.27 ± 1.87	4.81 ± 1.22	0.266
Postoperative hospitalization (d)	12.23 ± 2.23	11.29 ± 2.02	0.101

CMA: Cranial-medial mixed dominant approach; MA: Medial approach.

variation in the surgical trunk and its branches. Matsuda *et al*[4] proposed a cranial-to-caudal approach in 2015 and considered that it is easy to expose the pancreas and the root of the middle colic vessels and facilitate lymph node dissection along the surgical trunk for advanced right-sided colon cancer. Zou *et al* [11] proposed a caudal-to-cranial approach and showed that it was easier to enter the dorsal side of the fusion fascia of Toldt. These approaches all have some limitations. In clinical practice, based on the universal principle of embryonic development and fusion fascia theory, is there a more optimized surgical approach?

In recent years, the authors' team has proposed and practised the CMA to perform LRH with CME, with satisfactory results. Compared with the MA group, the CMA group had obvious advantages in the total operative duration, laparoscopic procedure duration and the number of lymph nodes dissected, while the intraoperative blood loss and the incidence of postoperative complications were basically the same between the two groups.

Table 3 Comparison of complication rates between the two groups, *n* (%)

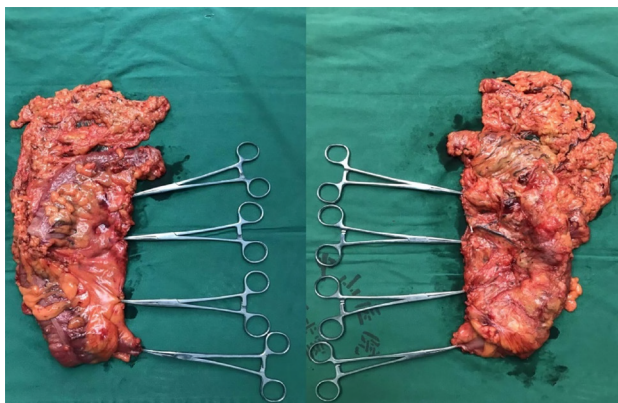
Item	CMA group (<i>n</i> = 26)	MA group (<i>n</i> = 31)	<i>P</i> value
Complications	6(23)	4(13)	0.486
Anastomotic fistula	0	0	
Anastomotic stenosis	0	0	
Bleeding	0	1	
Lymphatic fistula	3	1	
Ileus	2	0	
Incisional hernia	0	1	
Acute urine retention	0	0	
Incision infection prevention	1	1	
Intra-abdominal infection	0	0	
Pulmonary infection	0	0	

CMA: Cranial-medial mixed dominant approach; MA: Medial approach.

The theoretical framework of the CMA is derived from four aspects. First, the fascia of the primitive gut (which develops into the mesogastrium, mesocolon, mesostenium, *etc.*) is continuous during embryonic development[25,26]. Second, during embryological development, the midgut loop rotates 270 counterclockwise around the primary SMA, and the greater omentum and transverse mesocolon overlay the frontal surface of the mesoduodenum[27-29]. The peritoneal membrane at the attachment site fuses and degenerates to form membranous connective tissue called the fusion fascia[29]. Third, the right fusion fascia of Toldt is divided into the posterior pancreatic fascia of Treitz dorsally and the anterior pancreatic fascia of Fredet ventrally at the second portion of the duodenum[13,17]. These fusion fascias are delineated by the posterior layer of the ascending mesocolon ventrally (the mesofascial interface) and by the prerenal fascia, representing the posterior parietal peritoneum covering the retroperitoneum (the retrofascial interface) dorsolaterally[28]. Finally, CME with CVL was defined as follows[4,13]: (1) Dissection between the right mesocolon and the retroperitoneum, following the embryological plane, the dorsal side of the fusion fascia of Toldt and the fusion fascia of Fredet (the retrofascial interface); (2) High ligation of ileocolic vessels, right colic vessels, and the right branches of middle colic vessels; and (3) Removal of a sufficient length of the colon.

In the CAP, after entering the omental bursa, we emphasized the anatomical function of the first cut of the ultrasonic knife and produced the bubble effect when dissecting the fusion fascia in the innermost area adjacent to the gastric antrum (Figure 2A). The bubble effect allows the “angel fair” to form and the surgical space to be confirmed; then, the fusion fascia of the dorsal leaf of the transverse mesocolon and the dorsal mesogastrium can be separated, easily exposing the surgical plane between the fusion fascia of Fredet and the visceral duodenal-pancreatic peritoneum and allowing entry. Garcia-Granero *et al*[14] indicated that the fusion fascia of Fredet should be removed completely. Mike and Kano[17,30] proposed that there are three fusion modes between the transverse mesocolon and mesoduodenum. That is, fusion between the ventral leaf of the transverse mesocolon and mesoduodenum, between the dorsal leaf of the transverse colon and mesoduodenum, and almost no fusion. We found that regardless of which mode was found, through the CAP, we could obtain a clear surgical plane and achieve a bloodless field.

The GCTH enters the SMV, dividing it into the distal “surgical trunk” and proximal “Henle’s trunk area” (SAGCTH). The difficulty of LRH lies in the SAGCTH. Due to the anatomy of this region, the risk of injury to the SMV and perioperative bleeding is considered to be high. Causes of bleeding or injury include vascular variations in the GCTH[31-33], improper traction during the operation, and an uneven pancreatic surface. In most cases, the GCTH is close to the lower edge of the pancreas, joining the SMV at the uncinate process of the pancreas. The right gastroepiploic vein is near the upper edge of the pancreatic head, sometimes closely associated with the pancreas, and the signs are difficult to identify. The course of the SRCV is special in that it bridges the gap between the transverse mesocolon and the mesogastrium before it merges into the GCTH[34], and inappropriate tension needs to be avoided in dissection of the SRCV. How can this anatomical region be dissected under laparoscopy? We suggest that the SRCV can be used as a landmark, as its inflow mode is relatively constant[35]. By tracking the direction of SRCV inflow into the GCTH from the outermost side of the pancreatic head and performing ligation at its root, the risk of bleeding caused by anatomical relationships and improper techniques can be avoided. In addition, the dorsal side of the transverse mesocolon can be fully exposed at the lower edge of the uncinate process to overcome the obstacle of the visual field under the traditional MA.



DOI: 10.4240/wjqs.v14.i3.221 Copyright The Author(s) 2022.

Figure 4 The specimen from the operation.

In the MAP, we first incised the mesocolon in the ileocolic area approximately 3 cm below the projection of ileocolic vessels to the confluence of the SMV, where a natural depression with colour distinction (yellow-white junction), which is the boundary between the intestinal mesentery and the right mesocolon, can be seen under high-definition laparoscopy. Some experts[36] have called this site the “trijunction”, *i.e.*, the fusion point of the mesocolon, the visceral peritoneum, and the intestinal mesentery. Through the incision of this trijunction, we can enter the posterior space of the colon (the dorsal side of the fusion fascia of Toldt) behind the whole ascending colon and ileocecal part and can gently anatomize the whole plane of the posterior space of the colon. There is some controversy about the ideal surgical plane for colon separation. Zhang *et al*[37] considered the right retrocolic space to be ideal but did not define the level of the surgical plane. The separation plane should be behind the fusion fascia of Toldt, that is, between the fusion fascia of Toldt and the deep layer of the posterior subperitoneal fascia, as suggested by Mike M[17,30]. Based on autopsy experience, Culligan *et al*[38] proposed the view that the retrocolic space can be divided into two planes, the mesofascial plane and the retrofascial plane. Shinohara[16] pointed out the A line and the B line. The A line runs along the plane of the ventral side of the fusion fascia of Toldt without cutting it open. It does not affect the degree of lymph node dissection, but in most cases, the fusion fascia of Toldt is cut open, and it is easier to enter and expand the plane along the B line (dorsal side of the fusion fascia of Toldt). Therefore, he recommended dissociating along the B line. Our understanding is that we entered the mesofascial plane following the A line and the retrofascial plane following the B line. Coffey *et al*[39] suggested that the origin and termination of fascial lymphatics should be determined to partly address this question. A previous study[40] found that the fusion fascia of Toldt may serve a barrier function, as rarely in colorectal cancer does one observe the spread of colon cancer through the fascia into the retroperitoneum. Even where the mesocolon has been directly involved, spread through the fascia is unusual. Therefore, we agree with Mike M that complete removal of the fusion fascia of Toldt is necessary.

Coffey *et al*[41] proposed that attention should be given to maintenance of the surgical plane during LRH to meet the requirements of CME. How should the right plane be maintained? Our clinical viewpoint and theoretical basis are as follows: (1) In the process of embryonic development, the peritoneum and mesentery at the attachment site fuse and degenerate to form a single sheet of connective tissue called the fusion fascia at the end of intestinal rotation (the fusion fascias of Toldt and Fredet)[42,43], and the inside of the fusion fascia cannot be dissected by definition. It is easy to enter and expand the surgical plane behind the ascending colon from the dorsal side of the fusion fascia of Toldt; (2) The medial border of the fusion fascia of Fredet is the SMV and GCH[13]. A safe surgical plane with better exposure can be obtained by entering from the dorsal side of the fusion fascia of Fredet, which can reduce the risk of injury to this area and especially prevent tearing and thus bleeding of the SMV, which can lead to life-threatening complications[43]; and (3) Although Shinohara[16] suggested that separation from the ventral side of the fusion fascia does not affect lymph node dissection, there is no evidence-based medical evidence that this procedure can ensure the integrity of lymphatic dissection. More importantly, this method can easily lead to fascia fragmentation and residue. Our conclusion is that to achieve CME in right-sided colon surgery, complete resection of the fusion fascias of Toldt and Fredet is necessary. How do we judge whether we entered the ventral side of the fusion fascia of Toldt under laparoscopy? First, the plane covered by the smooth, deep subperitoneal fascia (Gerota fascia) can be seen in the operation field, the reproductive vessels and peristaltic ureter can be seen behind this fascia, and the white line of Toldt can be seen faintly laterally. Second, a thin layer of relatively dense connective tissue membrane can be seen below the duodenum when the plane is expanded cephalad, and the duodenal wall can be seen vaguely behind this membrane. Third, the whole dissection process is bloodless. Bleeding indicates entry of the incorrect plane.

Where is the core anatomical area in the rendezvous process of the surgical plane of the CAP and MAP? Matsuda *et al*[10,44] noted that lymph node dissection around the middle colic vessels is technically demanding. The difficulty comes from the fusion of the transverse mesocolon in the middle colic vessel region with the greater omentum, pancreas and duodenum during embryonic development, forming a complex three-dimensional anatomical structure (Figure 2). A substantial mesenteric tissue mass occurs at the root of the middle colic vessel region formed by midgut rotation during embryonic development. Although the fascia is contiguous, it is interrupted at points where vessels enter or leave the mesentery[39]. The position of the points is the edge of the envelope structure of the mesocolon. There is concentrated lymphatic flow and complex vascular variation at the lower edge of the uncinate process of the pancreas and the root of middle colic vessels[15,45-47]. Therefore, in LRH with CME, the dissection of the mesenteric area at the root of the middle colic vessels is the core anatomical area of the whole operation, and a simple approach such as the MA is difficult to complete. Under the CMA, we treated the cephalic part of the mesocolon of the middle colic vessel region first in the CAP, fully exposed the surgical plane behind the anterior pancreatic fascia to avoid pancreatic injury and safely exposed the GCTH and its branches; we exposed the mesenteric inner and lower boundaries of the SAGCTH and middle colic vessel region; and then we treated the caudal part of the middle colic vessel region to reach the rendezvous region of the surgical plane. Therefore, the mesentery in this area can be dissected in three dimensions to avoid residual mesenteric tissue, pancreatic injury, and injury to vessels such as the GCTH, which may lead to serious intraoperative bleeding.

Different researchers have different understandings of membrane anatomy but achieve the same result by different methods. Mike and Kano[17] have suggested that the membrane is continuous and that the membrane plane is continuous. Zhao *et al*[48] proposed the concept of a "mesenteric window". After incising the inferior edge of the ileocolic vascular pedicle, we could easily enter the natural right retrocolic space and extend the space laterally and cranially. Shinohara[16] affirmed that the SRCV and its confluence with the GCTH constituted the rotation centre of the mesocolon during embryonic development. Coffey *et al*[39] considered that the central mechanism of fixation of the mesocolon and posterior abdominal wall, that is, the connection point of the mesentery and blood vessels, constitutes the "hilum" of the mesentery, which determines the medial boundary of dissection, just as right peritoneal reflection (the white line of Toldt) determines the lateral boundary. Garcia-Granero *et al*[14] found that the medial limit of the fascia of Fredet is represented by the SMV and GCTH, which is also the hilum of the mesocolon. The above research results strongly promote the accuracy of surgery in LRH. According to our understanding, the right mesocolon is fan-shaped, and the SMV axis is the core anatomical marker of the right mesocolon, which connects the mesenteric window and hilum. These two landmarks are the result of fusion of the gastrointestinal mesentery after rotation during embryonic development and are also the important theoretical basis of membrane anatomy for the CMA.

Although this study discusses the surgical approach, the ultimate pursuit of the surgeon is oncological benefits for the patient. An early study by West *et al*[49] suggested that attention should be given to the quality classification of surgical specimens in the surgical treatment of colon cancer, as colon cancer patients who undergo resection with an intact mesocolon achieve 15% better 5-year overall survival than those with defects in the mesocolic specimens. Xie *et al*[50] recommended that in gastrointestinal surgery, the mesentery should be removed completely to prevent cancer leakage. Benz *et al*[51] proposed a new classification system for CME in right-sided colon cancer, with the following distribution: type 0 (best), type I, type II, and type III (poorest). In type 0, the true CME specimen, the stalks of the ileocolic vessels and middle colic vessels are connected by tissue of the surgical trunk (lymphatic tissue package covering the SMV), and the mesocolic window has a complete medial frame of mesocolic tissue. Bertelsen *et al*[52] recently reported five-year outcomes for right-sided colon cancer across the capital region, demonstrating a significant reduction in recurrence in the CME group (9.7% *vs* 17.9%) and the potential for improved long-term outcomes after the resection of all UICC stage I-III right-sided colon adenocarcinomas. The original intention of presenting the CMA was to standardize the surgical procedure and to obtain better specimen quality.

CONCLUSION

The CMA is based on the theory of embryonic development and membrane anatomy, and the technical route itself weakens the vascular and lymphoid anatomy. The unique advantages of LRH with the CMA are as follows: (1) The team learning curve can be significantly shortened; (2) The operation can be performed with little to no bleeding, with a reduced probability of conversion to laparotomy and improved safety and efficiency; and (3) Higher-quality specimens can be obtained. Therefore, we believe that the CMA is the dominant approach for laparoscopic radical resection of the right colon. However, the CMA currently lacks RCT-based evidence and needs to be validated in further multicentre prospective studies.

ARTICLE HIGHLIGHTS

Research background

Complete mesocolic excision (CME) with central vascular ligation (CVL) is the technical standard for colon cancer surgery. How to achieve CME with CVL in laparoscopic right hemicolectomy (LRH) is controversial. Several approaches have been proposed, but a unified standard approach is not yet available.

Research motivation

The authors' team has proposed and practised the cranial-medial mixed dominant approach (CMA) to perform LRH with CME for years. We would like to confirm that the CMA does have unique technical advantages through data rather than subjective opinions by comparing it with the classic medial approach (MA).

Research objectives

To compare the CMA with the classic MA to prove that the CMA has unique advantages in performing LRH.

Research methods

We compared the two groups (CMA and MA) by intraoperative data (operative duration, blood loss, specimen length, number of resected and positive lymph nodes, and postoperative data (exhaust time, liquid intake time, postoperative hospitalization, postoperative complications). Additionally, we described the procedure and technical points of the CMA in detail to facilitate the reader's understanding.

Research results

There were no significant differences in baseline data or the number of positive lymph nodes, intraoperative blood loss, postoperative exhaust time, feeding time, postoperative hospital stay or postoperative complication incidence between the two groups. The operation was shorter and the number of lymph nodes dissected was higher in the CMA group.

Research conclusions

The CMA weakens the vascular and lymphoid anatomy and has unique advantages for LRH with CME and CVL.

Research perspectives

More RCT-based evidence and further multicentre prospective studies are needed to validate the CMA.

FOOTNOTES

Author contributions: Lin L and Yuan SB designed, performed the research study, contributed new reagents and analytic tools and wrote the manuscript; Lin L and Guo H analyzed the data; all authors have read and approve the final manuscript.

Institutional review board statement: The study was reviewed and approved by the scientific research sub-committee of the medical ethics committee Institutional Review Board of Zhongshan Hospital Affiliated to Xiamen University (Approval No. xmzsyky-2021-159).

Informed consent statement: All study participants, or their legal guardian, provided informed written consent prior to study enrollment.

Conflict-of-interest statement: There are no conflict of interest.

Data sharing statement: The data underlying this article cannot be shared publicly due to the privacy of individuals that participated in the study. The data will be shared on reasonable request to the corresponding author.

STROBE statement: The authors have read the STROBE Statement checklist of items, and the manuscript was prepared and revised according to the STROBE Statement-checklist of items.

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