Int J Clin Exp Med 2016;9(6):9513-9520
www.ijcem.com /ISSN:1940-5901/IJCEM0019971

Original Article

Preoperative imaging of the mesenteric vasculature improves outcomes in laparoscopic complete mesocolic cancer excision

Yeting Hu[1,2*], Zhanhuai Wang[1,2*], Jinjie He[1,2], Haiyan Chen[1,2], Kejun Tang[1,2], Jun Li[1,2], Lifeng Sun[1,2], Ying Chen[3], Ying Yuan[2], Shugao Han[3], Kefeng Ding[1,2]

[1]*Department of Surgical Oncology, Second Affiliated Hospital of School of Medicine, Zhejiang University, Hangzhou, China;* [2]*The Key Laboratory of Cancer Prevention and Intervention, China National Ministry of Education, Hangzhou, China;* [3]*Department of Radiology, Second Affiliated Hospital of School of Medicine, Zhejiang University, Hangzhou, China.* **Equal contributors.*

Received November 17, 2015; Accepted March 29, 2016; Epub June 15, 2016; Published June 30, 2016

Abstract: Purpose: Despite convergent evidence indicating a wide range of advantages for computed tomography angiography (CTA) for evaluating vascular anatomy prior to laparoscopic complete mesocolic excision (CME), the operative effects of CTA remain to be determined. In this study, we investigated alterations in operative outcomes caused by preoperative CTA. Methods: Based on CTA, arterial and venous vessels were reconstructed prior to laparoscopic CME (CTA group) in 84 patients with colon cancer. Sixteen of these patients were excluded from the analysis of the operative outcomes because of undergoing either laparoscopic surgery combined with resection of other organs or radiofrequency ablation. The remaining 68 patients were enrolled in the CTA group for the analysis of the operative outcomes. For comparison, 61 patients had the same surgery without preoperative CTA (Control group). Results: We found that the right colon artery (RCA) and the right colon vein (RCV) were absent in 42.9% and 23.8% of patients, respectively. Some patients, 17.9%, had one superior RCA (SRCA) and 1.1% had two SRCAs. Many patients, 40.5%, had one superior RCV (SRCV), and 2.4% had two. The gastrocolic trunk (GCT) was observed in 89.3% of patients in CTA group. Compared to the Control group, operative time declined in CTA group (181.0 vs. 159.8 mins), and the intraoperative blood loss in CTA group decreased (157.0 vs. 108.2 ml, P=0.001). Additionally, the intraoperative blood loss decreased more in laparoscopic CME for right-sided tumors, from 174.2±121.0 ml to 107.6±67.3 ml in the Control and CTA groups respectively (P<0.001). Conclusions: Preoperative CTA performed in colon cancer patients could help reduce the intraoperative blood loss during the laparoscopic CME. Preoperative CTA is a novel technique to assist surgeons in the evaluation of individual mesenteric vascular variations and could reduce the risk of vessel injury during surgery.

Keywords: Computed tomography angiography, laparoscopic complete mesocolic excision, vascular variations, blood loss, operative time

Introduction

In past decades, several clinical trials have been carried out to test the feasibility and benefits of laparoscopic surgery for colorectal cancer [1-3]. Compared to open laparotomy, emerging evidence has demonstrated the superiority of laparoscopic surgery with smaller incisions, minimal visceral exposure, faster recovery, and less hospitalization [4] without compromising the long-term outcomes [5-9]. Despite these great benefits, there are several limitations that have delayed the extensive acceptance of this procedure. The most important of these limitations is the need to have an appropriate view of the entire operative field. Few solutions to this problem have been suggested; thus, more clinical research is needed.

Laparoscopic surgery for colon cancer showed a longer operation time compared to the original open laparotomy due to the need for a careful search for blood vessels and/or anatomical landmarks [10, 11]. If undiscovered, these features might increase the risk of vascular and visceral injuries, especially when unfavorable

Table 1. Clinical and operative data for all cases undergoing laparoscopic resection

Variables	CTA group	Control group	*P*
Female/Male	25 (36.8%)/43 (63.2%)	28 (45.9%)/33 (54.1%)	0.371[b]
Tumor location			0.219[b]
Left-side tumor	26 (38.2%)	30 (49.2%)	
Right-side tumor	42 (61.8%)	31 (50.8%)	
Age	62.5±12.6a	60.5±13.3[a]	0.374[c]
BMI	22.3±2.9[a]	23.0±3.0[a]	0.390[c]
TNM stage			0.254[b]
Stage I	6 (8.8%)	7 (11.5%)	
Stage II	19 (27.9%)	24 (39.3%)	
Stage III	36 (52.9%)	28 (45.9%)	
Stage IV	7 (10.3%)	2 (3.3%)	
Number of lymph nodes	17.0±7.8[a]	17.6±8.1[a]	0.284[c]
Blood loss	108.2±67.6[a]	157.0±104.0[a]	0.001[c]
Operative time	159.8±39.5[a]	181.0±40.7[a]	0.703[c]

[a]Age, BMI (body mass index), Number of lymph nodes, blood loss (mL), and operative time (minutes) were represented as mean ± standard error. [b]*P* value was calculated by the Chi-square test. [c]*P* value was calculated by the t-test.

anatomic variations are present. Therefore, prior to the operation, it is important to use high quality imaging techniques to obtain a view of the entire operative field, including the vascular anatomy of the lesions and the adjacent organs.

The revolutionizing development of multi-detector computed tomography (MDCT) and helical scanning techniques has dramatically enhanced our capabilities for human disease diagnosis and evaluation of the abdominal vasculature. The combination of high temporal and spatial resolution technologies has facilitated the applications of high quality computed tomography angiographies (CTA). Furthermore, using the volume-rendering technique, individual tomography slice data can be converted into three-dimensional (3D) imaging. Thus, with 3D construction imaging modality, surgeons can acquire preoperative views of the patient's vascular anatomy. For colon cancer, several studies have demonstrated the advantages of this advanced imaging modality for evaluating the vascular anatomy in laparoscopic complete mesocolic excision (CME) [12, 13]. These studies also indicated that using preoperative 3D computed tomography (CT) was helpful for laparoscopy [12, 13]. However, less data is available to confirm the efficacy of preoperative evaluation by CTA for CME. To the best of our knowledge, there are no studies that have carefully assessed to what extent a thorough preoperative evaluation of mesenteric vascular anatomy can affect the surgical outcomes.

Therefore, the present study had two goals. The first was to use CTA to determine the feasibility of getting a preoperative view of the major branches of mesenteric vessels that is needed for dissecting the important variations and cross vessel relationships. The second goal was to determine if preoperative evaluation of the vessels significantly improved the surgical outcomes, i.e., reducing both intraoperative blood loss and operative time during laparoscopic CME.

Materials and methods

Patients

CTA was performed in 84 consecutive patients who underwent laparoscopic CME for colon cancer at The Second Affiliated Hospital of Zhejiang University School of Medicine between March 2013 and December 2014. Sixteen of these patients underwent either laparoscopic surgery combined with resection of other organs or radiofrequency ablation. Because the combined resection of other organs or the radiofrequency ablation would affect the intraoperative blood loss and operative time, the analysis of the hemorrhage during surgery and operative time of these patients was excluded from the study. The remaining 68 patients had CTA prior to the laparoscopic CME for the colon cancer (CTA group). Between January 2011 and December 2014, 61 patients with colon cancer underwent the same surgery without performing preoperative CTA (Control group). The clinical characteristics were matched for both groups (**Table 1**). Informed consent was ob-

Table 2. Intraoperative blood loss and operative time for cases undergoing laparoscopic cme for different side tumors

	Laparoscopic CME for right-side tumor			Laparoscopic CME for left-side tumor		
Variables	CTA group	Control group	*P*	CTA group	Control group	*P*
Total blood loss	107.6±67.3[a]	174.2±121.0[a]	<0.001[b]	109.2±69.5[a]	139.3±81.2[a]	0.405[b]
Blood loss ≥300 ml (n, %)	1/42 (2.4%)	10/30 (33.3%)	0.001[c]	1/26 (3.8%)	2/30 (6.7%)	0.554[c]
Blood loss <300 ml (n, %)	41/42 (97.4%)	20/30 (66.7%)		25/26 (96.2%)	27/30 (93.3%)	
Operative time	158.4±39.5[a]	194.3±40.5[a]	0.470[b]	162.2±40.2[a]	169.1±37.5[a]	0.659[b]

[a]Age, blood loss (ml) and operative time (minutes) are presented as mean ± standard error. [b]*P* value was calculated by the *t*-test. [c]*P* value was calculated by the Chi-square test.

tained from all patients prior to surgery. This study was approved by the ethics committee of the Second Affiliated Hospital of Zhejiang University School of Medicine and complied with the tenets in the Declaration of Helsinki.

Computed tomography protocol

All CT examinations were performed with the second generation dual-source CT (Model: SOMATOM Definition Flash, Siemens Medical Solutions, Forchheim, Germany). A total of 120 ml of iodine-containing contrast agent (Model: Iopamiro 370 mg/ml, Bracco, Shanghai, China) was injected with an automated injector (Model: Mallinckrodt, St. Louis, MO, USA) at a flow rate of 5 ml/s followed by 20 ml 0.9% saline solution at the same flow rate. Image acquisition was started with an 8 s delay that corresponded to the measured contrast transit time that was individually assessed with the test bolus method. Arterial phase images were obtained using the bolus tracking method. In brief, arterial phase scanning started when the Hounsfield units reached 100 in the abdominal aorta at the level of renal hilum. The average scanning delay between the start of contrast material injection and the start of arterial phase scanning was 20 s (range 15-28 s). Portal vein phase scanning and early venous phase scanning were started 25 s and 28 s after arterial phase scanning, respectively. Images were transferred to an external workstation (Model: Syngo Multi-Modality Workplace VE36A, Siemens Medical Solutions, Munich, Germany) and reconstructed.

Image interpretation

The superior mesenteric artery (SMA) was defined as the anterior branch of the abdominal aorta supplying the mid-gut. The middle colic artery (MCA), right colon artery (RCA), and the ileocolic artery (ICA) branched from the right side of the main trunk of the superior mesenteric artery and supplied the terminal ileum, cecum, ascending colon, and two-thirds of the transverse colon. The superior RCA (SRCA) was defined as the branch of the marginal artery of the hepatic flexure. The superior mesenteric vein (SMV) drained blood from the small intestine, cecum, ascending colon, and transverse colon. The ileocolic vein (ICV), right colon vein (RCV), and middle colic vein (MCV) were defined as the tributaries from the marginal veins of the ileocecum, the ascending colon, and the transverse colon, respectively. The superior RCV (SRCV) was defined as the tributary from the marginal veins of the hepatic flexure. The gastrocolic trunk (GCT) was defined as the common trunk with the colic vein, the right gastroepiploic vein (RGEV), and/or the pancreatic duodenal vein (PDV).

The assessment of each vessel

The visibility of each vessel in CTA was graded and recorded by using the following four-level scale: [14] 3, excellent visibility in which the vessel was clearly seen as a round or oval structure; 2, good visibility in which the vessel was moderately visible; 1, poor visibility in which the vessel was visible, but the image was obscured; and 0, the vessel was not visible. The vessels in MDCT angiography were confirmed by two groups of radiologists and surgical oncologists.

Surgery

Patients in both the Control and the CTA groups underwent the laparoscopic CME surgery for colon cancer, which was performed by the same experienced surgeons. Perioperative out-

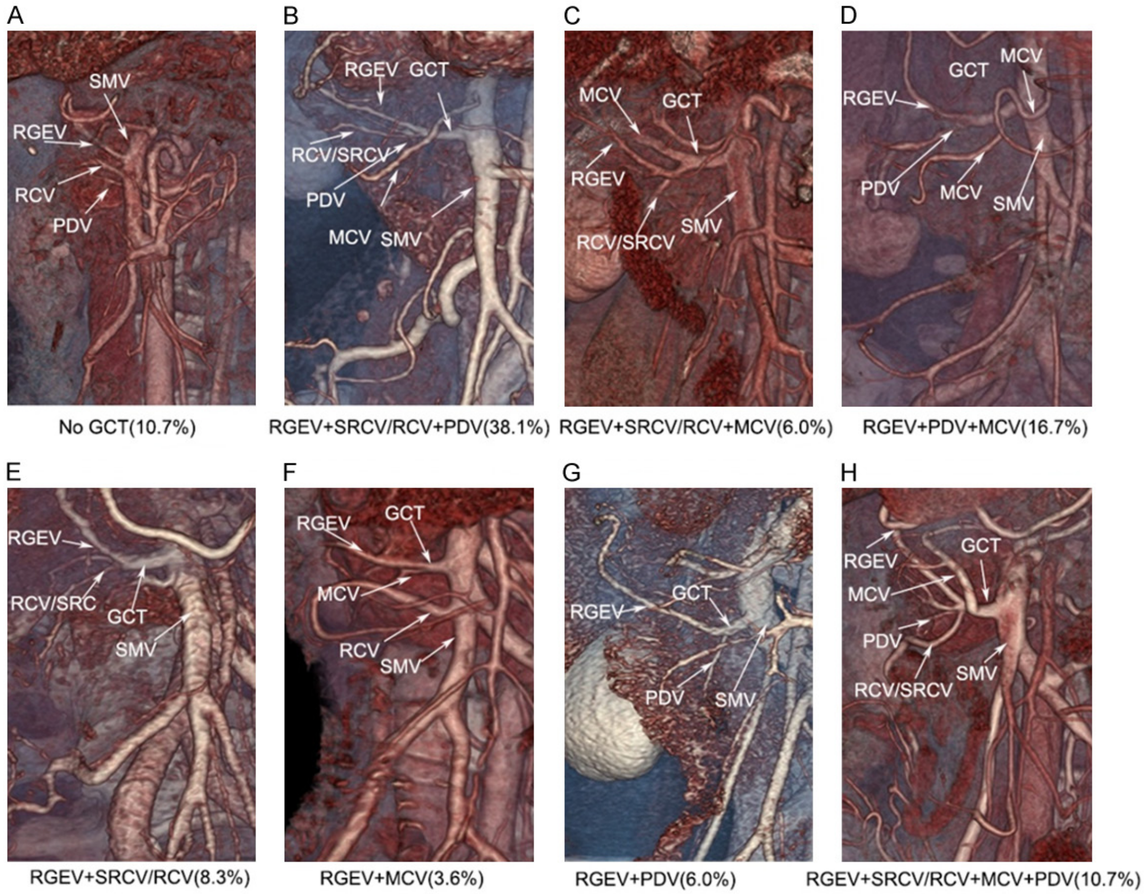

Figure 1. Variations of GCT were observed randomly in the CTA group. (A) Some patients, 10.7%, had no GCT, and (B-H) 89.3% of patients had seven different types of GCT (B-H). GCT, gastrocolic trunk; RCV, right colic vein; SRCV, superior RCV; MCV, middle colic vein; PDV, pancreatic duodenal vein; RGEV, right gastroepiploic vein.

comes included duration of operation and intraoperative blood loss. The intraoperative duration was defined as the time taken from skin incision to the completion of skin closure. The intraoperative blood loss was defined as the volume of blood collected in the suction container and estimated from gauze at the end of the operation.

Statistical analysis

All statistical analyses were performed using the SPSS software v19. Averages ± standard errors were calculated for each group of the study. Chi-square test was performed to compare the stage of disease and mass of blood loss between the CTA group and the Control group. In addition, Student's t-test was used to evaluate differences in intraoperative blood loss and operative time for the two groups. A value of $P<0.05$ was considered significant.

Results

All 145 patients were given laparoscopic CME without conversion to open surgery. Clinical data, the stage of disease, and operative outcomes for all cases are shown in **Table 1**, and the operative data for the different the tumor sites are shown in **Table 2**.

Usefulness of preoperative CTA during surgery

Blood loss in the Control group, 157.0±104.0 ml, was significantly greater than that in the CTA group, 108.2±67.6 ml ($P=0.001$, **Table 1**). While the operative time decreased from 181.0±40.7 minutes in the Control group to 159.8±39.5 minutes in the CTA group, the difference was not significant ($P=0.703$, **Table 1**). For the Control group, blood loss for right-sided tumor laparoscopic CME was 174.2±121.0 ml, which was significantly more than for the CTA

Table 3. Gastrocolic trunk composition and frequency

Type	Components	Occurrence
A	RGEV, SRCV, PDV	39.0%
B	RGEV, SRCV	9.8%
C	RGEV, PDV	6.1%
D	RGEV, SRCV, PDV, MCV	11.0%
E	RGEV, MCV	3.7%
F	RGEV, SRCV, MCV	6.1%
G	RGEV, PDV, MCV	17.1%

RGEV, right gastroepiploic vein; SRCV, superior right colon vein; PDV, pancreatic duodenal vein; MCV, middle colic vein.

group, 107.6±67.3 ml (*P*<0.001, **Table 2**). For left-sided tumors, the blood loss by the Control group, 139.3±81.2 ml, was more than for the CTA group, but the difference was not significant (*P*=0.405, **Table 2**). Moreover for right-sided tumors, 33.3% of the patients in the Control group lost over 300 ml of blood, whereas only 2.4% of patients in the CTA group lost over 300 ml (*P*=0.001, **Table 2**). For left-sided tumors, only a small percent of patients in either the Control or CTA groups, 6.7% and 3.8% respectively, had loss of blood greater than 300 ml (*P*=0.554, **Table 2**).

Significant variation of branches and tributaries of the superior mesenteric vessels

Based on the visible blood vessels, we focused on the vessels with high quality, i.e., those having a grade assessment of ≥2. All branches of the SMA were analyzed and quantified, and the images of most of the tributaries (94%-100%) to the SMV were confirmed to be of good or excellent quality. For the right colon, a single ICA and ICV were consistently found in the same, relatively fixed, locations in all patients. The MCA and MCV were absent in 1 patient (1.1%) and 5 patients (6%), respectively. The RCA and RCV were absent in 36 patients (42.9%) and 23 patients (23.8%), respectively. The SRCA was absent in 68 patients (81%), while 15 patients (17.9%) had one SRCA, and one patient (1.1%) had two SRCAs. Forty-five patients (40.5%) had one SRCV, and 2 patients (2.4%) had two SRCVs.

Relationships among the superior mesenteric branches and tributaries

The MCA crossed anterior to the SMV in most cases (67.8%). The length of the crossing MCA was 13.5±5.3 mm (range, 6.8-30.6 mm). The RCA arose from the SMA in 48 MDCT angiographies (57.1%). The RCA passed anterior to the SMV in 70.5% of these patients and posterior in 24.4%. In 5.1% of patients, the RCA did not cross the SMV.

The gastrocolic trunk

The SRCV, RGEV, PDV, and/or MCV often formed a GCT that drained into the SMV. Recently, the GCT was suggested as the new anatomic landmark during right-sided laparoscopic colectomy [15, 16]. In contrast to the ICV, the constituents of the GCT had numerous variations. In this study, the GCT was observed in 75 patients (89.3%). The average diameter of the GCT was 4.3±1.0 mm (range, 2.4-6.7 mm), and the average length was 10.7±4.9 mm (range, 2.2-22.7 mm). According to the different convergence conditions, the structure of GCT could be divided into seven types (**Figure 1**; **Table 3**). For Type A, the GCT consisted of the RGEV, SRCV, and PDV, and it was the most common type (39.0%). The other types were less numerous and varied in composition (**Table 3**).

Discussion

In the present study, we compared perioperative outcomes of laparoscopic CME with or without preoperative evaluation of mesenteric vascular variation. To the best of our knowledge, this was the first study to demonstrate that preoperative evaluation of the vessels could significantly improve the surgical outcomes in laparoscopic CME.

CME with central vascular ligation is now a standard procedure of colon cancer surgery [17] and requires high ligation of the colic artery and vein with a complete removal of the regional lymph node. Previous studies emphasized a careful dissection of the arterial and venous anatomy of the colon [18, 19], and MDCT was verified to reliably show the detailed relationships among the vessels [12, 13]. The complex relationship of the arteries and veins are likely to increase the surgical challenge, especially for laparoscopic surgery. Our results showed that all the major branches of the SMA and major tributaries that inflow into the SMV can be revealed in the MDCT before surgery. The MCA crossed anterior to the SMV in all cases. Meanwhile, the RCA passed anterior to the SMV in 70.5% of patients and posterior in 24.4%. Performing a systemic dissection under the SMV would be hazardous [12]. Hence, the posterior relationship of the RCA to the SMV increases the surgical challenge. Having this in mind, knowing the location of the RCA is exceedingly important.

Additionally, the GCT has previously been suggested as an important anatomical landmark during laparoscopic right hemi-colectomy as it is used to guide the superior limit of dissection [16, 20]. In our study, the GCT was present in 89.3% of patients and had seven different types according to the convergence condition of the venous tributaries. During the laparoscopic CME, the RCV and SRCV were ligated. One problem is that the RCV and SRCV have numerous variations in their association with the GCT. Most patients have a single RCV that flows into the GCT, while quite a few patients have an additional RCV that flows into the SMV or SRCV, which in turn, flows into the GCT. Additionally, the variations of the diameter and length of the GCT would also increase the difficulty of operation. Bleeding from an injured or avulsed GCT in a laparoscopic right colectomy would result in a potentially devastating lesion [21], which would directly increase the risk of the conversion to open surgery; thus, the management of the GCT is highly significant.

The misrecognition of mesenteric vascular constituents and their relationships with each other could cause bleeding during surgery. In a previous study, the bleeding frequently occurred in laparoscopic right colectomies, requiring conversion to open surgery [22]. Preoperative vascular assessment by MDCT would help solve this problem because surgeons could recognize the presence of critical variations before surgery. In our study, the intraoperative blood loss in the CTA group did decrease significantly for right-sided laparoscopic CME, and the operative time also decreased. Moreover, the percentage of occurrence of massive bleeding (blood loss >300 ml) occurring during surgery in the CTA group was significantly lower. All of these data highlight the importance and the need for a careful and complete preoperative mesenteric vascular assessment for laparoscopic right CME. With a clear demonstration of the vascular anatomy before the surgical procedure, it will help the surgeon in performing colectomy for cancer. This is especially true for a novice in laparoscopic surgery because there is a long learning curve for this procedure [23, 24].

Nonetheless, we are aware of the limitations in this study. Firstly, the enrolled patients in control group were ranged from January 2011 and December 2014, a part of patients were earlier than the CTA group, which may be subject to a potential effect of the learning curve, known to affect operative outcomes. However, our group performed the laparoscopic surgery for colorectal cancer since 2004 [25], the learning curve influenced little in our study. Secondly, the number of patients enrolled in this study is relatively small. This may have contributed to the lack of statistical significance in the operative times, which were shorter for the CTA group than the Control group.

In conclusion, CTA can display anatomical relationships among the major arteries and veins of the SMA/SMV. Preoperative CTA acquired for colon cancer patients could help reduce the intraoperative blood loss during the laparoscopic CME, especially for right-sided tumors. Hence, the application of preoperative MDCT angiography could assist the surgeons in managing the precise variant vessels and thereby reducing unnecessary injuries to vessels during laparoscopic colectomy for colon cancer. However, the clinical importance of preoperative CTA application should be evaluated in further studies.

Acknowledgements

This work was supported by grants from the National Natural Science Foundation of China (No. 81272455, 81472664), the Public Welfare in Health Industry, 2014, Health Ministry of China (NO. 201402015) and Key Projects in the National Science & Technology Pillar Program during the Twelfth Five-year Plan Period (No. 2014BAI09B07). The sponsors of the study had no role in study design, data collection, data analysis, results interpretation, writing the paper and the decision to submit the paper for publication.

Disclosure of conflict of interest

None.

Address correspondence to: Kefeng Ding, Department of Surgical Oncology, Second Affiliated Hospital of School of Medicine, Zhejiang University, 88 Jiefang Road, Hangzhou 310009, China. Tel: +86-571-87784760; Fax: +86-571-87214404; E-mail: dingkefeng@zju.edu.cn; Shugao Han, Department of Radiology, Second Affiliated Hospital, School of Medicine, Zhejiang University, 88 Jiefang Road, Hangzhou 310009, China. Tel: +86-571-87784720; E-mail: hanshugao@163.com

References

[1] Braga M, Vignali A, Gianotti L, Zuliani W, Radaelli G, Gruarin P, Dellabona P and Di Carlo V. Laparoscopic versus open colorectal surgery: a randomized trial on short-term outcome. Ann Surg 2002; 236: 759-766; disscussion 767.

[2] Guillou PJ, Quirke P, Thorpe H, Walker J, Jayne DG, Smith AM, Heath RM, Brown JM; MRC CLASICC trial group. Short-term endpoints of conventional versus laparoscopic-assisted surgery in patients with colorectal cancer (MRC CLASICC trial): multicentre, randomised controlled trial. Lancet 2005; 365: 1718-1726.

[3] Veldkamp R, Kuhry E, Hop WC, Jeekel J, Kazemier G, Bonjer HJ, Haglind E, Pahlman L, Cuesta MA, Msika S, Morino M, Lacy AM; Colon cancer Laparoscopic or Open Resection Study Group (COLOR). Laparoscopic surgery versus open surgery for colon cancer: short-term outcomes of a randomised trial. Lancet Oncol 2005; 6: 477-484.

[4] Clinical Outcomes of Surgical Therapy Study Group. A comparison of laparoscopically assisted and open colectomy for colon cancer. N Engl J Med 2004; 350: 2050-2059.

[5] Braga M, Frasson M, Zuliani W, Vignali A, Pecorelli N and Di Carlo V. Randomized clinical trial of laparoscopic versus open left colonic resection. Br J Surg 2010; 97: 1180-1186.

[6] Colon Cancer Laparoscopic or Open Resection Study G, Buunen M, Veldkamp R, Hop WC, Kuhry E, Jeekel J, Haglind E, Pahlman L, Cuesta MA, Msika S, Morino M, Lacy A and Bonjer HJ. Survival after laparoscopic surgery versus open surgery for colon cancer: long-term outcome of a randomised clinical trial. Lancet Oncol 2009; 10: 44-52.

[7] Fleshman J, Sargent DJ, Green E, Anvari M, Stryker SJ, Beart RW, Hellinger M, Flanagan R, Peters W and Nelson H. Laparoscopic colectomy for cancer is not inferior to open surgery based on 5-year data from the COST Study Group Trial. Ann Surg 2007; 246: 655-664.

[8] Jayne DG, Thorpe HC, Copeland J, Quirke P, Brown JM and Guillou PJ. Five-year follow-up of the Medical Research Council CLASICC trial of laparoscopically assisted versus open surgery for colorectal cancer. Br J Surg 2010; 97: 1638-1645.

[9] Lacy AM, Delgado S, Castells A, Prins HA, Arroyo V, Ibarzabal A and Pique JM. The long-term results of a randomized clinical trial of laparoscopy-assisted versus open surgery for colon cancer. Ann Surg 2008; 248: 1-7.

[10] Kang J, Kim IK, Kang SI, Sohn SK and Lee KY. Laparoscopic right hemicolectomy with complete mesocolic excision. Surg Endosc 2014; 28: 2747-2751.

[11] Senagore AJ, Delaney CP, Brady KM and Fazio VW. Standardized approach to laparoscopic right colectomy: Outcomes in 70 consecutive cases. J Am Coll Surgeons 2004; 199: 675-679.

[12] Spasojevic M, Stimec BV, Fasel JF, Terraz S and Ignjatovic D. 3D relations between right colon arteries and the superior mesenteric vein: a preliminary study with multidetector computed tomography. Surg Endosc 2011; 25: 1883-1886.

[13] Ogino T, Takemasa I, Horitsugi G, Furuyashiki M, Ohta K, Uemura M, Nishimura J, Hata T, Mizushima T, Yamamoto H, Doki Y and Mori M. Preoperative evaluation of venous anatomy in laparoscopic complete mesocolic excision for right colon cancer. Ann Surg Oncol 2014; 21 Suppl 3: S429-435.

[14] Ito K, Blasbalg R, Hussain SM and Mitchell DG. Portal vein and its tributaries: evaluation with thin-section three-dimensional contrast-enhanced dynamic fat-suppressed MR imaging. Radiology 2000; 215: 381-386.

[15] Bergamaschi R, Schochet E, Haughn C, Burke M, Reed JF and Arnaud JP. Standardized laparoscopic intracorporeal right colectomy for cancer: Short-term outcome in 111 unselected patients. Dis Colon Rectum 2008; 51: 1350-1355.

[16] Ignjatovic D, Spasojevic M and Stimec B. Can the gastrocolic trunk of Henle serve as an anatomical landmark in laparoscopic right colectomy? A postmortem anatomical study. Am J Surg 2010; 199: 249-254.

[17] Hohenberger W, Weber K, Matzel K, Papadopoulos T and Merkel S. Standardized surgery for colonic cancer: complete mesocolic excision and central ligation-technical notes and outcome. Colorectal Dis 2009; 11: 354-364.

[18] Yamaguchi S, Kuroyanagi H, Milsom JW, Sim R and Shimada H. Venous anatomy of the right colon: precise structure of the major veins and gastrocolic trunk in 58 cadavers. Dis Colon Rectum 2002; 45: 1337-1340.

[19] GarciaRuiz A, Milsom JW, Ludwig KA and Marchesa P. Right colonic arterial anatomy-Implications for laparoscopic surgery. Dis Colon Rectum 1996; 39: 906-911.

[20] Gundara JS, Gill AJ, Hugh TJ and Samra JS. Redefining the apical lymph node at right hemicolectomy. Eur J Surg Oncol 2013; 39: 662-665.

[21] Ignjatovic D and Bergamaschi R. Venous bleeding from traction of transverse mesocolon. Am J Surg 2007; 194: 141-141.

[22] Marcello PW, Roberts PL, Rusin LC, Holubkov R and Schoetz DJ. Vascular pedicle ligation techniques during laparoscopic colectomy-A prospective randomized trial. Surg Endosc 2006; 20: 263-269.

[23] Tekkis PP, Senagore AJ, Delaney CP and Fazio VW. Evaluation of the learning curve in laparoscopic colorectal surgery: comparison of right-sided and left-sided resections. Ann Surg 2005; 242: 83-91.

[24] Akiyoshi T, Kuroyanagi H, Ueno M, Oya M, Fujimoto Y, Konishi T and Yamaguchi T. Learning curve for standardized laparoscopic surgery for colorectal cancer under supervision: a single-center experience. Surg Endosc 2011; 25: 1409-1414.

[25] Ding KF, Chen R, Zhang JL, Li J, Xu YQ, Lv L, Wang XC, Sun LF, Wang JW, Zheng S and Zhang SZ. Laparoscopic surgery for the curative treatment of rectal cancer: results of a Chinese three-center case-control study. Surg Endosc 2009; 23: 854-861.