International Journal of Surgery 41 (2017) 106–111

Contents lists available at ScienceDirect

International Journal of Surgery

journal homepage: www.journal-surgery.net

Original Research

Anatomic variations of inferior mesenteric artery and left colic artery evaluated by 3-dimensional CT angiography: Insights into rectal cancer surgery – A retrospective observational study

Jia Ke [a, 1], Jiawei Cai [a, 1], Xiaofeng Wen [a], Xianrui Wu [a], Zhen He [a], Yifeng Zou [a], Jianping Qiu [b], Xiaowen He [a], Xiaosheng He [a], Lei Lian [a], Xiaojian Wu [a], Zhiyang Zhou [b, *], Ping Lan [a, **]

[a] Department of Colorectal Surgery, The Sixth Affiliated Hospital, Sun Yat-sen University, 26 Yuancun Erheng Rd, Guangzhou, 510655, Guangdong, People's Republic of China
[b] Department of Radiology, The Sixth Affiliated Hospital, Sun Yat-sen University, 26 Yuancun Erheng Rd, Guangzhou, 510655, Guangdong, People's Republic of China

HIGHLIGHTS

- Different types of left colic artery anatomy was displayed.
- Intersectional patterns among IMA, LCA and IMV were evaluated.
- There were specific clinical characteristics for type A LCA.

ARTICLE INFO

Article history:
Received 11 December 2016
Received in revised form
2 February 2017
Accepted 4 March 2017
Available online 18 March 2017

Keywords:
Anatomy
Inferior mesenteric artery
Left colic artery
3-dimensional computed tomography angiography

ABSTRACT

Objective: To demonstrate the clinical applicability of 3-dimensional CT angiography (3D-CTA) in evaluating the anatomic variations of inferior mesenteric artery (IMA) and left colic artery (LCA), to help make pre-operative strategies of rectal cancer surgery.
Methods: 188 patients with abdominal and pelvic contrast-enhanced CT scan were retrospectively enrolled and 3D-CTA was reconstructed. The origin and branching patterns of IMA, tracking patterns of LCA, intersectional patterns among IMA, LCA and inferior mesenteric vein (IMV) were examined, and their associations with clinical features were analyzed.
Results: The origin of IMA was located 42.1 ± 7.7 mm above iliac artery bifurcation, 64.4% within the area of the 3rd lumbar vertebra. 47.3% of LCA arose independently from IMA, 27.1% arose at the root of sigmoid artery (SA), 20.7% shared a common trunk with SA while 4.8% of LCA was absent. As for track of LCA before anastomosis with marginal artery, 53.2% went straight upward while medial to the inner border of left kidney (Type A), 27.1% traveled diagonally across left kidney (Type B) and14.9% went infero-laterally to the lower border of left kidney (Type C). Short IMA trunk was independently associated with type A LCA and lower site of IMA origin. At the horizontal level of IMA origin, 29% of the LCA went distant from IMV, while 71% (21% medial, 50% lateral) were mutually close, and the close type was independently associated with type A LCA.
Conclusion: Preoperative understanding of the vascular variations and the mutual relationship among LCA, IMA and IMV could be obtained by 3D-CTA, which would further help surgeons to set detailed plans for laparoscopic rectal cancer surgery.

1. Introduction

Recently, laparoscopic surgery for colorectal cancer (CRC) has gained wide clinical acceptance. However, due to the narrow view

* Corresponding author.
** Corresponding author.
E-mail addresses: zhouzyang@hotmail.com (Z. Zhou), lanping@mail.sysu.edu.cn (P. Lan).
[1] Co-first authors, these authors contributed equally to this study.

http://dx.doi.org/10.1016/j.ijsu.2017.03.012
1743-9191/

and lack of tactile sensation under laparoscopy, vascular bifurcation and variations could to be misidentified and injured, which may cause severe complications, such as massive bleeding and bowel ischemia [1]. Therefore, it is required to preoperatively aware the arterial branching or variations, which are very helpful for surgeons to make pre-operative strategies and perform safe and rapid vessel ligation and lymph node dissection.

Many surgeons prefer to perform high ligation of inferior mesenteric artery (IMA) during rectal cancer surgery, to gain complete lymphadenectomy and better mesenteric mobilization [2,3]. According to our experience, after IMA was ligated at its root, the left colic artery (LCA) is always divided together with inferior mesenteric vein (IMV) if it runs close to IMV, or kept intact if it travels distant from IMV. However, this scenario has not been thoroughly investigated and theoretically proven, since the anatomic ambiguity among IMA, LCA and IMV.

Low ligation of IMA is recommended to protect blood supply of anastomosis during rectal cancer surgery. However, it increases the operational difficulty under laparoscopy because of the lymhpo-adipose tissue surrounding IMA trunk and the highly variant pattern of IMA bifurcation, especially when some dense fibrous tissue surrounding IMA seems like vessel branch [4]. If the length of IMA trunk and vessel variations were preoperatively visualized, these surgical procedures would be much less challenging.

Recently, 3D-CT angiography has become an less invasive method to evaluate vascular anatomy [5,6]. Using visual tracking method on high definition images, contract-enhanced mesenteric artery can be traced to its terminal branches besides colon wall. However, 3D-CT angiography has not been reported to evaluate detailed anatomy of mesenteric artery system, such as IMA and LCA. In this study, we aimed to demonstrate the bifurcation and track of IMA and LCA, by following the operational steps in rectal cancer surgery, to help achieving safe and prompt tumor resection.

2. Methods

2.1. Patient selection

A total of 188 patients (124 men and 64 women) with abdominal and pelvic enhancement CT scan at the Sixth Affiliated Hospital of Sun Yat-Sen University from September 2014 to January 2016 were retrospectively enrolled in this study. Patients with previous abdominal surgery were excluded. Median age of the patients was 52.5 years old (range, 12–80 years).

2.2. Three-dimensional CT angiography protocol

3D-CT angiography was performed using Toshiba Aquilion ONE 64-detector CT scanner. The tube potential was 100–120 kVp, and the tube current was 280–330mAs. Fasting for at least 4 h, patients were supine on the scanner for a plain scan. 60–90 ml iopamidol (370 mgI/mL) was injected into median cubital vein at a rate of 4.5 mL/s. The bolus tracking method was used to decide the scan timing. Arterial phase scanning was automatically initiated when the signal within abdominal aorta at celiac trunk level reached 180 Hounsfield units. The 64-slice multidetector-row CT (MDCT) scanner can generate 0.75 mm slices, which can be re-constructed into 0.5 mm images. Image processing analysis was performed using a 3D volume rendering technique with the ANYTHINK GVCM System (CREALIFE, Beijing, China; Figs. 1 and 2).

2.3. Measurements and classification

To locate IMA origin, 3D distance from IMA origin to iliac artery bifurcation (D_{IMA}) and the vertebral level of IMA origin were measured. The branching of IMA, track of LCA and relations among LCA, IMA and IMV at the level of IMA root were classified into different categories. The length of IMA was defined as the distance from IMA origin to the first branch and it was measured by vessels 3D-tracing.

2.4. Statistical analysis

Student *t*-test and chi-square test were applied to evaluate differences in continuous variable and categorical variable respectively. Logistic regression analyses were applied for univariate and multivariate analyses. All of the analyses were performed using the IBM SPSS Statistic 22 software, and differences at $p < 0.05$ were considered statistically significant.

3. Result

3.1. The location of IMA origin

Locating the origin of the IMA is the first key step in rectal cancer surgery. In this study, we locate it by the distance (D_{IMA}) from iliac

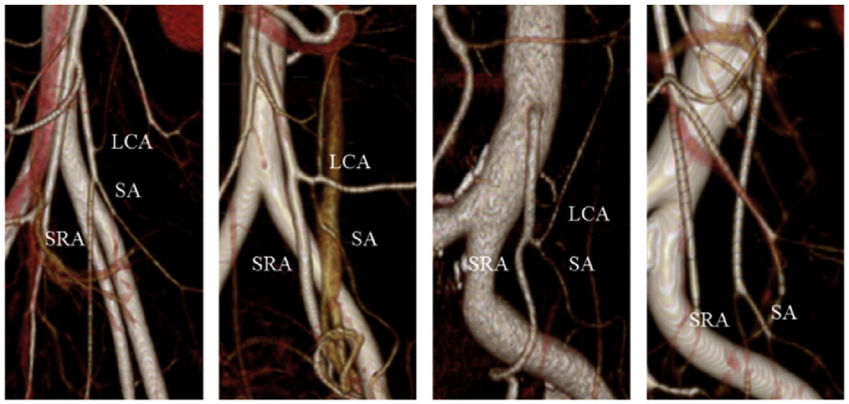

Fig. 1. Bifurcating Patterns of IMA. Type 1, LCA arises independently from IMA; Type 2, LCA and SA were given off at the same point; Type 3 LCA and SA were branched from a common trunk from IMA; Type 4, LCA was lacking; LCA = left colic artery; SA = sigmoid artery; SRA = superior rectal artery.