

# Laparoscopic complete mesocolic excision for right-sided colon cancer using a cranial approach: anatomical and embryological consideration

Takeru Matsuda<sup>1</sup> · Takeshi Iwasaki<sup>2</sup> · Yasuo Sumi<sup>3</sup> · Kimihiro Yamashita<sup>1</sup> · Hiroshi Hasegawa<sup>1</sup> · Masashi Yamamoto<sup>1</sup> · Yoshiko Matsuda<sup>1</sup> · Shingo Kanaji<sup>1</sup> · Taro Oshikiri<sup>1</sup> · Tetsu Nakamura<sup>1</sup> · Satoshi Suzuki<sup>1</sup> · Yoshihiro Kakeji<sup>1</sup>

Accepted: 30 September 2016 / Published online: 6 October 2016  
© Springer-Verlag Berlin Heidelberg 2016

## Abstract

**Background** Complete mesocolic excision (CME) with central vascular ligation (CVL) should be employed for the treatment of colon cancer patients because of its superior oncological outcomes. However, this technique is technically challenging in laparoscopic right hemicolectomy because of the anatomical complexity of the transverse mesocolon.

**Methods** We focused on the embryology and anatomy of the transverse mesocolon to overcome the difficulty of this surgery. The validity and efficacy of a cranial approach in achieving CME with CVL in laparoscopic right hemicolectomy was elucidated from the embryological point of view.

**Results** In total, 28 consecutive patients with right-sided colon cancer were treated by laparoscopic right hemicolectomy using a cranial approach. There were no conversion to open surgery or switching to another approach. Using this approach, torsion and fusion of the transverse mesocolon, which occurred during embryological development, could be reversed and the complex anatomy of the transverse mesocolon could be simplified before performing CVL of colonic vessels.

**Conclusions** A cranial approach is considered valid and useful for CME with CVL in laparoscopic right hemicolectomy from the embryological point of view.

**Keywords** Embryology · Anatomy · CME · Cranial approach

## Introduction

The total mesorectal excision (TME) technique is known to result in superior oncological outcomes in rectal cancer surgery and has been employed worldwide [1, 2]. A similar technique has also been proposed for the treatment of colon cancer using complete mesocolic excision (CME) with central vascular ligation (CVL) based on the same concepts as TME [3, 4]. However, this surgery is technically challenging because of the anatomical complexity of the transverse mesocolon, and it has not been standardized.

The transverse mesocolon carrying the middle colic vessels is originally located between the terminal portion of the midgut and the beginning of the hindgut. During embryological development, the midgut grows in length and forms the primary intestinal loop. It rotates around an axis formed by the superior mesenteric artery (SMA), and its terminal part (corresponding to the right two thirds of the transverse colon) and mesentery fuse with the greater omentum and pancreas, which are foregut structures. Because of this embryological and anatomical peculiarity, CME with CVL remains challenging in laparoscopic right hemicolectomy. For successful CME with CVL in this surgery, an adequate dissection technique based on the anatomy and embryology needs to be established.

We have reported the feasibility of the cranial approach in laparoscopic right hemicolectomy [5, 6]. In the present study, the key characteristics of this approach have been described

✉ Takeru Matsuda  
takerumatsuda@nifty.com

<sup>1</sup> Division of Gastrointestinal Surgery, Department of Surgery, Kobe University Graduate School of Medicine, 7-5-2 Kusunoki-chou, Chuo-ku, Kobe 650-0017, Japan

<sup>2</sup> Department of Surgery, National Hospital Organization Kobe Medical Center, Kobe, Japan

<sup>3</sup> Division of Minimally Invasive Surgery, Department of Surgery, Kobe University Graduate School of Medicine, Kobe, Japan

from the embryological point of view. We also elucidated its efficacy in achieving CME with CVL in laparoscopic right hemicolectomy based on embryology.

## Materials and methods

### Embryological development

By the fifth embryonic week, the foregut, the midgut, and a major part of the hindgut are suspended from the abdominal wall by the dorsal mesentery [7]. During the following weeks, the developing stomach rotates 90° clockwise around its longitudinal axis, and the pancreas grows into the mesoduodenum [7, 8]. Simultaneously, the midgut grows in length and forms the primary intestinal loop. The cephalic limb of the loop develops into the small intestine, while the caudal limb becomes the terminal ileum, ascending colon, and right two thirds of the transverse colon. Until the third month, this loop rotates 270° counterclockwise around SMA and the superior mesenteric vein (SMV). The ascending colon and its mesentery fuse with the retroperitoneum, and Told's fusion fascia is formed. The dorsal mesogastrium bulges out to form the greater omentum and omental bursa. The greater omentum expands rightward, and the posterior layer of the greater omentum fuses with the anterior wall of the transverse mesocolon. Until the fifth month, the transverse mesocolon fused with the greater omentum covers the frontal surface of the dorsal mesoduodenum. The superior right colic vein (SRCV) or middle colic vein (MCV) sometimes joins the right gastroepiploic vein, and the gastrocolic trunk (GCT) is formed. In the newborn, the transverse mesocolon has been folded and fused with the duodenum and pancreas.

### Operative procedure

Laparoscopic right hemicolectomy using a cranial approach was performed as reported previously [6]. In the present study, our approach was divided into the following two steps: the first step was reversal of the torsion and fusion of the transverse mesocolon and the second step was performance of CME with CVL in a cranial-to-caudal manner.

**First step** The omental bursa was first opened wide, and the transverse mesocolon adhered to the posterior wall of the stomach was detached by sharp dissection. The pedicle of the right gastroepiploic vessels was raised ventrally, and the transverse mesocolon was dissected from the pancreatic head and right gastroepiploic vessels by entering the embryological avascular plane. Then, the transverse mesocolon was completely separated from the pancreatic head and right gastroepiploic vessels by dividing the greater omentum. Separation of the transverse mesocolon from the pancreatic

head and duodenum proceeded rightward, and the hepatic flexure was mobilized. Then, the GCT was exposed and the SRCV was divided. At this point, the SRCV derived from the terminal part of the midgut was separated from the right gastroepiploic vein derived from the foregut. After the division of the SRCV, separation of the transverse mesocolon from the pancreas and duodenum proceeded medially. The procedures described above reversed the torsion and fusion of the transverse mesocolon, which occurred during embryological development. Until this step, the folded mesentery of the right two thirds of the transverse colon was spread out and almost completely mobilized and was ready for CME with CVL.

**Second step** The anterior sheet of the transverse mesocolon was dissected at the inferior border of the pancreas just above the SMV. This dissection proceeded caudally, and the MCV was exposed. After dividing the MCV at its root, lymph node (LN) dissection along the SMV was conducted in a cranial-to-caudal manner. Concurrently, the middle colic artery, or its right branch, was exposed and divided at its origin, which enabled CVL of the middle colic vessels to be performed without injury of the regional mesocolon. LN dissection along the SMV and SMA in a cranial-to-caudal direction was performed as much as possible in parallel with the separation of the ascending mesocolon from the parietal fascia. The right colic and ileocolic vessels were divided at their origins. Then, the transverse colon was raised ventrally, and the remnant attachment of the terminal ileum, cecum, and ascending colon was detached from the retroperitoneal tissues using a medial approach. These procedures enabled us to remove the tumor with its entire regional mesocolon in an intact fascial-lined package.

### Results

Between April 2013 and December 2015, 28 patients with right-sided colon cancer were treated by laparoscopic right hemicolectomy using a cranial approach. No serious intraoperative complications developed, and there was no conversion to open surgery or switching to another approach. The mean operative time and intraoperative blood loss were 208 min and 15 mL, respectively. The mean number of harvested LNs was 21. There were eight cases with positive LN metastasis. No recurrent cases were observed with a median follow-up period of 17 months.

### Discussion

CME with CVL has been proposed for the treatment of patients with colon cancer because of its superior oncological

outcomes [3, 4]. Although several studies emphasizing this technique in open or laparoscopic right hemicolectomy have been reported to date [9, 10], most of them have focused on the topographic anatomy, such as venous variations. In the present study, this technique in laparoscopic right hemicolectomy has been discussed with focus on embryology.

Understanding the anatomy based on embryology is essential to observe the concept of CME with CVL in this surgery. Its importance has already been described in laparoscopic surgery for gastric cancer, particularly with LN dissection around the root of the gastroepiploic vessels [11]. For optimal LN dissection in this area, the gastroepiploic vessels need to be separated from the transverse mesocolon and pancreas according to the embryological planes. Hence, we emphasized on the importance of anatomical knowledge based on embryology to discuss CME with CVL in laparoscopic right hemicolectomy.

We consider that the technical difficulty in this area is mainly due to the fusion of the transverse mesocolon with the greater omentum and pancreas, which occurs during embryological development. The transverse mesocolon, which derived from the terminal portion of the midgut, fuses with foregut structures such as the greater omentum and pancreas, although they are apart at the beginning of embryonic development. Reversal of the fusion and of the position to that at the beginning of embryonic development should simplify the anatomy and help in the following lymphadenectomy. Our cranial approach is considered reasonable for this purpose because it employs the following two steps: (1) preparation for CME and (2) performing CME with CVL.

In laparoscopic right hemicolectomy, a medial-to-lateral approach has conventionally been used [12], in which CVL of the middle colic and ileocolic vessels is performed before spreading of the embryological fusion and folding of the transverse mesocolon. However, in contrast to CME, this approach may cause injury of not only the pancreas and vessels but also the regional mesocolon. On the other hand, open surgery has conventionally employed a lateral approach [9]. Using a lateral approach, embryological fusion of the transverse mesocolon can be completely reversed from the adjacent organs, without injuring the mesocolon, before dividing the middle colic vessels. Thus, a lateral approach seems reasonable for performing CME with CVL in right hemicolectomy. However, it is extremely difficult to use a lateral approach in laparoscopic surgery because the operative space and maneuverability of the forceps are much more limited under laparoscopic conditions.

A cranial approach can overcome this problem. In this approach, reversal of the torsion and fusion of the transverse mesocolon precedes CVL of the middle colic vessels. After the first step, folding of the transverse mesocolon is spread out and the transverse mesocolon is completely mobilized. Therefore, CME with CVL should be safer and more feasible using a cranial approach in laparoscopic right hemicolectomy.

In conclusion, a dissection technique using a cranial approach according to embryological planes is valid and useful for performing CME with CVL in laparoscopic right hemicolectomy. To perform this surgery, accurate knowledge of the anatomy based on embryology is essential.

#### Compliance with ethical standards

**Conflict of interest** The authors declare that they have no conflict of interest.

#### References

- Kapiteijn E, Putter H, van de Velde CJ (2002) Impact of the introduction and training of total mesorectal excision on recurrence and survival in rectal cancer in the Netherlands. *Br J Surg* 89(9):1142–1149
- Martling AL, Holm T, Rutqvist LE, Moran BJ, Heald RJ, Cedemark B (2000) Effect of a surgical training programme on outcome of rectal cancer in the county of Stockholm. Stockholm Colorectal Cancer Study Group. *Basingstoke Bowel Cancer Res Proj Lancet* 356(9224):93–96
- Hohenberger W, Weber K, Matzel K, Papadopoulos T, Merkel S (2009) Standardized surgery for colonic cancer: complete mesocolic excision and central ligation—technical notes and outcome. *Color Dis* 11(4):354–364 discussion 364–355
- West NP, Hohenberger W, Weber K, Perrakis A, Finan PJ, Quirke P (2010) Complete mesocolic excision with central vascular ligation produces an oncologically superior specimen compared with standard surgery for carcinoma of the colon. *J Clin Oncol* 28(2):272–278
- Matsuda T, Iwasaki T, Mitsutsuji M, Hirata K, Maekawa Y, Tanaka T, Shimada E, Kakeji Y (2015) Cranial-to-caudal approach for radical lymph node dissection along the surgical trunk in laparoscopic right hemicolectomy. *Surg Endosc* 29(4):1001
- Matsuda T, Iwasaki T, Mitsutsuji M, Hirata K, Maekawa Y, Tsugawa D, Sugita Y, Sumi Y, Shimada E, Kakeji Y (2015) Cranially approached radical lymph node dissection around the middle colic vessels in laparoscopic colon cancer surgery. *Langenbecks Arch Surg* 400(1):113–117
- Sadler TW (2012) *Langman's medical embryology*, 12th edn. Lippincott, Philadelphia
- Standring S (2015) *Gray's anatomy—the anatomical basis of clinical practice*, 41st edn. Elsevier, Amsterdam
- Acar HI, Comert A, Avsar A, Celik S, Kuzu MA (2014) Dynamic article: surgical anatomical planes for complete mesocolic excision and applied vascular anatomy of the right colon. *Dis Colon Rectum* 57(10):1169–1175
- Ogino T, Takemasa I, Horitsugi G, Furuyashiki M, Ohta K, Uemura M, Nishimura J, Hata T, Mizushima T, Yamamoto H, Doki Y, Mori M (2014) Preoperative evaluation of venous anatomy in laparoscopic complete mesocolic excision for right colon cancer. *Ann Surg Oncol* 21(Suppl 3):S429–S435
- Shinohara H, Kurahashi Y, Kanaya S, Haruta S, Ueno M, Udagawa H, Sakai Y (2013) Topographic anatomy and laparoscopic technique for dissection of no. 6 infrapyloric lymph nodes in gastric cancer surgery. *Gastric Cancer* 16(4):615–620
- Hasegawa S, Kawamura J, Nagayama S, Nomura A, Kondo K, Sakai Y (2007) Medially approached radical lymph node dissection along the surgical trunk for advanced right-sided colon cancers. *Surg Endosc* 21(9):1657