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Three-Dimensional Vascular Anatomy Relevant to Oncologic Resection of Right Colon Cancer

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We analyzed data on the three-dimensional vascular anatomy of the right colon from the operative documents of 215 patients undergoing oncologic resection for right colon cancer. The right colic artery (RCA) was absent in 146 patients (67.9%), with the ileocolic artery (ICA) crossing the superior mesenteric vein (SMV) ventrally in 78 patients (36.3%). When the RCA was present, both the ICA and the RCA crossed the SMV ventrally in 44 patients (20.5%), dorsally in 10 patients (4.7%), the RCA crossed the SMV ventrally and the ICA dorsally in 10 patients (4.7%), and the RCA crossed the SMV dorsally and the ICA ventrally in 5 patients (2.2%). The arterial branches toward the hepatic flexure crossed the SMV ventrally in 151 eligible cases: the branch originated from the common trunk of the middle colic artery in 97 patients (64.2%) and 1 and 2 arteries directly originated from the SMA in 49 patients (32.5%) and in 5 patients (3.3%), respectively. These data would be useful to safely perform lymph node dissection around the SMV.

Key words: Superior mesenteric artery – Superior mesenteric vein – Colon cancer – Lymphadenectomy – Colectomy

Because the superior mesenteric artery (SMA) is located mostly on the left side of the superior mesenteric vein (SMV), the branches originating directly from the SMA, such as the ileocolic artery (ICA), the right colic artery (RCA), and the middle colic artery (MCA), cross the SMV ventrally or dorsally. Familiarity with the three-dimensional relations of these arteries and the SMV would enable safer and easier performance of oncologic resection for right colon cancer. However, because

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of the limited data,[1,2] the three-dimensional vessel anatomy relevant to oncologic resection for right colon cancer has not yet been documented sufficiently, although the anatomies of the colonic arteries[3] and veins[4] of the right colon have been described extensively. This study was undertaken to clarify the patterns of the arteries crossing the SMV on the basis of operative documents of patients with right colon cancer treated by surgical resection.

Patients and Methods

The subjects were 215 Japanese patients (127 men and 88 women) who underwent right (hemi) colectomy with standard lymph node dissection for right colon cancer through a conventional open or minilaparotomy approach[5–7] at our hospital between January 1999 and September 2009. The standard lymph node dissection included removal of the epicolic, paracolic, intermediate, and main lymph nodes, corresponding to D3-level lymph node dissection according to the General Rules for Clinical and Pathological Studies on Cancer of the Colon, Rectum, and Anus in Japan.[8] Cancers of the right colon was defined as located in the cecum, ascending colon, or hepatic flexure. The median age of the patients was 68 years (range, 34–92 years). The tumors were classified according to the TNM classification[9] as stage I in 32 patients (14.9%), stage II in 90 patients (41.9%), stage III cases in 76 patients (35.3%), and stage IV in 17 patients (7.9%). In the present series, standard lymph node dissection was also performed in selected patients with stage IV disease in combination with synchronous resection of a hepatic metastasis, or in patients who were candidates for hepatic and/or pulmonary metastatectomy after effective chemotherapy. We retrospectively analyzed the three-dimensional relations of the arteries directly originating from the SMA with the SMV based on operative findings that were prospectively recorded by operating surgeons.

Results

The SMA was identified on the left side of the SMV in all 215 patients. Information on the ICA and RCA was also obtained from all the patients, whereas that on the MCA or its branches was obtained from 151 patients as lymph node dissection around the MCA was not always necessary (e.g., in cases of cancer of the cecum or ascending colon). The RCA was absent

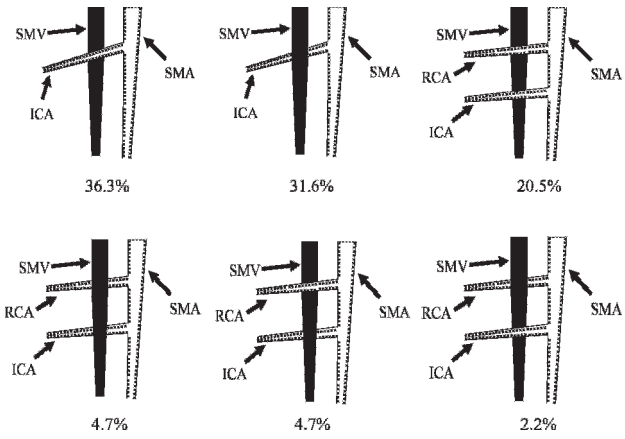

Fig. 1 Six patterns of the three-dimensional structure of the right colic artery (RCA), ileocolic artery (ICA), superior mesenteric artery (SMA), and superior mesenteric vein (SMV). The black box indicates arteries. The blank box indicates the SMV.

in 146 patients (67.9%), whereas the ICA was identified in all patients. In the absence of the RCA, the ICA crossed the SMV ventrally in 78 patients (36.3%) and dorsally in 68 patients (31.6%). When the RCA was present, both the ICA and the RCA crossed the SMV ventrally in 44 patients (20.5%), dorsally in 10 patients (4.7%), the RCA crossed the SMV ventrally and the ICA dorsally in 10 patients (4.7%), and the RCA crossed the SMV dorsally and the ICA ventrally in 5 patients (2.2%) (Fig. 1). Concerning the arterial branches running toward the hepatic flexure, the right branch of the MCA originated from the common trunk in 97 patients (64.2%), and 1 and 2 arteries directly originated from the SMA in 49 patients (32.5%) and 5 patients (3.3%), respectively (Fig. 2). The common trunk as well as the directly originating branches of the SMA crossed the SMV ventrally.

Discussion

Lymph node dissection by ligation of the ICA and RCA (if present) on the right side of the SMV with removal of the epicolic, paracolic, and intermediate lymph nodes (D2-level lymph node dissection) may be insufficient for proper oncologic resection in patients with right colon cancer. In Japan, as standard lymph node dissection (D3-level), division of the ICA and RCA is performed to the left side of the SMV with additional removal of the main lymph nodes, where metastasis has been found to occur in 8% to 17% of the patients.[10,11] The choice of performing D2- or D3-level lymph node dissection may be based on the likelihood of metastasis found

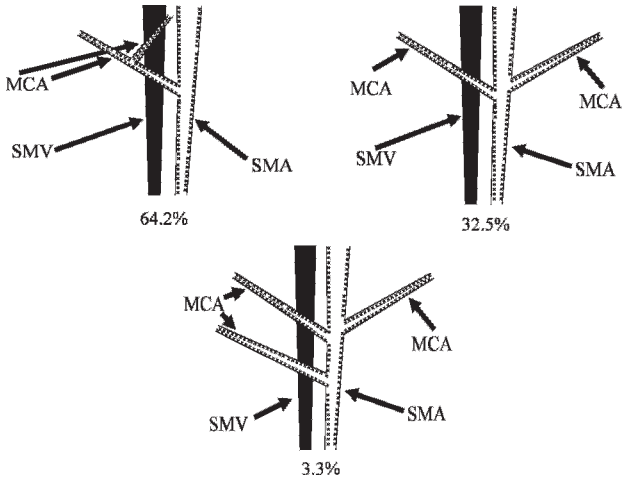

Fig. 2 Three patterns of the three-dimensional structure of the common trunk, and 1 or 2 branches of the middle colic artery and the SMV.

in the main nodes. Whichever level of dissection is performed (D2 or D3), arterial bleeding may occur after division of the ICA and RCA because of a loose clip, fallen ligature, or stapler misfire. Therefore it is very important for surgeons to have precise knowledge of the anatomy when performing oncologic resection for right colon cancer, especially with a laparoscopic-assisted approach, because of the lack of tactile sensation. Bleeding during ligation of the vascular pedicle in laparoscopic-assisted right (hemi) colectomy has been reported to occur in 3% to 9% of patients,[12] requiring conversion to open surgery in 1% to 2% of the patients.[13]

Concerning the vessel anatomy of the right colon, there were a few reports showing the three-dimensional structure of the SMV and the branches of SMA. These reports investigated a small number of cadavers. In the context of oncologic resection, there are several in-depth studies[3,4] of the arteries and veins. Therefore, we analyzed the pattern of vessel anatomy in right-sided colon in many cases to expand our knowledge. Shatari *et al*[1] described 5 patterns of the three-dimensional structure of SMV and the branches of SMA from 27 cadavers, as well as our data. In their report, the ICA was recognized in all cases, whereas the RCA was identified in 30% of the cases. The most common pattern was absence of RCA and ICA crossing the SMV dorsally (40.7%), followed by absence of the RCA and ICA crossing the SMV ventrally (29.6%). In cases with presence of the RCA, the pattern of RCA crossing the SMV ventrally and ICA crossing the SMV dorsally was found in 4 cases (14.8%). Both ICA and RCA crossed the SMV dorsally in 3 cases (11.1%), and both ICA and RCA crossed the SMV ventrally in one case (3.7%). Among the patients analyzed in their series, there were no cases with the pattern of RCA crossing the SMV dorsally and ICA ventrally. Ignjatovic *et al*[2] analyzed 30 cadavers and reported identification of the ICA in all cases, with the artery crossing the SMV dorsally in 63% of the cases. On the other hand, the RCA was identified in 63% of the cases, with the vessel crossing the SMV ventrally in 84% of the cases. Unfortunately, Ignjatovic *et al*[2] did not analyze the relationship of the ICA and RCA collectively with the SMV.

In the present study, all 6 patterns, all logically possible combinations of ICA and RCA crossing the SMV, were identified. There may be some criticisms for confirming the anatomic positions during surgery. The significance of this study is that the patterns of ICA and RCA crossing the SMV were documented prospectively and that the number of cases far exceeds those of the previous 2 reports based on a study of cadavers. A noteworthy fact clarified from this study was that when the RCA was nonexistent, the possibilities of the ICA crossing the SMV ventrally and dorsally were about the same, as the frequency was 36.3% and 31.6%, respectively. In addition, when both the ICA and RCA were present, they tended to cross the SMV on the same side, more commonly the ventral side (20.5%). In only 6.9% of all cases did the ICA and RCA cross the SMV from different sides.

For resection of cancers in and around the hepatic flexure, division of the common trunk of the MCA or division of the root of 1 to 2 arteries branching directly from the SMA is required. In all 151 cases analyzed, we confirmed that these arteries, whose branching patterns correspond to those described in a previous report,[14] cross the SMV ventrally. We cannot completely refute the possibility of these arteries crossing the SMV dorsally, but we can safely suggest that this would be a very rare occurrence. Venous hemorrhage during oncologic resection of the colon in this area is annoying and, in some cases, may be dangerous. The venous anatomy of this area has been described in detail from cadaveric studies,[4] but it is rather complex and difficult to categorize into simple patterns. We were also unable to clarify the anatomy, especially as the confirmation was carried out intraoperatively. To understand the venous anatomy of this area, recognizing the gastrocolic trunk of Henle is surgically important

because it drains several smaller tributaries, including the right gastroepiploic, right superior colic, and anterosuperior pancreaticoduodenal veins, and is a landmark to lymph node dissection for right-sided colon cancer. However, the precise relationship of the gastrocolic trunk of Henle with the arterial branches has not yet been clarified.[15]

The clinical implication of our results is that a precise anatomic knowledge may help lower the risk of vascular complications during oncologic resection for right colon cancer, especially by a laparoscopic-assisted approach. Whether the crossing pattern is ventral or dorsal to the SMV determines how these bleeding arterial stumps can be accessed without damaging the SMV. For example, one can expect the bleeding arterial stump to retract behind the SMV. This is likely to be the case of a bleeding ICA stump, which has a posterior crossing pattern in 40.8% of the cases.

Recently, the usefulness of three-dimensional computed tomography CT (3D-CT) in the assessment of branches arising from the SMA and SMV has been reported.[16,17] 3D-CT may be a promising tool for preoperative evaluation of the vascular anatomy by surgeons. However, 3D-CT has some limitations.[18,19] First, it requires intravenous contrast material injection for 3D-CT imaging of the vessels. Not all patients can receive contrast material, including decreased renal function, past history of allergic reaction to intravenous contrast material, asthma, or other risk factors. In addition, multiple CT scans are required to obtain 3D-CT imaging of both arteries and veins, which would result in an increase of the radiation dose to the patients. Second, patient movement, improper timing of the scanning, and technical error can result in unsatisfactory 3D-CT imaging quality. Third, 3D-CT is not always available at all hospitals.

In conclusion, we consider that surgeons should be aware of the three-dimensional relations of the branches of the SMA and SMV when performing radical right (hemi) colectomy to avoid inadvertent vessel injuries and confusion due to unexpected vessel anatomy. In addition, we believe that our data will be useful in situations where facilities for preoperative evaluation of the branches of the SMA and the SMV are unavailable.

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