Research Square

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Overcoming Obstacles in Middle Colic Vein Dissection Using CT-based 3D Vascular Reconstructions

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Abstract

Purpose: Complete mesocolic excision requires central mesenteric dissection near the middle colic vein (MCV) confluence, where anatomic variability may increase operative risk. However, MCV multiplicity, confluence patterns, and relationships to the middle colic artery (MCA) are not sufficiently defined.

Methods: Three-dimensional vascular reconstructions were performed on 300 multidetector CT datasets from patients with right-sided colon cancer (age 65±9 years; 59% female). MCV branches (MCV1–3, right to left), their confluence patterns, and their spatial relationships to the MCA were analyzed using descriptive statistics. The reconstruction method had been previously validated intraoperatively and was performed by a single investigator.

Results: The MCV was identified in all cases (397 veins total). It was single in 68.7%, double in 30.3%, and triple in 1.0% of patients. Confluences were most often into the superior mesenteric vein (65.7%), followed by the inferior mesenteric vein (12.6%) and gastrocolic trunk (9.8%). MCV1 drained mainly into the SMV (72.7%). MCV2 showed variable drainage into the SMV (45.7%), IMV (31.9%), jejunal vein (9.6%), left SMV (3.2%), and left colic angular vein (2.1%). MCV3 drained into the IMV in 66.7% and the left SMV in 33.3%. The MCV and MCA were separate in 67.0% of cases, with anterior crossing in 17.7% and posterior crossing in 15.3%. Left-sided drainage patterns were seen in 20–50% of patients with double or triple MCVs.

Conclusions: MCV anatomy is highly variable, with multiplicity in 31.3% and frequent atypical confluences. Preoperative 3DCT can identify high-risk variants and may support safer, tailored vascular ligation during lymphadenectomy.

Introduction

The development of oncologic surgery over the last few decades has introduced broader surgical dissection to achieve adequate lymph node harvest. Thus, complete mesocolic excision (CME) with central vascular ligation and D3 lymph node dissection has led surgeons to dissect the central mesentery in the area of the pancreatic notch, namely, the area of the superior mesenteric vessels, the MCA origin, and MCV confluence [1, 2]. Of all these vessels, the MCV has received the least attention [3].

The Anatomy textbook states that the MCV serves as the primary drainage vessel for the transverse colon, typically emptying into the SMV, alongside the trajectory of the MCA as it traverses the mesocolon transversum [4]. Subsequently, blood is led into the hepatic portal system through the portal vein. The veins and their typical drainage points are important in colorectal surgery because injuries or variations can affect surgical outcomes and present as bleeding risks [5]. While the number of MCVs and the positions of their confluences have been reported in the literature, the confluences of the second/third MCV, as well as the confluence pattern and the topographic relations to the MCA trunk still remain unreported [6].

Preoperative workup for colon cancer surgery includes computerized tomography (CT) imaging for disease staging [7]. The CT dataset also offers crucial preoperative insights on the vascular anatomy of the specific patient [8]. The radiologist and surgeon can study the staging CT or be provided with a CT-based 3D vascular reconstruction, that will facilitate both the reporting of variations by radiologists and intraoperative orientation for surgeons [9, 10]. In this manner, the surgeon can evade pitfalls and shorten operative time when performing CME [11].

The aim of this study was to analyze the number of MCVs, their confluences in total and according to their position (MCV1, 2, and 3). A further aim was to compare the confluence pattern of the MCV2 and 3 to that of the MCV1. The third aim was to analyze and categorize the topographic relations found between the MCV and the MCA trunk.

Material and Methods

The CT datasets

A total of 300 MDCT datasets of patients included in the "Safe Radical D3 Right Hemicolectomy for Cancer through Preoperative Biphasic MDCT Angiography" were procured. The present study was registered at clinicaltrials.gov as NCT01351714 and approved by the Norwegian South-East Regional Ethical Committee under number 2010/3354. All patients provided signed consent for participation in the study.

Image processing

The datasets were reconstructed in 3D using the FDA-approved software Osirix MD v.14.0 (Pixmeo, Bernex, Switzerland), which is available for the Macintosh platform. Subsequently, the Mimics Medical imaging processing software, version 24.0, along with the 3-matic medical software version 16.0, were employed on a computer running Windows 10 Pro x64 2017 (Materialise NV, Leuven, Belgium). Additionally, the 3D virtual representation of the vascular tree undergoes a comprehensive morphological and morphometric analysis and was ultimately exported as a 3D volume rendering model (including images and videos), as STL files, or 3D PDFs with annotations. The segmentation method and morphometry

have been validated at surgery and published [12, 13] and have demonstrated superiority over semiautomatic segmentation [14]. We examined the venous blood vessels within the region of interest (ROI) and conducted identification, determining the caliber where feasible and the confluence position of the specified venous vessel [15]. The MCV is recognized as the main venous structure draining blood from the transverse colon. When multiple MCVs are present, they are named from the patient's right to his left as MCV1, MCV2, and MCV3. Particular emphasis was placed on the reconstruction of the following veins: the right colic (RCV), ileocolic (ICV), gastrocolic trunk of Henle GTH, LCAV, pancreaticoduodenal vein (PDV), terminal ileal venous trunk (TIVT), right colic (RCV), right gastro-omental vein (RGOV), IMV, jejunal (JV), as well as bifid SMV with right (RSMV) and left (LSMV) trunks, when present. The distances between the ICA origin and the MCA origin were measured in centimeters (cm) using the Length tool in 3DVR (Osirix) and the Distance and Radius tools (3-matic).

Statistics

For continuous variables, the mean ± standard deviation was utilized, while categorical values were presented as numbers (percentages of the total repetitions for each category). Excel for Mac ver. 16.103.4 software was used for the mean and standard deviation.

Results

Three hundred most recent, consecutive 3D vascular reconstructions of patients who underwent surgery for right-sided colon cancer were analyzed (mean age 65±9 years, 178 (59.33%) female). The surgeries were performed from November 2017 until December 2022.

1. MCVs and their confluences

The MCV was present in all patients (300/100%). Overall, we detected a total of 397 MCVs. A single MCV occurred in 206 patients (68.7%), a double MCV occurred in 91 patients (30.3%), while a triple MCV occurred in 3 patients (1%). A MCV2 was found in 94 cases (31.3%), while MCV3 occurred in only 3 patients (1%).

Confluences were analyzed for all 397 MCVs. The majority of MCVs have their confluence to the SMV (65.7%) for the whole group, while the second most frequent confluence position was unexpectedly the IMV. All these IMVs also terminated into the SMV. The variability of MCV confluences is presented in Tab. 1. Moreover, a subgroup consisting of 11 double SMVs were encountered. In 7 of these cases (single MCV), the MCV followed the usual trajectory terminating in the RSMV trunk. A further 3 cases with double MCVs had a confluence to both SMV trunks, the MCV1 to the RSMV and MCV2 to the LSMV trunk. A single case with a triple MCV revealed the MCV1 and 2 draining into the RSMV, and the MCV3 to the LSMV trunk.

2. Stratification of confluences and trajectories for MCV1, 2, and 3

Further stratification of the MCV confluences was based on the number of MCVs per patient, namely single (MCV1), double (MCV2), and triple (MCV3). Table 1 demonstrates that the MCV1 tends to follow a normal trajectory in 72.7% of patients, while the MCV2 and MCV3 tend to follow an aberrant trajectory.

a. A single MCV confluence to the SMV was present in 218 (72.7%), the GTH in 38 (12.7%), the IMV in 18 (6.0%), the JV in 17 (5.7%), the SV in 8 (2.7%) and LCAV in 1 (0.3%) (Fig. 1a).

b. For the whole group of double MCVs (94 cases) the MCV2 confluence was to the SMV in 43 (45.7%), IMV 30 (31.9%), JV 9 (9.6%), SV 6 (6.4%), LSMV 3 (3.2%), LCAV 2 (2.1%) (Fig. 5b, c), and to the GTH 1 (1.1%) cases (Table 1. Fig. 1b). Out of the 94 cases with double MCV, 47 (50.0%) were cases where both MCVs terminated into the same vessel, most often to the SMV (39, 83%)(Fig. 2,3). In the remaining half (50.0%), they terminated into different vessels. In this group, the trajectory of the MCV1 was to the patient's right, while the trajectory of MCV2 was always to the left (Fig. 4a,b,c).

c. When triple MCVs are in concern, the first and second MCV trajectories are to the patient's right, while that of the MCV3 is to the left, namely, the confluences of the MCV3 were to the IMV in 2 cases (66.6%) (Fig. 1c), and to the LSMV in 1 (33.3%) case (Fig. 5a).

3. Relationship between MCV and MCA trunk

In 201 instances (67%), the MCV and MCA were separate and did not intersect (Fig. 6a,c). In 53 instances (17.7%), the MCV crossed in front of the MCA (Fig. 6b), while in 46 instances (15.3%), the MCA crossed in front of the MCV (Fig. 6d). There were no instances of topographic relations of the MCA trunk with more than one MCV.

4. The jejunal veins (JV)

JV occurred in 291 (97%) patients, resulting in a total of 593 JV. The remaining 9 (3.0 %) were cases of double SMVs. Overall, 11 cases with a double SMV were found. Nine of these cases didn't have JVs, namely, the LSMV trunk replaced the JVs (Fig. 4c). In 2 cases with a double SMV, a JV crossed the SMA posteriorly and drained into the RSMV (Fig. 5a).

A single JV was found in 39 (13%) patients, average caliber of 0.85±0.26 cm, while two jejunal veins were present in 202 (67.3%) patients. The average caliber of the second JV measured 0.71±0.24 cm, and in 50 (16.7%) patients, where a third JV was found, the average caliber was 0.61±0.22 cm.

5. Additional anatomical structures and measurements of interest:

We present the venous vessels of interest in the order of occurrence: TIVT (300, 100%), ICV (298, 99.3%), GTH (289, 96.3%), LCAV (70, 23.3%), PDV (68, 22.7%), RCV (59, 19.7%), and the RGOV (34, 11.3%) patients. The mean distance from ICV to GTH measures 3.51±1.02 cm, and ICA to MCA measures 2.24±1.13 cm.

Discussion

The main finding of this study was the overwhelming and unexpected number of MCV variations when venous multiplicity and confluence variability are combined with the topographic variety of the MCVs described in this article. The consistency of the MCV, namely, its presence in all patients (100%), does not imply simple anatomical relations.

The Literature states that most commonly, a single middle colic vein occurs in approximately 72%–84% of individuals [16]. Two middle colic veins are found in 10%–46% of cases [17]. Three middle colic veins are less common, occurring in 1%–12% of individuals [18]. When compared with our results, we have a slightly lower proportion of single MCVs (68.7%), while the double MCVs (30.3%) are consistent with the literature. A triple MCV was found only in 1.0% of our material, falling low in the above-mentioned range. Maki et al. have stated that [6] the thickest, dominant MCV is considered the "main" MCV because it is, as the authors claim, clinically most important during surgery, due to the risk of bleeding [19, 20]. In our experience, we have had the impression that the MCV1 and MCV2 were of similar caliber and thicker than that of the MCV3; thus, we named the veins as MCV 1, 2, and 3, going from the patient's right to the left.

When single, the MCV1 has the SMV as the dominant confluence site in 72.7%, somewhat higher than reported by Maki et al (62.5%) [6]. These authors, however, show a much higher GTH confluence rate (29.3%) vs 12.7% implying a possibly different pattern of variations in different populations [21]. The same can be said for the less common sites that include the IMV at 6% vs 4.8%, SV at 2.7% vs 2.7%, and a considerably more frequent (10-fold) confluence rate to the JV in our series at 5.7% vs 0.6% [6, 22]. To our knowledge, a confluence on the LCAV at 0.3% has not been described in the literature. Given that our reconstruction technique, the thickness of the CT slices, and the sample size align closely with the study conducted by Maki et al, the significance of this comparison is greatly improved.

When compared to the MCV1, the deviation of the MCV2 termination from common anatomy seems to be more pronounced. Namely, the SMV remains the most common confluence site; however, there is a notable decline to 45.7%, while the IMV rises to second place at 31.9%. The JV follows with 9.6%, after that the SV with 6.4%, the LSMV with 3.2% and the LCAV confluence with 2.1%. Surprisingly, the rarest confluence of the MCV2 was to the GTH, encountered in only one 3D reconstruction [23]. Another curiosity, not previously reported in the literature, is LSMV confluence that was found in 3 cases in our series. Further analysis of cases involving the triple MCVs reveals an even higher variability in confluence patterns. MCV3 were found in 3 cases, draining to the IMV (2 cases, 66.7%) and to a pseudo bifid LSMV branch (1 case, 33.3%), with no SMV or GTH drainage noted [24, 25]. Multiple MCVs, thus, favor aberrant paths, emphasizing the anatomical complexity that surgeons face, and showing an increased left-sided or atypical drainage in 20–50% of multi-vein cases [26]. Nevertheless, in all cases, all confluences were to the veins of the portal circulation [27].

The narrow area of dissection within the pancreatic notch represents a challenge for the operating surgeon [28]. Bleeding can arise from unforeseen locations, as indicated by the venous confluences (SMV, IMV, JV, LCAV, GTH) in case of MCV injury. Performing a lymphadenectomy (in right colectomy) may represent a greater challenge when the MCV2 and/or MCV3 are present. A possible solution would be to ligate MCV1 and preserve MCV2/MCV3 when multiple MCVs are present. Hence, the lymphadenectomy would be carried out between the two vessels, namely MCV1 and MCV2. This approach is supported through the trajectories of the above-mentioned vessels.

The remaining factor contributing to the variety of the MCV is its topographic relationship to the MCA trunk [29]. Due to the size of the superior mesenteric vessels as well as the levels of the MCV confluences and the MCA origins, a substantial gap exists between these two structures [30]. Thus, it is no surprise that “no topographic relation” is found in 67.0% of cases. However, clinical value can be assigned to the two remaining variants (MCV or MCA lies anterior or posterior), which comprise 33.0%. Recognizing these variants before surgery could be crucial, as additional caution is required when dissecting the vein first, since it is more susceptible to traction and accidental damage, as troublesome bleeding can occur [31, 32, 33]. This variant occurs in 17.7% cases, while the posterior variant occurs in 15.3% and could be just as dangerous.

Intraoperative bleeding from the middle colic vein or its tributaries—specifically during the dissection (traction and countertraction) of the gastrocolic trunk of Henle (GCTH) —is a recognized complication during laparoscopic right colectomy with complete mesocolic excision (CME) [34], often stemming from vascular anatomy variations [35, 36, 37]. It is one of the more common sources of bleeding in this procedure, alongside injury to the ileocolic artery stump or superior mesenteric vein [38, 39].

The distances between the ICV-GTH, the ICA-MCA, and the number and caliber of JVs have previously been reported by our research group [13]. These distances (length and caliber), as well as the named structures, are anatomical landmarks that radiologist or any decidated specialist can add in there reporting, thus facilitating the surgeon's orientation when analyzing CTs [40].

The strength of this study lies in the robust sample size of high-quality CT scans (slice 0.67 mm) and in the experience of BVS in providing these 3D reconstructions. Furthermore, this technique of 3D reconstruction has been validated (NTM) at surgery [41]. A possible weakness is the fact that traditionally small caliber vessels (such as the PDV) are not easily visualized with standard preoperative portovenous phase CT image.

Conclusion

Despite a consistent presence, the MCV anatomy is profoundly complex and unpredictable due to multiplicity, aberrant confluences, and topographic relations to the MCA. A possible solution is the review of preoperative CT images with a 3D vascular anatomy reconstruction for better intervascular visualization.

Declarations

Ethics approval:

All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki Declaration and its later amendments or comparable ethical standards. The data and images of all participants are completely anonymized.

The prospective study named "Safe D3 Right Hemicolectomy for Cancer Through Multidetector Computed Tomography (MDCT) AngioStudy," identified by NCT01351714 and registered at ClinicalTrials.gov, began in May 2011 and wrapped up in January 2021. The study was approved by the Norwegian South-East Regional Ethical Committee (REK sør-øst) under number 2010/3354.

Consent to participate: Informed consent was obtained from all individual participants included in the study.

Consent to Publish declarations: not applicable. (Exceptions where it is not necessary to obtain consent: Images such as x rays, laparoscopic images. https://link.springer.com/journal/276/submission-guidelines#Instructions%20for%20Authors_Research%20involving%20human%20participants,%20their%20data%20or%20biological%20material).

The authors have actively participated in writing parts of the manuscript and revising it and, in the end, have given final approval for its publication.

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References

1. 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. Colorectal Dis 11(4):354–364 discussion 364-5. 10.1111/j.1463-1318.2008.01735.x
2. Gillot C, Hureau J, Aaron C, Martini R, Thaler G, Michels N (1964) The Superior Mesenteric Vein, An Anatomic and Surgical Study of Eighty-One Subjects. J Int Coll Surg 41:339–369 Pmid: 14147012
3. Andersen BT, Stimec BV, Kazaryan AM, Rancinger P, Edwin B, Ignjatovic D (2022) Re-interpreting mesenteric vascular anatomy on 3D virtual and/or physical models, part II: anatomy of relevance to surgeons operating splenic flexure cancer. Surg Endosc 36(12):9136–9145.

10.1007/s00464-022-09394-5. Epub 2022 Jun 30. PMID: 35773607; PMCID: PMC9652173

4. Standring S (ed) (2021) Gray's Anatomy: The Anatomical Basis of Clinical Practice, 42nd edn. Elsevier Limited, New York
5. Sun KK, Zhao H (2020) Vascular anatomical variation in laparoscopic right hemicolectomy. Asian J Surg 43(1):9–12. 10.1016/j.asjsur.2019.03.013. Epub 2019 Apr 10. PMID: 30979567
6. Maki Y, Mizutani M, Morimoto M, Kawai T, Nakagawa M, Ozawa Y, Takeuchi M, Maki H, Kurosaka K, Shibamoto Y (2016) The variations of the middle colic vein tributaries: depiction by three-dimensional CT angiography. Br J Radiol 89(1063):20150841. 10.1259/bjr.20150841. Epub 2016 Apr 25. PMID: 27109734; PMCID: PMC5257301
7. Dighe S, Purkayastha S, Swift I, Tekkis PP, Darzi A, A'Hern R, Brown G (2010) Diagnostic precision of CT in local staging of colon cancers: a meta-analysis. Clin Radiol. ;65(9):708 – 19. doi: 10.1016/j.crad.2010.01.024. PMID: 20696298
8. Andersen BT, Stimec BV, Edwin B, Kazaryan AM, Maziarz PJ, Ignjatovic D (2022) Re-interpreting mesenteric vascular anatomy on 3D virtual and/or physical models: positioning the middle colic artery bifurcation and its relevance to surgeons operating colon cancer. Surg Endosc 36(1):100–108. 10.1007/s00464-020-08242-8. Epub 2021 Jan 25. PMID: 33492511; PMCID: PMC8741724
9. Willard CD, Kjaestad E, Stimec BV et al (2019) Preoperative anatomical road mapping reduces variability of operating time, estimated blood loss, and lymph node yield in right colectomy with extended D3 mesenterectomy for cancer. Int J Colorectal Dis 34(1):151–160
10. Moen TM, Stimec B, Ignjatovic D (2022) The Use of a Vascular Roadmap at Surgery Evens out Surgeons' Expectations on Operating Time, Blood Loss, Lymph Nodes Harvest and Operative Difficulty when Performing Right Colectomy with Extended D3 Mesenterectomy. Chirurgia (Romania) 117(5):579–584
11. Nerad E, Lahaye MJ, Maas M, Nelemans P, Bakers FC, Beets GL, Beets-Tan RG (2016) Diagnostic Accuracy of CT for Local Staging of Colon Cancer: A Systematic Review and Meta-Analysis. AJR Am J Roentgenol 207(5):984–995 Epub 2016 Aug 4. PMID: 27490941
12. Stimec BV, Ignjatovic D (2020) Navigating the mesentery: Part III. Unusual anatomy of ileocolic vessels. Colorectal Dis 22(12):1949–1957. 10.1111/codi.15284. Epub 2020 Aug 17. PMID: 32734680
13. Nesgaard JM, Stimec BV, Bakka AO, Edwin B, Ignjatovic D, RCC study group (2015). Navigating the mesentery: a comparative pre- and per-operative visualization of the vascular anatomy. Colorectal Dis. ;17(9):810-8. 10.1111/codi.13003. PMID: 25988347
14. Luzon JA, Kumar RP, Stimec BV, Elle OJ, Bakka AO, Edwin B, Ignjatovic D (2020) Semi-automated vs. manual 3D reconstruction of central mesenteric vascular models: the surgeon's verdict. Surg Endosc 34(11):4890–4900. 10.1007/s00464-019-07275-y. Epub 2019 Nov 19. PMID: 31745632
15. Andersen BT, Kazaryan AM, Stimec BV, Edwin B, Rancinger P, Ignjatovic D (2022) Personalized surgery for the splenic flexure cancer: new frontiers. Br J Surg 109(9):880–881. 10.1093/bjs/znac153. PMID: 35640281; PMCID: PMC10364751
16. Yamaguchi S, Kuroyanagi H, Milsom JW, Sim R, Shimada H (2002) Venous anatomy of the right colon: precise structure of the major veins and gastrocolic trunk in 58 cadavers. Dis Colon Rectum. ;45(10):1337-40. 10.1097/01.DCR.0000027284.76452.84. PMID: 12394432
17. 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. 10.1245/s10434-014-3572-2. Epub 2014 Mar 17. PMID: 24633663
18. Alsabilah J, Kim WR, Kim NK (2017) Vascular Structures of the Right Colon: Incidence and Variations with Their Clinical Implications. Scand J Surg 106(2):107–115. 10.1177/1457496916650999. Epub 2016 May 23. PMID: 27215222
19. Wu C, Ye K, Wu Y et al (2019) Variations in right colic vascular anatomy observed during laparoscopic right colectomy. World J Surg Onc 17:16. https://doi.org/10.1186/s12957-019-1561-4
20. Asensio JA, Petrone P, Garcia-Nuñez L, Healy M, Martin M, Kuncir E (2007) Superior mesenteric venous injuries: to ligate or to repair remains the question. J Trauma. ;62(3):668 – 75; discussion 675. 10.1097/01.ta.0000210434.56274.7f. PMID: 17414345
21. Gao Y, Lu Y (2018) Variations of Gastrocolic Trunk of Henle and Its Significance in Gastrocolic Surgery. Gastroenterol Res Pract 2018:3573680. 10.1155/2018/3573680. PMID: 29977286; PMCID: PMC6011069
22. Hamabe A, Park S, Morita S et al (2018) Analysis of the Vascular Interrelationships Among the First Jejunal Vein, the Superior Mesenteric Artery, and the Middle Colic Artery. Ann Surg Oncol 25:1661–1667. https://doi.org/10.1245/s10434-018-6456-z
23. Ignjatovic D, Stimec B, Finjord T, Bergamaschi R (2004) Venous anatomy of the right colon: three-dimensional topographic mapping of the gastrocolic trunk of Henle. Tech Coloproctol. ;8(1):19–21; discussion 21 – 2. 10.1007/s10151-004-0045-9. PMID: 15057584
24. Negoi I, Beuran M, Hostiuc S, Negoi RI, Inoue Y (2018) Surgical Anatomy of the Superior Mesenteric Vessels Related to Colon and Pancreatic Surgery: A Systematic Review and Meta-Analysis. Sci Rep 8(1):4184. 10.1038/s41598-018-22641-x. PMID: 29520096; PMCID: PMC5843657
25. Stefura T, Kacprzyk A, Droś J, Pędziwiatr M, Major P, Hołda MK (2018) The venous trunk of henle (gastrocolic trunk): A systematic review and meta-analysis of its prevalence, dimensions, and tributary variations. Clin Anat 31(8):1109–1121. 10.1002/ca.23228. Epub 2018 Aug 30. PMID: 30133829
26. Nepal P, Mori S, Kita Y, Tanabe K, Baba K, Sasaki K, Kurahara H, Arigami T, Ohtsuka T (2021) Anatomical study of the inferior mesenteric vein using three-dimensional computed tomography angiography in laparoscopy-assisted surgery for left-sided colorectal cancer. Surg Today

51(10):1665–1670. 10.1007/s00595-021-02292-8. Epub 2021 Apr 23. PMID: 33893527

27. Mai PT, Hoang VT, Nguyen TTT, Vo THT, Le VP (2025) Portal vein confluence variants on contrast-enhanced CT: distribution, IMV-confluence distance, and novel patterns in 199 adults. Surg Radiol Anat. ;47(1):237. 10.1007/s00276-025-03754-1. PMID: 41120551
28. Ielpo B, d'Addetta MV, Anselmo A, Rosso E, de Blasi V, Sanchez-Velazquez P, Vellalta G, Podda M, Burdio F (2024) Levels of Robotic Mesopancreas Dissection According to Malignancy and Vascular Anatomy: What Surgeons Need to Know. Ann Surg Oncol 31(3):1916–1918. 10.1245/s10434-023-14686-8. Epub 2023 Dec 10. PMID: 38071705; PMCID: PMC10838235
29. Nigah S, Patra A, Chumber S (2022) Analysis of the Variations in the Colic Branching Pattern of the Superior Mesenteric Artery: A Cadaveric Study With Proposal to Modify Its Current Anatomical Classification. Cureus 14(5):e25025. 10.7759/cureus.25025. PMID: 35719766; PMCID: PMC9199573
30. Stelzner S, Hohenberger W, Weber K, West NP, Witzigmann H, Wedel T (2016) Anatomy of the transverse colon revisited with respect to complete mesocolic excision and possible pathways of aberrant lymphatic tumor spread. Int J Colorectal Dis 31(2):377–384. 10.1007/s00384-015-2434-0. Epub 2015 Nov 6. PMID: 26546443
31. Bertani E, Zugni F, Radice D, Spada F, Bonomo G, Fumagalli Romario U, Fazio N, Funicelli L (2022) Predicting resectability of primary tumor and mesenteric lymph-node masses in patients with small-intestine neuroendocrine tumors. Updates Surg 74(5):1697–1704. 10.1007/s13304-022-01251-3. Epub 2022 Feb 27. PMID: 35224681
32. Ignjatovic D, Bergamaschi R, Stimec BV (2025) The forgotten nodes: a narrative review. Ann Laparosc Endosc Surg 10:6. https://dx.doi.org/10.21037/ales-24-23
33. Anania G, Campagnaro A, Chiozza M, Randolph J, Resta G, Marino S, Pedon S, Agrusa A, Cuccurullo D, Cirocchi R (2024) SICE CoDIG (ColonDx Italian Group). A SICE (Società Italiana di Chirurgia Endoscopica e Nuove Tecnologie) observational prospective multicenter study on anatomical variants of the superior mesenteric artery: intraoperative analysis during laparoscopic right hemicolectomy-CoDIG 2 database (ColonDx Italian Group). Updates Surg 76(3):933–941. 10.1007/s13304-024-01787-6. Epub 2024 Mar 25. PMID: 38526696; PMCID: PMC11129964
34. Croner RS, Ptok H, Merkel S, Hohenberger W (2018) Implementing complete mesocolic excision for colon cancer - mission completed? Innov Surg Sci 3(1):17–29. 10.1515/iss-2017-0042. PMID: 31579762; PMCID: PMC6754049
35. Ye K, Lin J, Sun Y, Wu Y, Xu J, He S (2018) Variation and treatment of vessels in laparoscopic right hemicolectomy. Surg Endosc 32(3):1583–1584. 10.1007/s00464-017-5751-2. Epub 2017 Jul 21. PMID: 28733739
36. Yamaguchi S, Kuroyanagi H, Milsom JW, Sim R, Shimada H (2002) Venous anatomy of the right colon: precise structure of the major veins and gastrocolic trunk in 58 cadavers. Dis Colon Rectum. ;45(10):1337-40. 10.1097/01.DCR.0000027284.76452.84. PMID: 12394432
37. Sánchez-Rodríguez M, Pastor C, Jiménez-Ruiz J, Dujovne-Lindenbaum P, Craus-Miguel A, Tejedor P (2026) D3 Lymph Node Dissection in Right-Sided Colon Cancer: A video Insight into Key Vascular Variations. Dis Colon Rectum. Feb 24. 10.1097/DCR.0000000000004128. Epub ahead of print. PMID: 41733135
38. Wu C, Ye K, Wu Y, Chen Q, Xu J, Lin J, Kang W (2019) Variations in right colic vascular anatomy observed during laparoscopic right colectomy. World J Surg Oncol 17(1):16. 10.1186/s12957-019-1561-4. PMID: 30636641; PMCID: PMC6330569
39. Zhao LY, Li GX, Zhang C, Yu J, Deng HJ, Wang YN, Hu YF, Cheng X (2012) [Vascular anatomy of the right colon and vascular complications during laparoscopic surgery]. Zhonghua Wei Chang Wai Ke Za Zhi 15(4):336–341 Chinese. PMID: 22539376
40. Flor N, Campari A, Ravelli A, Lombardi MA, Pisani Ceretti A, Maroni N, Opocher E, Cornalba G (2015 Jul-Aug) Vascular Map Combined with CT Colonography for Evaluating Candidates for Laparoscopic Colorectal Surgery. Korean J Radiol 16(4):821–826. 10.3348/kjr.2015.16.4.821. Epub 2015 Jul 1. PMID: 26175581; PMCID: PMC4499546
41. Banipal GS, Stimec BV, Andersen SN, Edwin B, Nesgaard JM, Šaltytė Benth J, Ignjatovic D, RCC study group (2024) Are Metastatic Central Lymph Nodes (D3 volume) in right-sided Colon Cancer a Sign of Systemic Disease? A sub-group Analysis of an Ongoing Multicenter Trial. Ann Surg 279(4):648–656 Epub 2023 Sep 27. PMID: 37753647; PMCID: PMC10922660

Table 1

Table 1 is available in the Supplementary Files section.

Figures

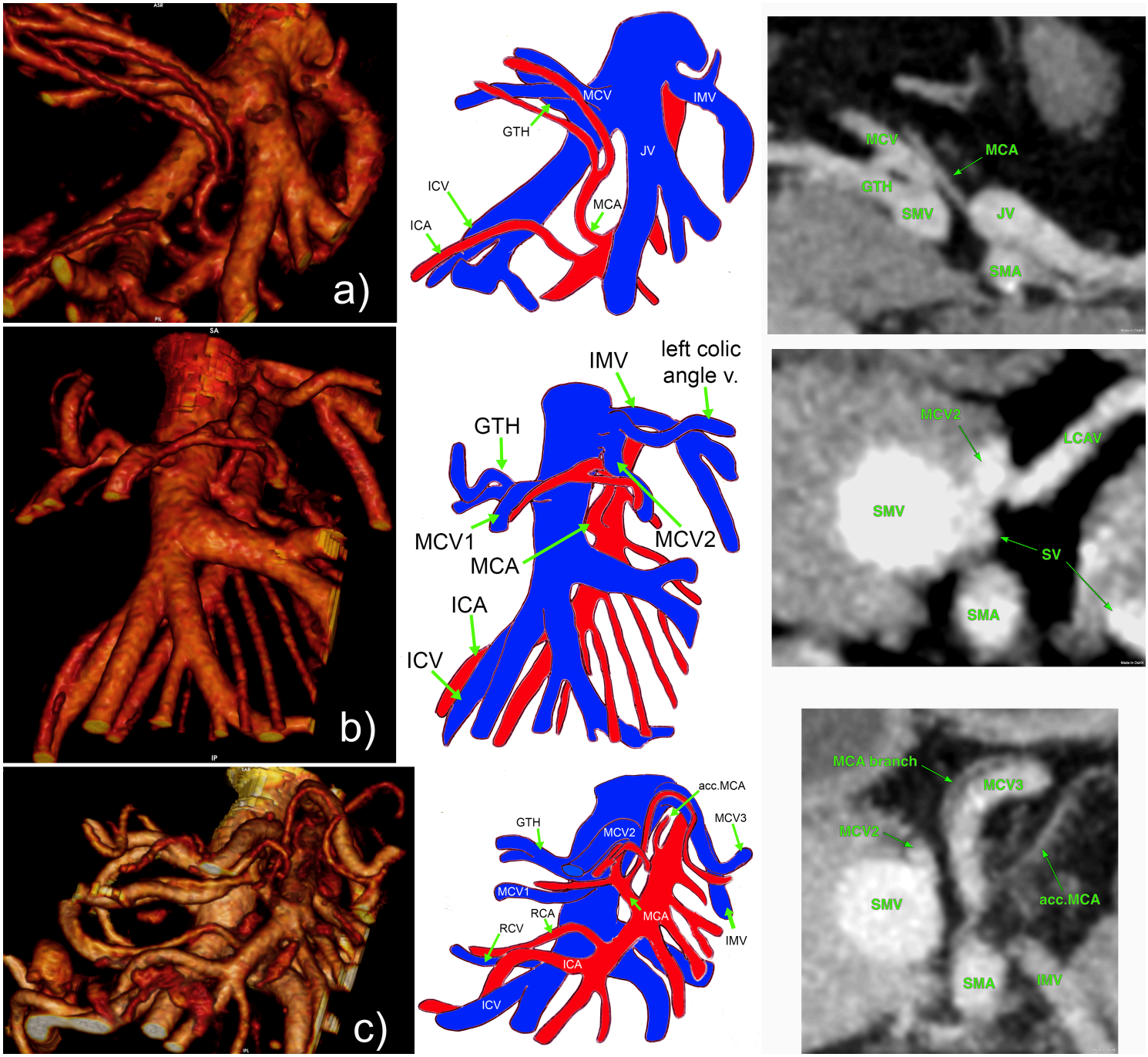


Figure 1

Cases with single, double, and triple MCV. Osirix 3DCT reconstruction on the left and Multiplanar reconstruction - MPR on the right. a) MCV drain into SMV; b) MCV1 drain into GTH and MCV2 drain into SMV; c) MCV1 and MCV2 into SMV, MCV3 into IMV. MCV - middle colic vein, SMV – superior mesenteric vein, IMV – inferior mesenteric vein, MCA – middle colic artery, GTH – gastrocolic trunk Henle, JV – jejunal vein, ICV – inferior colic vein, ICA – ileocolic artery, TIVT - terminal ileal venous trunk, RCA-right colic artery, SMA – superior mesenteric artery, LCAV – left colic angle vein, SV – splenic vein, RCV – right colic vein, acc MCA – accessory middle colic artery.

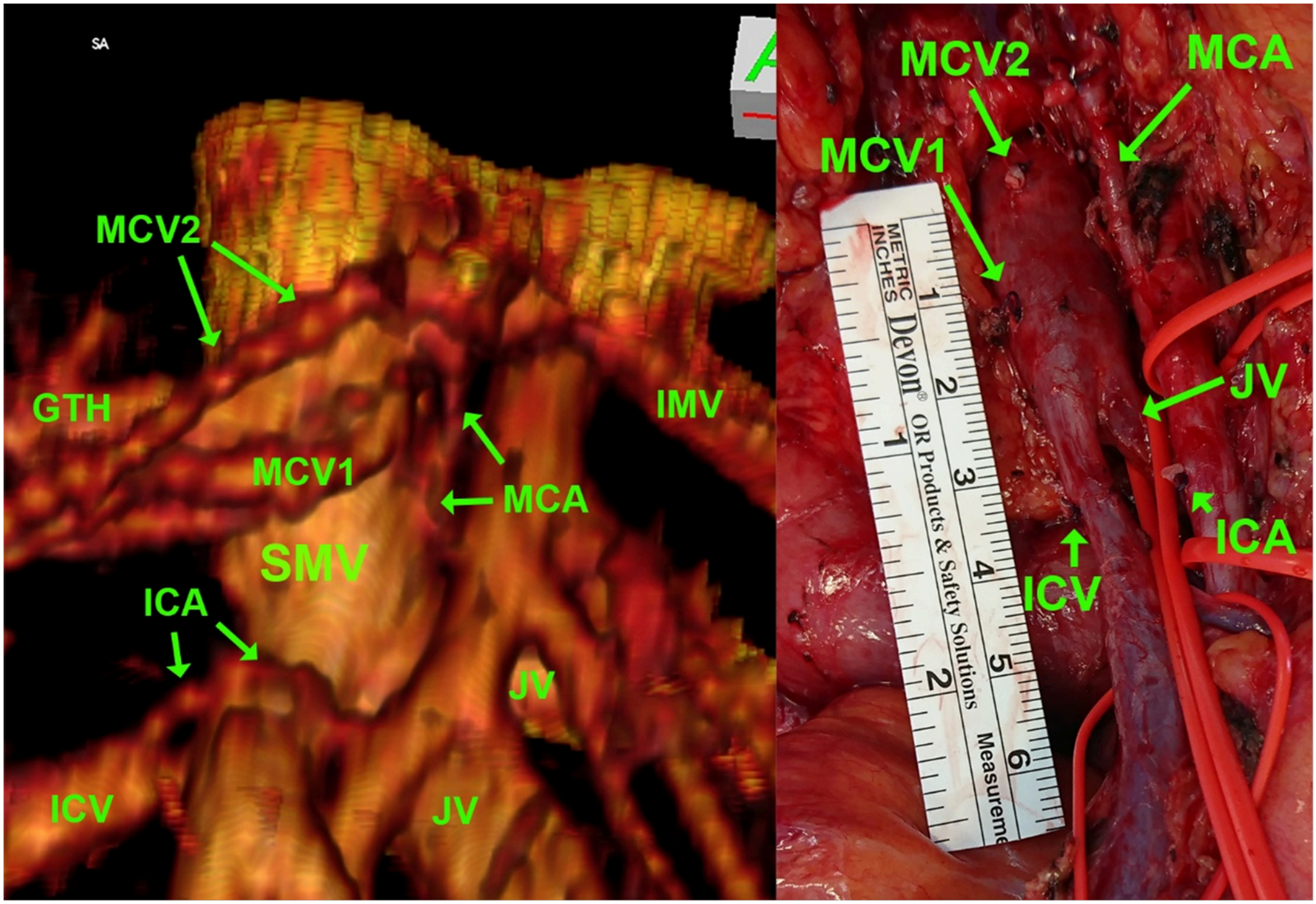


Figure 2

Osirix 3DCT reconstruction and picture at the open surgery: MCV 1,2 entering superior mesenteric vein. MCV - middle colic vein, IMV – inferior mesenteric vein, SMV – superior mesenteric vein, MCA – middle colic artery, GTH – gastrocolic trunk Henle, JV – jejunal vein, ICV – inferior colic vein, ICA – ileocolic artery.

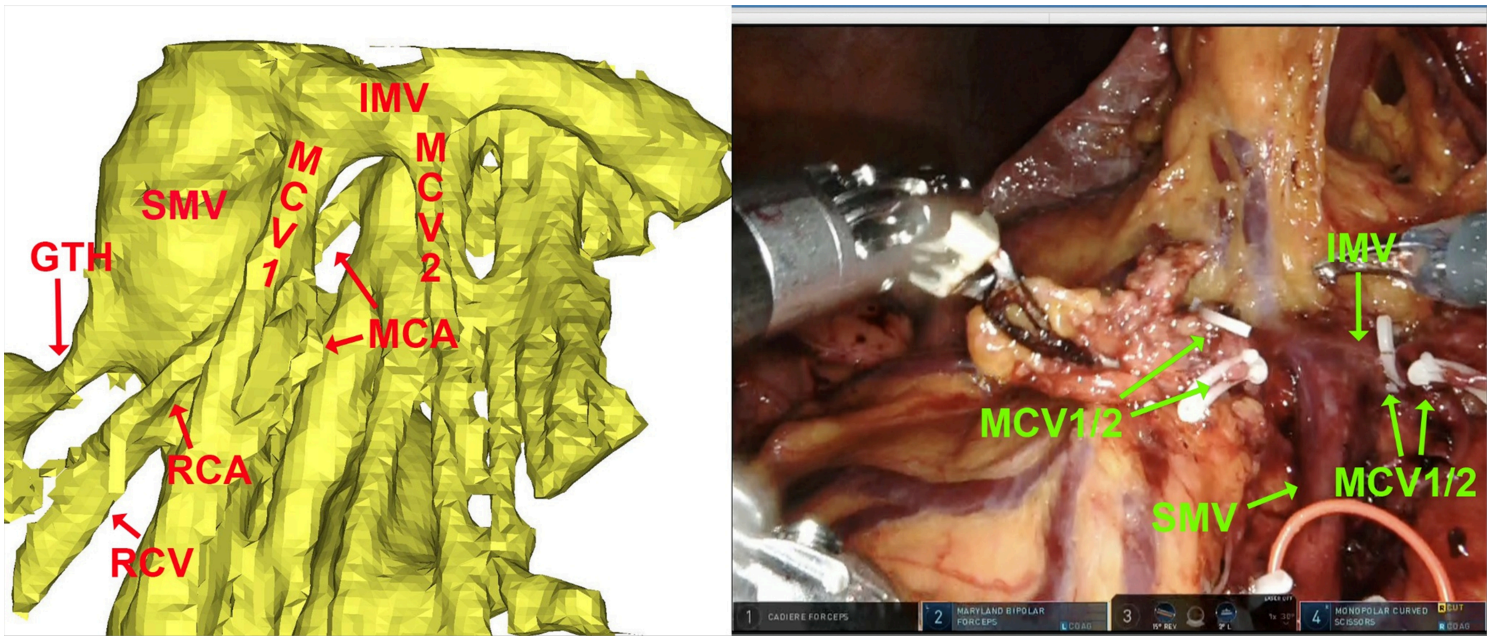


Figure 3

Materialise Mimics 3DCT reconstruction and picture at the robotic surgery: MCV 1,2 entering inferior mesenteric vein. MCV - middle colic vein, IMV – inferior mesenteric vein, SMV – superior mesenteric vein, MCA – middle colic artery, GTH – gastrocolic trunk Henle, RCA-right colic artery, RCV – right colic vein.

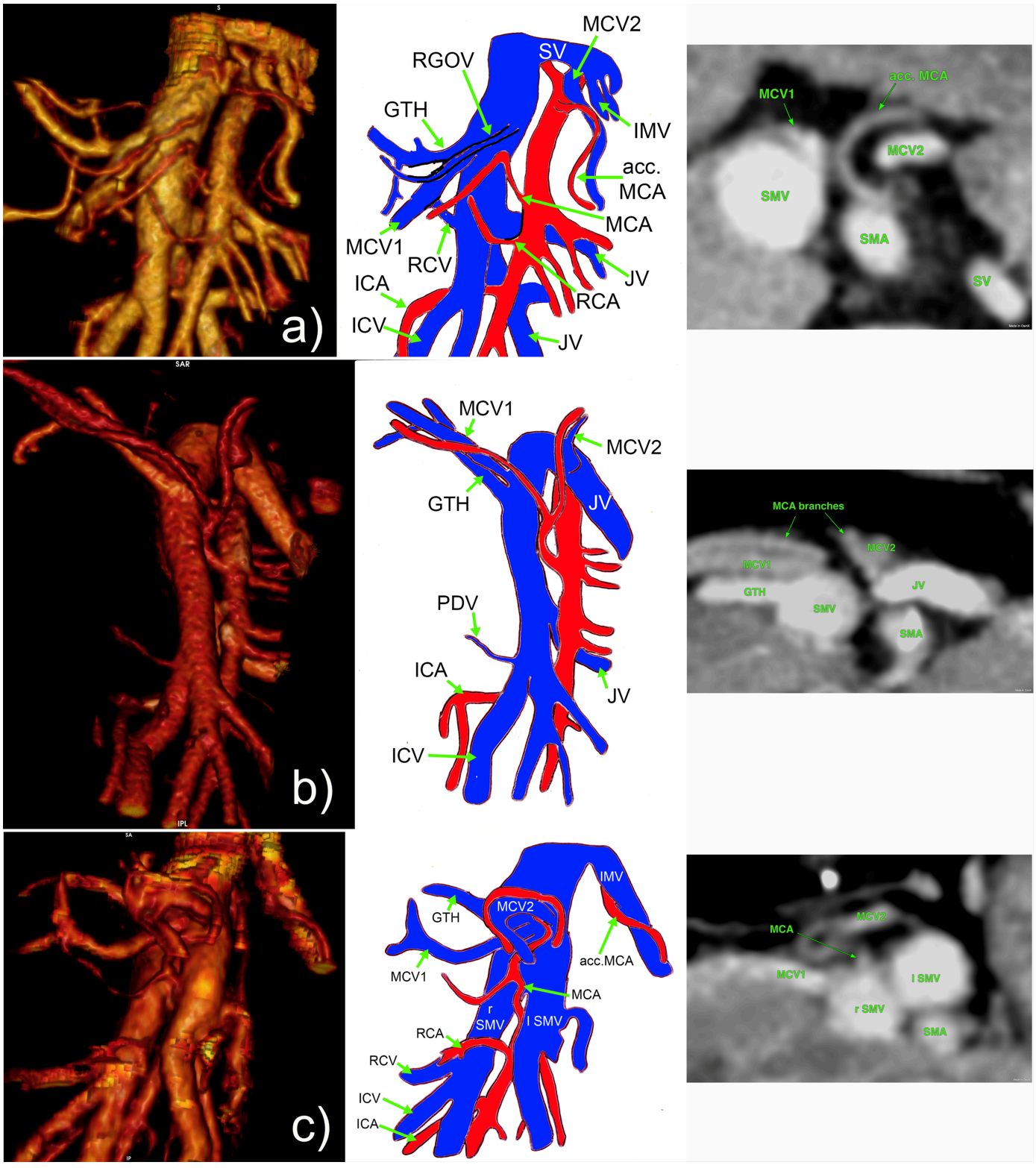


Figure 4

Cases with aberrant confluences. Osirix 3DCT reconstruction on the left and Multiplanar reconstruction - MPR on the right. a) MCV2 drain into SV; b) MCV2 drain into JV; c) MCV2 drain into LSMV. MCV - middle colic vein, SMV – superior mesenteric vein, IMV – inferior mesenteric vein, lSMV-left superior mesenteric vein, rSMV-right superior mesenteric vein, MCA – middle colic artery, GTH – gastrocolic trunk Henle, JV – jejunal vein,

ICV – inferior colic vein, ICA – ileocolic artery, TIVT - terminal ileal venous trunk, RCA-right colic artery, RCV – right colic vein, RGOV – right gastroomental vein, SV – splenic vein, acc MCA – accessory middle colic artery, PDV – pancreatico duodenal vein.

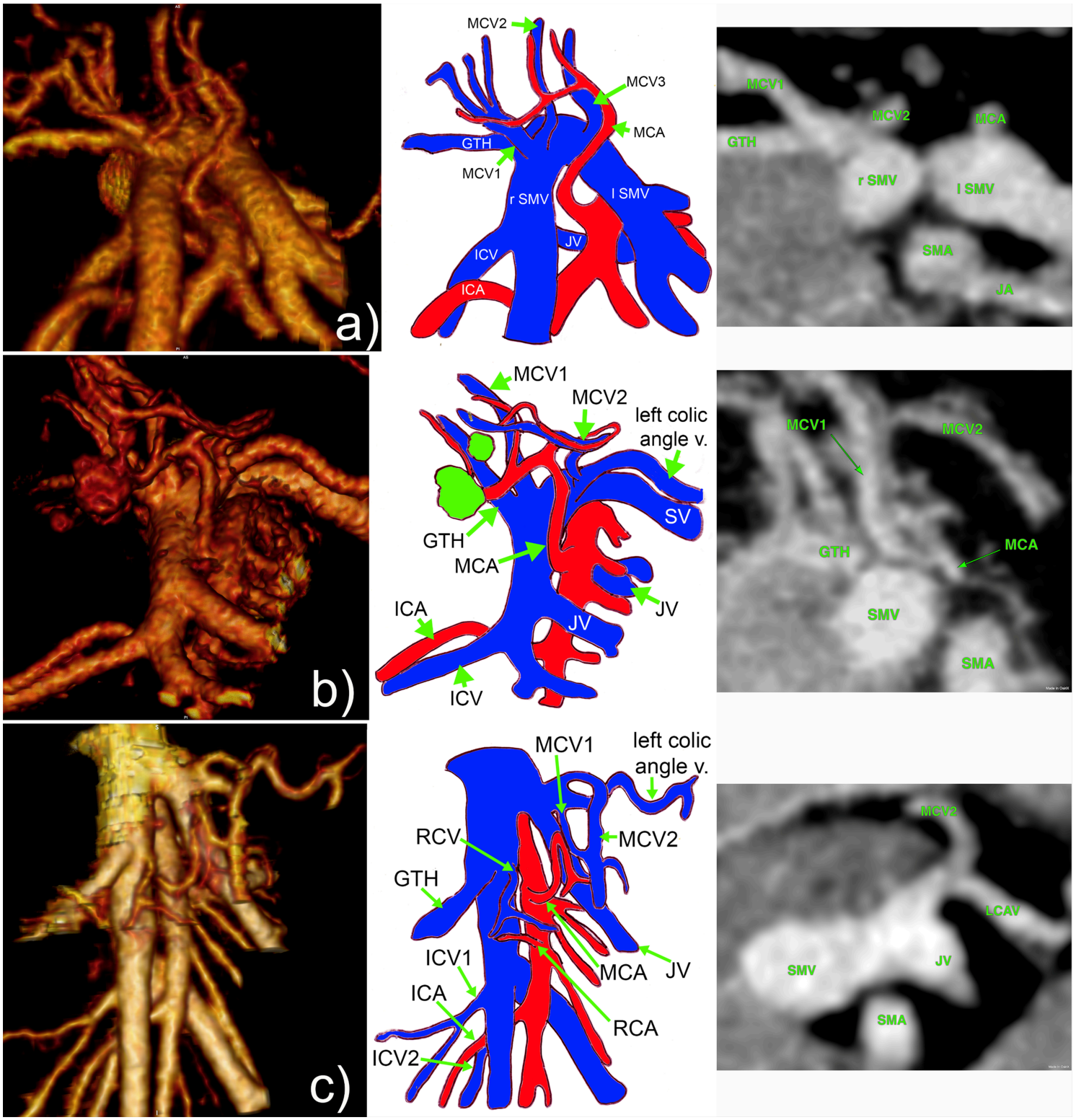


Figure 5

MCV Trajectories. Osirix 3DCT reconstruction on the left and Multiplanar reconstruction - MPR on the right. a) MCV1 drains side-by-side with the GTH to the RSMV. MCV2 drains only 0.28 cm to the left of MCV1 base, also to the RSMV. MCV3 drains to the terminal portion of the LSMV. All three MCVs are followed by MCA branches, which pass inferiorly, i.e., superficial to them; b) MCV1 drains into the SMV side-by-side with the GTH. MCV2 drains into the terminal portion of the LCAV, just before it terminates in the proximity of the splenomesenteric junction. The MCV is followed by the MCA left branch, which runs first on its deep (upper surface), then on its left-hand side. The MCV2 is directed to the right, entering the drainage area of the MCV1 and GTH; c) MCV1 and MCV2 drain into the terminal portion of the LCAV, just before this vein itself terminates in

the LSMV. MCV1 drains from below, and the MCV2 from above. However, both MCVs descend in front of the LSMV and the LCAV and anastomose within the transverse mesocolon in the form of a precoce arcade. They are followed by the right branch of the MCA, while the left MCA branch is concomitant to the LCAV. MCV - middle colic vein, SMA – superior mesenteric artery, SMV – superior mesenteric vein, IMV – inferior mesenteric vein, lSMV-left superior mesenteric vein, rSMV-right superior mesenteric vein, MCA – middle colic artery, GTH – gastrocolic trunk Henle, JV – jejunal vein, JA – jejunal artery, ICV – inferior colic vein, ICA – ileocolic artery, TIVT - terminal ileal venous trunk, RCA-right colic artery, LCAV – left colic angle vein, SV – splenic vein.

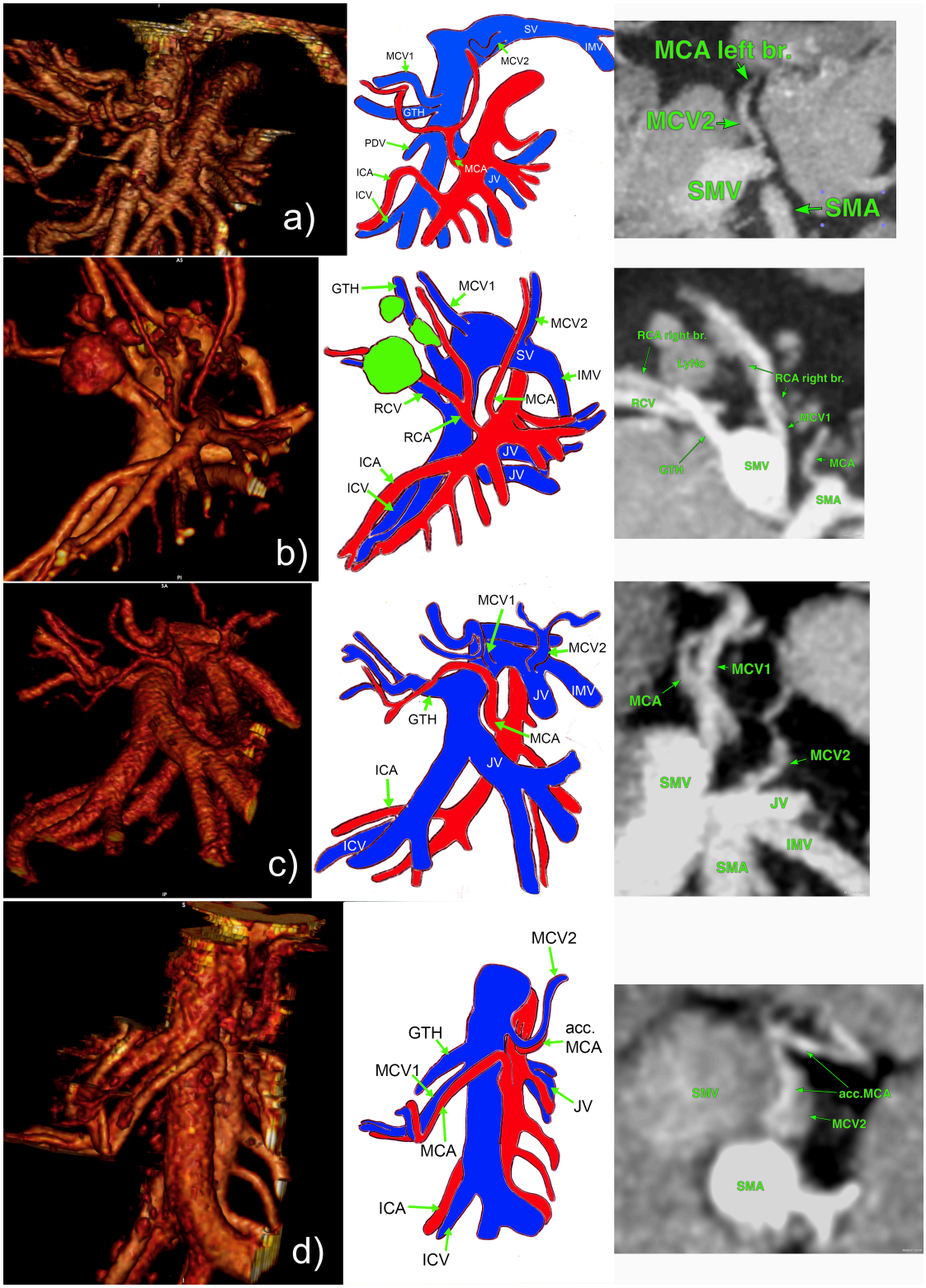


Figure 6

Topography of MCV. Osirix 3DCT reconstruction on the left and Multiplanar reconstruction - MPR on the right. a) MCV and MCA were separate and did not intersect; b) MCV in front of MCA; c) MCV and MCA were separate but close. Confluence of JV, MCV2, and IMV; d) MCA in front of MCV. MCV - middle colic vein, IMV – inferior mesenteric vein, PDV – pancreatico duodenal vein, SV – splenic vein, MCA – middle colic artery, GTH – gastrocolic trunk Henle, JV – jejunal vein, ICV – inferior colic vein, ICA – ileocolic artery, RCA-right colic artery, SMA – superior mesenteric artery, SMV – superior mesenteric vein, JV – jejunal vein, acc MCA – accessory middle colic artery.

Supplementary Files

This is a list of supplementary files associated with this preprint. Click to download.

- Table1.docx
- D3data.xlsx