3D Printing in Medicine

CASE REPORT

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Clinical application of three-dimensional printing technology in laparoscopic right hemicolectomy for colon cancer: a pilot study and video demonstration

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Abstract

Background Patients who undergo laparoscopic right hemicolectomy often have vascular anomalies, creating challenges for surgeons. Preoperative identification of vascular anomalies and intraoperative precise navigation can enhance surgical safety and reduce the difficulty of the procedure. Accordingly, this study aimed to explore and evaluate the application of three-dimensional (3D) reconstruction and printing technology in laparoscopic right hemicolectomy and its assistance in preoperative planning and intraoperative navigation.

Method 11 3D-reconstructed images and printed models of right hemicolectomy vasculature were preoperatively created to assist in developing individualized surgical plans. Intraoperatively, essential vessels (gastrocolic trunk of Henle, GTH) were identified and located with the help of the 3D printed models. Additionally, 36 cases without the assistance of 3D printing were retrospectively collected for the control group. Statistical analysis was performed to evaluate the impact of the 3D printed models on surgery-related characteristics.

Results The 3D-printed models accurately depicted anatomical structures, particularly the positions and adjacent relationships of essential vessels, including the superior mesenteric artery (SMA), superior mesenteric vein (SMV), GTH and related arterial/venous branches. The operation time was significantly lower in the 3D printing group (198.6 ± 8.8 min in 3D printing group vs. 230.7 ± 47.5 min in control group, $P = 0.025$).

Conclusions In conclusion, this study represents a novel vascular 3D printed modelfor surgical planning and intraoperative navigation in laparoscopic right hemicolectomy. It underscores the potential clinical applications of 3D printing in this context. Preoperative identification of vascular anomalies and precise intraoperative navigation can feasibly reduce surgical difficulty and enhance safety.

Keywords 3D printing, Laparoscopic right hemicolectomy, Surgical planning, Intraoperative navigation, Vascular anomalies

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Background

Colorectal cancer (CRC) is the most common malignant tumor of the digestive tract. According to the latest global cancer epidemiological survey, there are 150, 000 estimated new cases and 53, 000 estimated deaths due to CRC each year [1]. With the improvement in public health standards and average life expectancy, the widespread adoption of endoscopy, more sensitive imaging examinations, the incidence of colorectal cancer has been gradually increasing [2]. To date, surgery remains the primary treatment modality for colorectal cancer, combined with adjuvant therapy, neoadjuvant therapy, targeted therapy, and immunotherapy [3]. As minimally invasive techniques (such as laparoscopic and robotic surgery) advance, there is a growing emphasis on refined, minimally invasive, and standardized treatments [4, 5]. It is well known that minimally invasive techniques, compared to traditional open surgery, place higher demands on surgeons [6]. These demands include a more comprehensive understanding of anatomy, more meticulous surgical operations, and the ability to quickly respond to and resolve unexpected issues. Particularly, vascular anatomical variations in the right-side colon are common and present a greater challenge for surgeons during surgery [7]. Anatomical variations can make this process precarious, where even a slight misstep can lead to serious consequences. In laparoscopic right hemicolectomy, meticulous handling of the ileocolic artery (ICA) and vein (ICV), right colic artery (RCA) and vein (RCV), middle colic artery (MCA) and vein (MCV), and gastrocolic trunk of Henle (GTH) is crucial [8]. During surgery, it is often necessary to precisely dissect and expose specific vessels for preserving or cutting certain small vessels. It is common to ligate and cut the ICA and ICV, the RCA and RCV and the right branch of the MCA. In particular, the GTH needs to be carefully exposed and dissected during the operation. Its tributaries, namely the right gastroepiploic vein (RGeV) and the anterior superior pancreaticoduodenal vein (ASPDV), need to be preserved, while the RCV and the accessory RCV (if exist) need to be ligated and divided. Additionally, the left branch of the MCA must also be safeguarded. The Henle trunk exhibits a notably high incidence of anatomical variations. It is present in approximately 90% of cases and can be classified into four main types: (1), The gastro-pancreato-colic trunk, which can be formed by the right gastroepiploic vein (RGeV), superior right colic vein (SRCV) or/and RCV, and anterior superior pancreaticoduodenal vein (ASPDV); (2), The gastro-colic trunk, which can consisting of the RGeV and SRCV; (3) The gastro-pancreatic trunk, which can be formed by the RGeV, ASPDV or/and anterior inferior pancreaticoduodenal vein (AIPDV); (4) The pancreatic-colic trunk, where the ASPDV and SRCV converge [9, 10]. In addition, the Henle trunk may receive contributions from other veins, including the MCV, accessory middle colic vein (aMCV), accessory superior right colic vein (aSRCV), right transverse colic vein (RTCV) at al. The complex and highly variable vascular anatomy significantly increases the technical challenge of the procedure. Therefore, preoperative identification of vascular anomalies and Intraoperative precise navigation are paramount. Currently, 3D printing has successfully been used to fabricate personalized medical instruments and even tissues and organs for implantation, making significant contributions to the advancement of the medical industry [11, 12]. However, up to now, the clinical applications of 3D printing in CRC have not been reported.

In this research, we applied 3D printing technology for the first time in laparoscopic right hemicolectomy, aiming to accurately identify vascular anatomy before operation. By constructing 3D printing models, we aim to explore the clinical application of 3D printing technology in right-side colon cancer for preoperative planning and intraoperative guidance.

Method

Study population

The study was conducted at Fuyang City People's Hospital from January 2024 to August 2024. The inclusion criteria were as follows: (1) age over 18 years old; (2) tumors located in the right-sided colon, as identified by imaging examination (enhanced CT); (3) preoperative pathology confirmed the diagnosis of adenocarcinoma; (4) patients who underwent an abdominal double-phase enhanced scan prior to surgery; (5) patients who provided informed written consent to participate in the study; (6) patients underwent laparoscopic right hemicolectomy or laparoscopic extended right hemicolectomy. The exclusion criteria were as follows: (1) occurrence of distant metastasis; (2) presence of other concurrent malignancies; (3) comorbid severe heart and lung disease; and (4) comorbid schizophrenia or other mental health disorders, lack of independent behavior ability, or inability to cooperate with treatment. Of these, 3 patients were excluded due to invasion of surrounding organs (duodenum), making an R0 resection unattainable; 2 patients were excluded due to liver metastasis; 3 patients underwent open right hemicolectomy due to concurrent cardiopulmonary diseases and were excluded. The remaining 11 patients underwent laparoscopic right hemicolectomy with the assistance of 3D reconstruction and 3D printing. Meanwhile, patients who underwent laparoscopic right hemicolectomy during the same period were collected as controls ($n = 36$). The study design and flow chart are shown in Fig. 1. This study was approved by the Ethics Committee of Fuyang City People's Hospital.

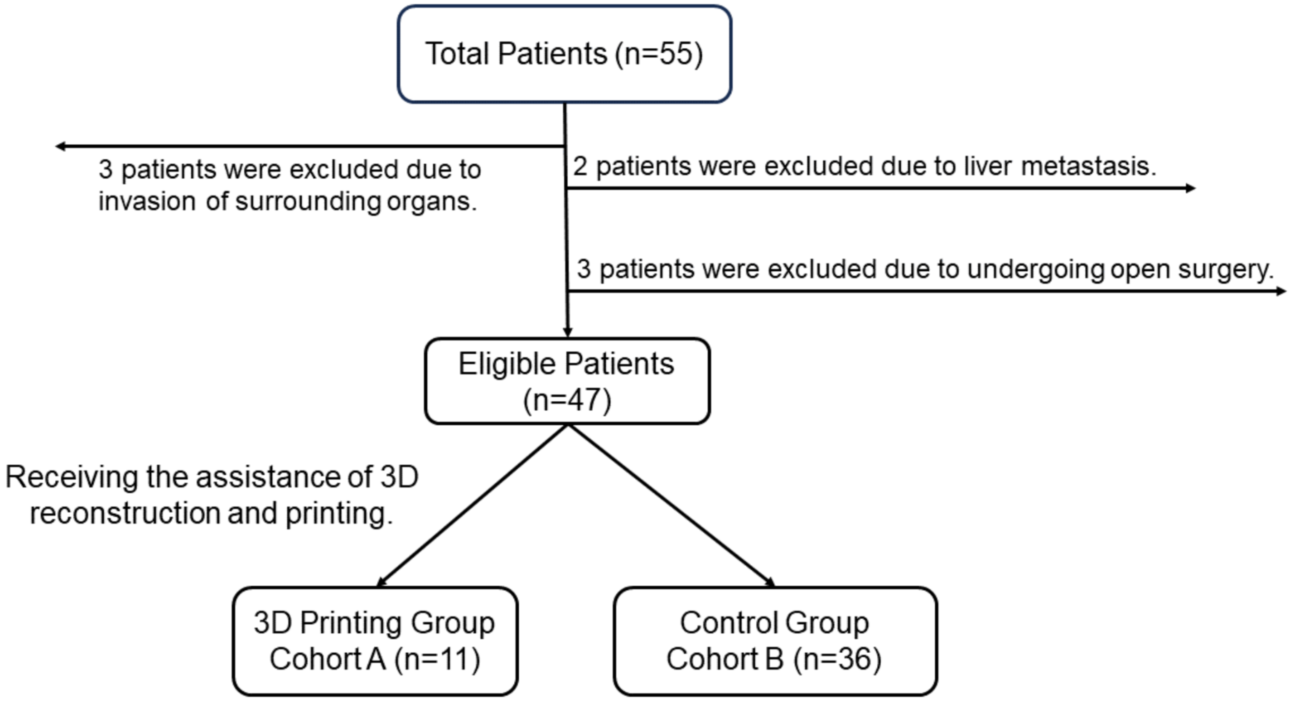

Fig. 1 The design and flowchart of this study

Observation index

The basic characteristics of patients were collected, including gender, age, clinical stage, tumor location, operating time, intraoperative blood loss, length of stays, tumor invasion depth (T stage), presence of lymph node metastasis (N stage) and the incidence of postoperative complications. In addition, the radiography data (images) were collected properly. We defined the operation time as the period from the start of the surgery after anesthesia to its end. To minimize the impact of the surgical operators on the research, we ensured that the surgeons in the control group and the 3D - printing group were the same (a total of four surgeons).

3D reconstruction and printing

Preoperatively, we performed 3D reconstruction and 3D printing of the patient's surgical-related vessels and organs based on the enhanced CT scan. In detail, the CT scans were imported into 3D modeling software (3D slicer 5.2.2, mimics 19.0) in DICOM format for 3D reconstruction. The abdominal aorta, superior mesenteric artery (SMA), superior mesenteric vein (SMV), ICA, ICV, RCA, RCV, head of the pancreas and Henle trunk were examined and chosen for 3D reconstruction. The surface of the 3D virtual model was subsequently refined through a smoothing process. After ensuring the absence of any structural deformation or deviation, the resin white material was 3D-printed using a high-precision SLA photocuring process (CHUNLEI SLA 600). Approximately, the entire 3D model reconstruction took 60 min, and the printing time took 210 min. The 3D models were then cured, polished, and colored. Red was used to color the arteries, blue was used to color the veins, yellow was used to color the pancreas. Before entering the operating room, the model was disinfected with 75% alcohol.

3D model application

The completed model was subsequently provided to the surgeon prior to the surgery for preoperative evaluation and surgical planning. We decided whether it was necessary to expose the Henle trunk during the operation according to tumor location and AJCC clinical stage (TNM) and the composition of Henle trunk. During the surgery, guided by the vascular anatomy and adjacent relationships depicted in the 3D printing models, we meticulously handled the critical vessels and successfully completed the operation (Supplement file, Video). Postoperatively confirmed, the 3D printing model perfectly matched the patient's actual anatomy (Fig. 2A and B).

Statistical analysis

Using GraphPad Prism 8 software for statistical analysis, measurement data were analyzed using the Student's t-test or Mann–Whitney U test, while enumeration data were analyzed using the chi-square or Fisher's exact tests. Statistical significance was set at $P < 0.05$.

Results

The clinical and vascular anatomical characteristics.

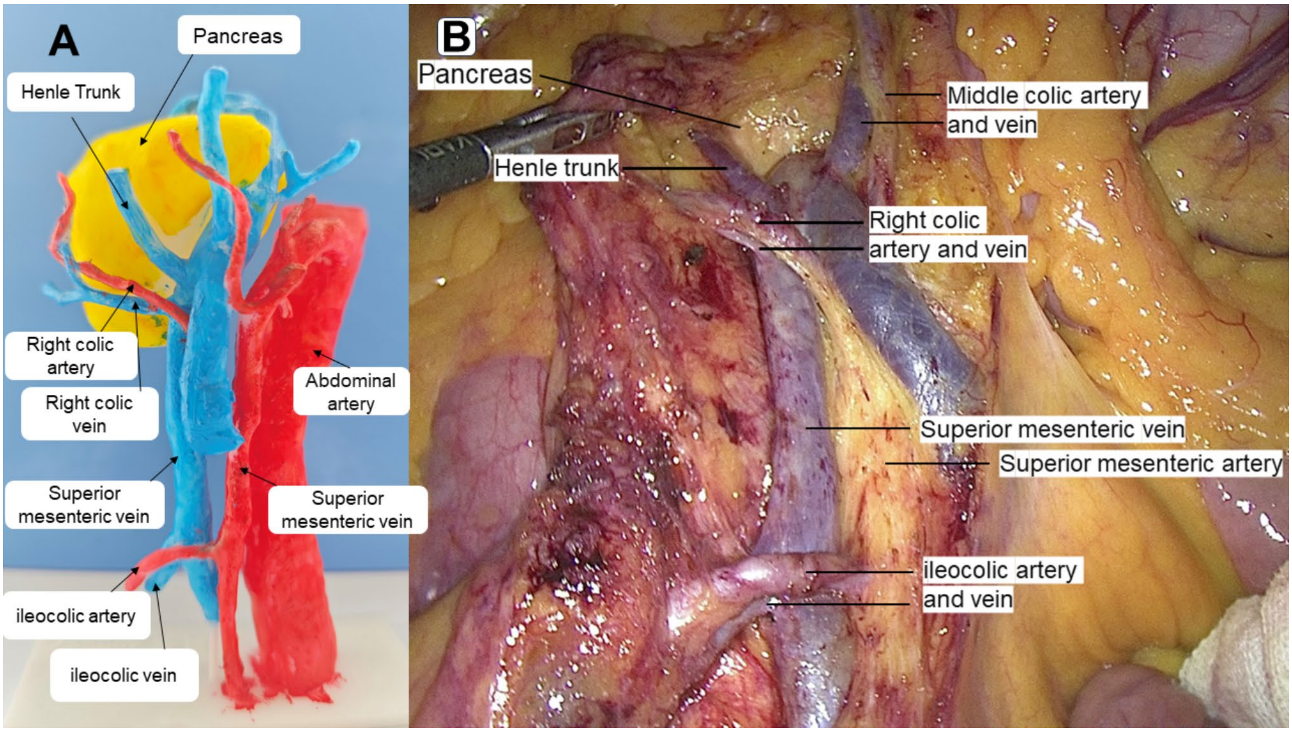

Fig. 2 Clinical application of 3D vascular model in laparoscopic right hemicolectomy. The 3D printing model (**A**) and the patient's actual intraoperative anatomy (**B**)

Table 1 Clinical characteristics and 3D reconstruction images of 11 patients with right-sided colon cancer

Patient	Gender	Old	Height(cm)	Weight(kg)	3D reconstruction linkage
1	Female	68	150	49	https://stl.xingyuanguoji3d.com/model/20240910X02.html
2	Female	62	160	65	https://stl.xingyuanguoji3d.com/model/240628YG2.html
3	Male	58	167	59	https://stl.xingyuanguoji3d.com/model/240512Y03.html
4	Male	81	170	48	http://twoc.e3d-med.com/scene/?sceneID=2a161b4b-496e-4f52-8d01-86f976cfc90a%26;u=1234567890
5	Female	70	158	57	https://stl.xingyuanguoji3d.com/model/240724Y01.html
6	Male	45	165	63	https://stl.xingyuanguoji3d.com/model/240508Y02.html
7	Male	74	172	86	https://stl.xingyuanguoji3d.com/model/240910YG1.html
8	Male	42	182	62	http://twoc.e3d-med.com/scene/?sceneID=fe21dcc0-768e-4ee9-93e6-8f8fafa2a272%26;u=1234567890
9	Male	72	172	63	https://stl.xingyuanguoji3d.com/model/240512Y04.html
10	Female	55	162	74	http://twoc.e3d-med.com/scene/?sceneID=0d08483d-16c1-4173-acae-683105d07d67%26;u=1234567890
11	Female	81	160	55	https://stl.xingyuanguoji3d.com/model/240910X01.html

The 11 patients who were diagnosed with right-side colon cancer and related 3D reconstruction images (linkage) were included in this study (Table 1). Among these patients, six (54.5%) were male and five (45.5%) were female with a mean age of 61.4 (range: 35–81) years. All patients had ICA and ICV (100%); a total of 10 patients had RCA (91.0%), just one patient was missing the RCA (9.0%), one patient had an accessory right colic artery. Among them, the right colic artery arose independently from the superior mesenteric artery in 5 patients (45.5%), shared a common trunk with the ileocolic artery in 3 patients (27.3%), and shared a common trunk with the middle colic artery in 2 patients (18.2%). A total of 4 patients had the RCV draining directly into the superior mesenteric vein (36.4%), while in 7 patients, the RCV was either absent or drained into the Henle trunk (63.6%). Of the 11 patients, 6 exhibited a gastro-pancreato-colic trunk (54.5%), 4 had a gastro-colic trunk (36.4%), and 1 had a gastro-pancreatic trunk (9.0%). No patients were found to have a pancreatic-colic trunk (Table 2). Among them, the most common composition of the Henle trunk was RGeV, SRCV and ASPDV (45.5%).

Table 2 The types and composition of the Henle trunk in all 11 patients

Patients	Types	Composition
1	Gastro-pancreato-colic trunk	RGeV + RCV + SRCV + ASPDV
2	Gastro-pancreatic trunk	RGeV + ASPDV
3	Gastro-colic trunk	RGeV + SRCV
4	Gastro-pancreato-colic trunk	RGeV + SRCV + ASPDV
5	Gastro-pancreato-colic trunk	RGeV + SRCV + ASPDV
6	Gastro-colic trunk	MRV + RGeV + SRCV + RCV
7	Gastro-pancreato-colic trunk	RGeV + SRCV + ASPDV
8	Gastro-pancreato-colic trunk	RGeV + SRCV + ASPDV
9	Gastro-colic trunk	RGeV + SRCV
10	Gastro-pancreato-colic trunk	RGeV + SRCV + ASPDV
11	Gastro-colic trunk	RGeV + SRCV + RCV

RGeV: right gastroepiploic vein; RCV: right colic vein; SRCV: superior right colic vein; ASPDV: superior pancreaticoduodenal vein; AIPDV: anterior inferior pancreaticoduodenal vein; MCV: middle colic vein

Surgical navigation

During the surgery, guided by the vascular anatomy and adjacent relationships depicted in the 3D reconstruction and printing models, we meticulously handled the critical vessels and successfully completed the operation (Supplement file, Video). Postoperatively confirmed, the 3D printing model perfectly matched the patient's actual anatomy (Fig. 2A and B). Based on our preliminary research and clinical experience, 3D-printed models play a highly effective navigational role, particularly in locating and differentiating the positions of the ICA and ICV, independently arising RCA and RCV, the SRCV, and the Henle trunk. Additionally, for patients with tumors located in the ascending colon and ileocecal region, it is not necessary to transect the RGeV during surgery. The anatomical position and composition of the Henle trunk provide important navigation for lymph node dissection at the root of the Henle trunk. In contrast, for patients with tumors in the hepatic flexure or near the transverse colon, it is necessary to expose the Henle trunk branches and transection of the RGeV, SRCV, and RCV, and retain the ASPDV. Preoperative identification of the Henle trunk's anatomy, along with precise intraoperative investigation, plays a significant role in ensuring the success of the procedure (Fig. 3A and B). Specially, traction and manipulation of the patient's omentum and mesentery by the surgeon and assistant may result in changes in the position of the RGeV, SRCV between the 3D reconstructed and printed model and their actual position during surgery.

Intraoperative and postoperative characteristics

In this pilot study, a total of 47 eligible patients were selected and divided into two groups according to receive the assistance of 3D reconstruction and printing or not (Table 3). The control group ($n = 36$) underwent surgery without the use of a 3D printing model for preoperative rehearsal and intraoperative navigation, while the observation group ($n = 11$) underwent surgery following the construction of a 3D printing model. The two groups had similar baseline characteristics, including gender ($P = 0.508$), age ($P = 0.513$), tumor location ($P = 1.000$), tumor invasion depth (T stage) ($P = 0.740$), lymph node metastasis (N stage) ($P = 0.739$), clinical stage ($P = 0.736$), tumor differentiation ($P = 1.000$), lymph vessel invasion ($P = 0.732$), nerve invasion ($P > 0.725$). Operating time (198.6 ± 8.8 min in 3D printing group vs. 230.7 ± 47.5 min in control group, $P = 0.035$) were significantly lower in the 3D printing group than in control group. However, there were no significant differences between the two groups in the intraoperative blood loss ($P = 0.179$), duration of hospitalization ($P = 0.424$), occurrence of postoperative complications ($P = 0.312$). We speculate that the lack of

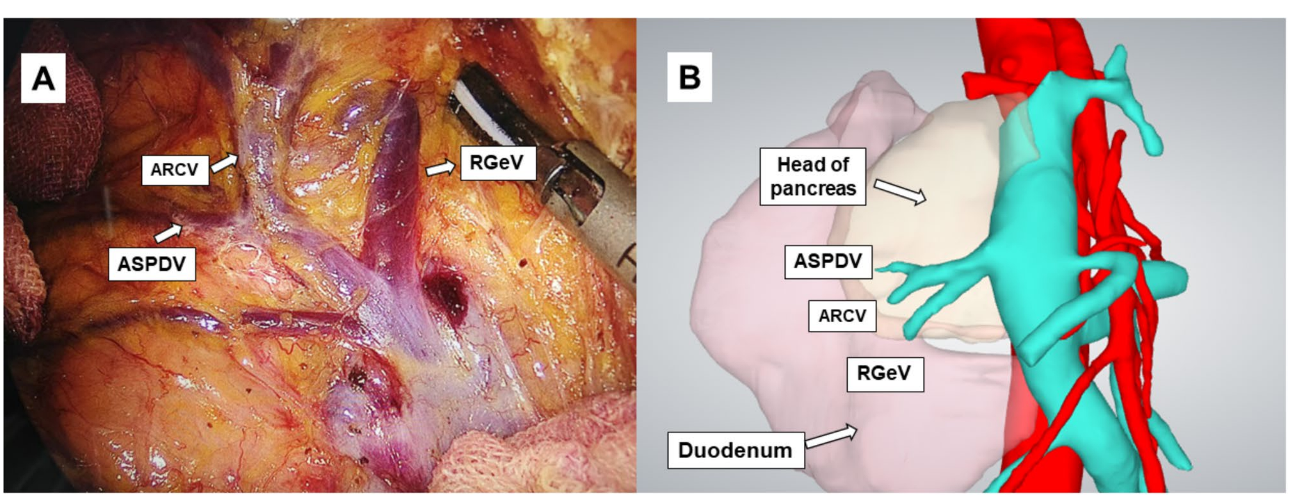

Fig. 3 Comparison of the 3D reconstruction with the intraoperative photograph of the Henle trunk. (**A**) 3D reconstruction image. (**B**) The patient's actual intraoperative anatomy of Henle trunk. RGeV: right gastroepiploic vein; SRCV: superior right colic vein; ASPDV: superior pancreaticoduodenal vein

Table 3 Intraoperative and postoperative characteristics of right-side colon cancer patients

Characteristic	3D printing group (*n* = 11)	Control group (*n* = 36)	t	*P* value
Age (years)				
Mean (SD)	64.4 ± 12.6	65.6 ± 11.9	0.636	0.513
Median (IQR)	68.0 (56.5, 73.0)	67.0 (58.0, 74.3)		0.867
Gender				0.508
Male	6	19		
Female	5	27		
Tumor Location				1.000
Ascending and ileocecal	7	21		
Hepatic flexure and near the transverse	4	15		
T				0.740
T1/T2/T3	5	19		
T4	6	17		
N				0.736
N0	4	16		
N+	7	20		
AJCC stage				0.736
I-II	4	16		
III	7	20		
Lymph vessel invasion				0.732
Yes	5	20		
No	6	16		
Nerve invasion				0.725
Yes	3	13		
No	8	23		
Tumor differentiation				
Poorly	3	12		1.000
Moderately/Well	8	24		
Operating time (min)				
Mean (SD)	198.6 ± 8.8	230.7 ± 47.5	2.179	**0.035**
Median (IQR)	200.0 (192.5, 205.0)	220.0 (200.0, 250.0)		**0.025**
Intraoperative blood loss (ml)	30.0 ± 11.3	46.9 ± 39.8	1.366	0.179
Intestinal obstruction				1.000
Yes	0	2		
No	11	34		
Anastomotic leakage				1.000
Yes	0	0		
No	11	36		
Wound infection				1.000
Yes	0	2		
No	11	34		
Conversion to open surgery				1.000
Yes	0	2		
No	11	34		
Postoperative complications				0.312
Yes	0	6		
No	11	30		
Duration of hospitalization (days)	14.2 ± 1.9	15.5 ± 5.2	0.807	0.424

SD: Standard Deviation; IQR: Interquartile Range statistical significance may be due to the small sample size in the 3D printing group.

Discussion

Surgical treatment continues to be the most essential and primary approach for right-side colon cancer [13]. To reduce surgical trauma and expedite patient recovery, the concept of minimally invasive surgery is increasingly being adopted in clinical practice [14]. During minimally invasive operation, inadequate visualization of the surgical field, excessive traction for tissues, loss of tactile feedback might result in intraoperative bleeding and even surgical failure, particularly for less experienced surgeons. Additionally, anatomical variations, especially vascular anomalies, present challenges for surgeons. As for carcinoma located at right-side colon, right hemicolectomies need to dissect, cut or expose the ICA, ICV, RCA, RCV, MCA, MCV, GTH and completed mesentery for D3 lymphadenectomy. However, anatomical variations in the vessels are frequently encountered during laparoscopic right hemicolectomy [8]. According to a previous study, both ICA and MCA were regularly identified (100%), with right colic artery only present in 40% of patients [15]. The ICV drains the right colonic vein into the SMV normally (100%). Compared to the ICV, MCV predominantly drains into the SMV, with a small portion (approximately 5%) draining into the GTH [15]. Some researches found that GTH have different classifications [8, 15, 16]. Its most common configuration is the union of the right gastroepiploic vein (RGEV), the anterior superior pancreaticoduodenal vein (ASPDV) and the superior right colic vein (SRCV) (40-50%). Secondly, its configuration can be the union of the right gastroepiploic vein, the anterior superior pancreaticoduodenal vein and RCV, or right gastroepiploic vein, the anterior superior pancreaticoduodenal vein, RCV and the superior right colic vein [17, 18]. In summary, the complex and varied vascular anomalies increase the difficulty of the surgery, bringing challenges to the surgeon.

In this pilot research, we utilized 3D printing technology for the the treatment of right-side colon cancer. With the aid of 3D printed models, we were able to identify critical blood vessels preoperatively and plan the surgical approach. During the operation, the model guided us in successfully finding and locating all necessary vessels, ensuring a smooth and efficient procedure. Additionally, based on the tumor location, types and composition of the Henle trunk, we developed a surgical plan. If the tumor is located in the ileocecal region or ascending colon, during the procedure, we perform D3 lymphadenectomy by dissecting the lymph nodes at the root of the Henle trunk with the assistance of 3D reconstruction and printing models. We also ligate the SRCV and RCV while preserving the ASPDV and RGeV. On the other hand, if the tumor is located in the hepatic flexure or near the transverse colon, we perform lymph node dissection at the Henle trunk, ligating and cutting the SRCV, RCV, and RGeV while preserving the ASPDV with the assistance of 3D reconstruction and printing model. Based on our preliminary research, we found that preoperative 3D reconstruction and 3D printing of right hemicolon vascular models can effectively reduce surgery time (198.6 ± 8.8 min in 3D printing group vs. 230.7 ± 47.5 min in control group, $P < 0.05$) and decrease the complexity of the procedure.

Laparoscopic extended right hemicolectomy for colon cancer with D3 lymphadenectomy requires ligation of the RGeV, SRCV and RCV at their confluence with the Henle trunk, while preserving the ASPDV (or and AIPDV). D3 lymphadenectomy is one of the main challenges of the surgery, particularly due to the complexity of laparoscopic dissection, which includes separating the Henle trunk and its branches, as well as the anterior region of the pancreas head's vascular structures, including the RGeV. ASPDV is a major source of intraoperative bleeding. This occurs because surgeons might not recognize that the ASPDV is a branch of the Henle trunk. Excessive traction during dissection of the RGeV can lead to bleeding from the ASPDV, which runs forward and upward from the pancreas head into the Henle trunk. The Henle trunk is wide and short, with limited resistance to traction and is closely related to the pancreas. During laparoscopic surgery, bleeding control in this area may lead to SMV rupture, often resulting in conversion to open surgery and potentially life-threatening complications. Preoperative identification of the Henle trunk type and ASPDV location, combined with intraoperative navigation from 3D printed models, significantly aids in the smooth execution of the procedure.

In the vast realm of surgical research, the application of 3D printing in right hemicolectomy remains a relatively paucity - stricken domain. To date, only a handful of studies have explored this area, each contributing valuable insights [19–22]. A prospective clinical controlled study showed that compared to the control group, the 3D–printing group had significantly reduced surgery duration and bleeding volume [19]. A small - sample study ($n = 5$) used a flexible 3D - printing material to create 3D models of the SMA/SMV for aiding laparoscopic right hemicolectomy. It was found that mobilizing the transverse colon could change the spatial arrangement of the branches of the SMA and SMV. Another study focused on the spatial structure of blood vessels and the distances between 3D - printed models and real anatomy situations [21]. It was discovered that there was an acceptable inter - arterial correlation between the 3D - printed models and the mesenteric vessels in real tissue anatomy. There was also a study that uses 3D printing technology to help identify the bifurcation sites of the MCA, thus assisting in laparoscopic surgeries for splenic flexure colon cancer [22]. Overall, 3D - printing technology was beneficial for surgeons. Even so, there are still certain differences between this study and previous research. Our 3D - printed model is more concise. We removed multiple confounding blood vessels and only retained some surgery related and landmark blood vessels and organs. This unique approach not only simplifies the model - making process but also provides a more targeted and efficient tool for surgeons, further highlighting the potential of 3D - printing technology in surgical applications [23, 24].

Currently, 3D printing is widely used in medicine, including the customization of specialized surgical tools, preoperative simulation and planning, medical education, personalized prosthetics and implants, and the production of personalized medications, among other applications [25, 26]. In this research, the individualized 3D printing models display the patient's vascular anatomy and anomalies preoperatively, reducing surgical complexity and increasing safety, and showed the therapeutic potential of such technology in the future. However, through our clinical practice, there are still limitations that need to be addressed. Firstly, the reconstruction of 3D printed models for laparoscopic right hemicolectomy requires close collaboration between specialized radiologists, surgeons, and 3D reconstruction technicians. During the 3D reconstruction process, we need to select multiple specific arteries and veins (ICV, ICA, RCV, RCA, MCV, MCA, SMV, SMA, ASPDV, RGeV, SRCV, AIPDV), especially the Henle trunk. While selecting arteries using enhanced CT is relatively straightforward, the selection of veins and small veins (MCV, ASPDV, RGEV, SRCV) often requires careful image reading and extensive clinical experience. In the process of selecting specific vessels, some unrelated vessels, which is not associated with operation need to be excluded, such as the ileal vascular arcades, right renal arteries and veins, and branches of the pancreatic arteries and veins. Secondly, excessive and overly complex 3D printed models not only increase printing time and compromise model stability but also reduce the model's navigational effectiveness. Thirdly, in this case, the 3D printed models omitted some anatomical landmarks (such as the ureter), and including these landmarks could further reduce surgical difficulty and enhance safety. Fourth, this study is a preliminary single-center study with a small sample size, and further validation with multicenter and larger sample studies is needed. Fifth, this study did not include follow-up on patient outcomes, so it is unable to assess the impact of 3D-printed models on long-term prognosis. We plan to further optimize the 3D printed models for laparoscopic right hemicolectomy and conduct clinical controlled studies in our subsequent research.

Conclusion

This study used patient-specific 3D printed models for surgical planning and intraoperative navigation for laparoscopic right hemicolectomy. Our research highlights the potential clinical applications of 3D printing models in laparoscopic right hemicolectomy. Preoperative identification of possible vascular anomalies and intraoperative navigation can feasibly reduce surgical difficulty and increase surgical safety.

Abbreviations

CRC	Colorectal cancer
3D	3-dimensional
ICA	Ileocolic artery
ICV	Ileocolic vein
RCA	Right colic artery
RCV	Right colic vein
MCA	Middle colic artery
MCV	Middle colic vein
SMA	Superior mesenteric artery
SMV	Superior mesenteric vein
GTH	Gastrocolic trunk of Henle
ASPDV	Anterior superior pancreaticoduodenal vein
AIPDV	Anterior inferior pancreaticoduodenal vein
RGeV	Right gastroepiploic vein
SRCV	Superior right colic vein
aMCV	Accessory middle colic vein
aSRCV	Accessory superior right colic vein
RTCV	Right transverse colic vein

Supplementary Information

The online version contains supplementary material available at https://doi.org/10.1186/s41205-025-00258-x.

Supplementary Material 1: Operation video: The laparoscopic right hemicolectomy vascular model assists the surgeon in intraoperative vessel identification and dissection

Acknowledgements

None.

Author contributions

Z.H. and F.W. assisted with manuscript writing and submission. Z.Z. and R.Y. were major contributors in writing the manuscriptand 3D printing. Y.Y. and Z.H. were the chief surgeons of the operation. S.Z. prepared Figs. 1, 2 and 3. All authors read and approved the final manuscript.

Funding

This article was supported by Health Commission of Fuyang City, Anhui, China (NO. FY2023-45 to Zongju Hu) and Bengbu Medical College of Bengbu City, Anhui, China (NO. 2023byzd215).

Data availability

No datasets were generated or analysed during the current study.

Declarations

Ethics approval and consent to participate

This study was approved by the Ethics Committee of Fuyang City People's Hospital.

Consent for publication

Consent for publication was given in writing by the patient's relatives.

Competing interests

The authors declare no competing interests.

Received: 10 July 2024 / Accepted: 13 February 2025
Published online: 28 February 2025

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