

Leiomyosarcoma of the colon: A challenging diagnosis in a young woman - A case report

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Abstract:

Leiomyosarcoma (LMS) of the colon is an extremely rare colorectal malignancy, accounting for less than 0.1% of all colorectal cancers. The clinical symptoms of colonic LMS are often vague and nonspecific, including abdominal pain, changes in bowel habits, rectal bleeding, or an abdominal mass, which makes early diagnosis difficult. The majority of cases occur in middle-aged adults, with a slight male predominance. We report a rare case of colonic LMS in a young woman, whose clinical symptoms closely resembled those of a ruptured bleeding ovarian cyst or ectopic pregnancy, leading to an initial misdiagnosis. The definitive diagnosis was made through laparoscopic surgery and histopathological biopsy. Histopathological examination using Haematoxylin and eosin (H&E) staining and immunohistochemistry (IHC) confirmed colonic LMS. Metastatic involvement was identified in 7 out of 11 regional lymph nodes. Our report highlights a very rare case of LMS involving the cecal base, underscoring the diagnostic challenge in young female patients and emphasising the importance of surgical exploration and pathological confirmation in atypical pelvic presentations.

Keywords: bleeding ovarian cyst, colon cancer, leiomyosarcoma.

Classification numbers: 3.2, 3.6

1. Introduction

Leiomyosarcoma of the colon is a rare and aggressive malignant tumour arising from the smooth muscle cells of the muscularis propria. Unlike adenocarcinomas, which are the most common colorectal malignancies, LMS belongs to the group of soft tissue sarcomas and accounts for only a small percentage of colorectal cancers [1]. The clinical characteristics of smooth muscle tumours depend on their size, location, and associated bleeding complications. Symptoms are often non-specific and may include abdominal pain, changes in bowel habits, rectal bleeding, weight loss, or the presence of an abdominal mass. In some cases, the tumour may cause obstruction or perforation, leading to acute complications [2-5]. The majority of cases occur in adults between the ages of 36 and 89 years [3]. Imaging studies such as CT scan and MRI help identify the tumour's location, size, and extent of tumour invasion. Colonic leiomyomas originate from the muscle layer of the colon and are characterised by spindle cells with eosinophilic cytoplasm. The result

of IHC staining of leiomyoma is typically positive for desmin and smooth muscle actin. Biopsy and IHC staining (e.g., positive for smooth muscle markers such as desmin and actin) confirm the diagnosis [6, 7]. Surgical resection with negative margins remains the primary treatment approach. Unlike adenocarcinomas, LMS is less responsive to chemotherapy and radiotherapy, though these may be considered in advanced cases. Prognosis is generally poor due to the aggressive nature of the tumour and its tendency to recur and metastasise, particularly to the liver and lungs [8].

2. Case presentation

A 21-year-old woman with no significant medical history presented with severe right pelvic pain and mild blood loss. No significant findings were noted in her family history. On abdominal examination, there was marked tenderness over the right iliac fossa and a positive guarding response. Ultrasonography revealed a large amount of blood in the abdomen and a mixed-echo mass (~3 cm) near the right ovary (Fig. 1).

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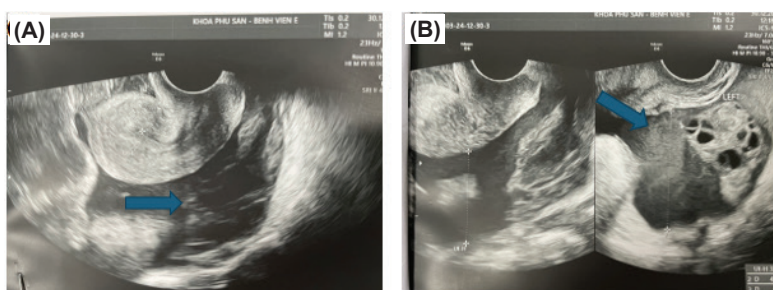


Fig. 1. Ultrasonography showing (A) a large amount of blood in the abdominal cavity and (B) a solid structure in the right pelvis (indicated by the arrows).

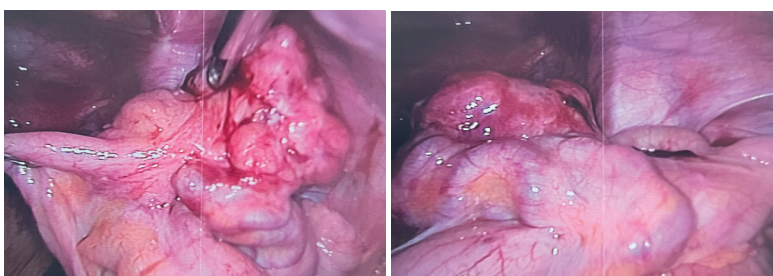


Fig. 2. Image of bleeding tumour at the cecal base.

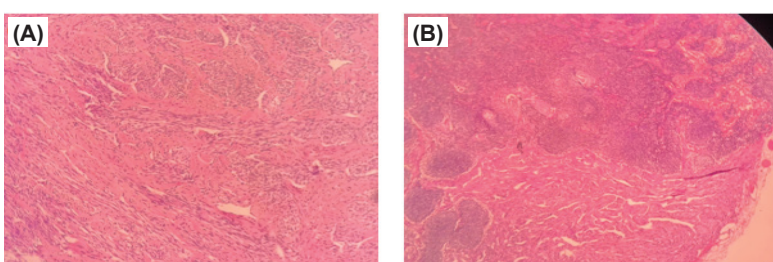


Fig. 3. Histological images showing (A) numerous spindle cells of the tumour and (B) the spindle cells metastasising to lymph nodes (Haematoxylin and Eosin staining; 10^x).

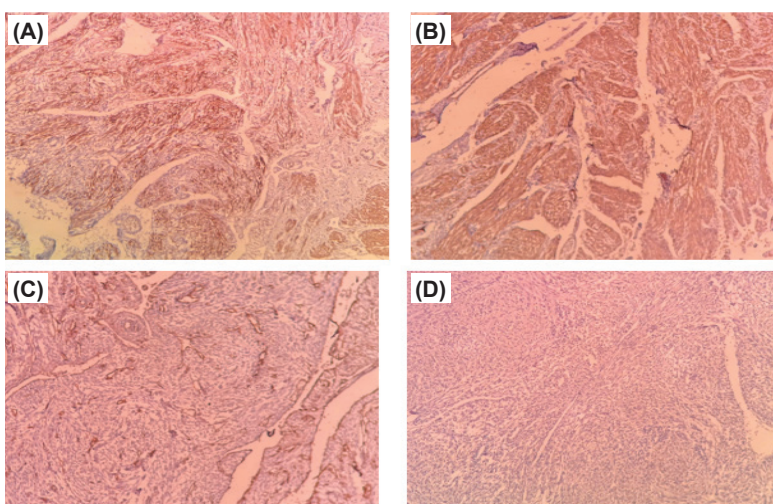


Fig. 4. Immunohistochemistry showing spindle cells positive for Desmin (A) and SMA (B), and spindle cells negative for CD34 (C), CD117 (D) (Immunohistochemistry staining; 10^x).

Blood test results were as follows: RBC 3.33 T/L, Hb 102 g/l, Hct 0.296 l/l, and β -hCG <2 mIU/ml. The patient underwent emergency surgery with a preliminary diagnosis of intra-abdominal bleeding due to a ruptured ovarian follicular cyst. During laparoscopy, a large volume of fresh blood was found in the abdominal cavity, and both ovaries appeared normal. An actively bleeding tumour was detected at the cecal base, extending into the pelvis near the right ovary (Fig. 2). Immediate frozen section histopathology revealed that the tumour tissue consisted of spindle cells, with an increased nuclear-to-cytoplasmic ratio and rare mitoses. During surgery, a friable, scabrous tumour mass accompanied by multiple enlarged mesenteric lymph nodes was identified. Given the intraoperative suspicion of malignant LMS, wide excision and lymph node dissection were performed to evaluate the presence of nodal metastases. An immediate biopsy confirmed a leiomyoma, excluding gastrointestinal stromal tumours (GIST). The surgical procedure involved the complete resection of the ascending colon, caecum (which contained the tumour), appendix, and a segment of the ileum, along with mesenteric lymph node dissection. Metastasis was identified in 7 of the 11 lymph nodes (Fig. 3). An anastomosis between the ileum and transverse colon was then performed. The initial procedure was performed laparoscopically; however, upon intraoperative identification of a suspected malignant LMS, the operation was converted to an open approach for wide excision and lymph node dissection.

Histopathological examination (H&E) and IHC staining confirmed the diagnosis of colonic LMS (Desmin and SMA positive; CD34, CD117, and DOG1 negative) (Figs. 3 and 4). The sample also tested negative for CD117, DOG1, and CD34, further confirming its smooth muscle origin and consistency with colonic LMS. Post-operatively, the patient was clinically monitored without additional specific treatment and was subsequently referred to the Oncology Department for further management and follow-up.

3. Discussion

Colonic LMS are rare malignant tumours, accounting for approximately 0.1% of all malignant tumours of the colon [2]. The clinical manifestations of colonic LMS are non-specific and are often discovered incidentally during colonoscopy. Some tumours appear polypoid, while others develop within the colonic wall

and may protrude into the lumen as submucosal masses. Symptoms depend on the tumour's size and location. Tumours larger than 2 cm that protrude into the colon may cause symptoms of subacute intestinal obstruction, such as abdominal pain, bloating, constipation, and bleeding [8, 9].

In young women, rectosigmoid LMS may present with non-specific clinical manifestations such as acute abdominal pain, pelvic fullness, or haemoperitoneum, which can closely resemble gynaecological emergencies. This overlap frequently directs initial diagnostic consideration toward reproductive tract pathology. Among the most relevant differentials are ectopic pregnancy, ruptured ovarian cyst, ovarian neoplasms, tubo-ovarian abscess, and uterine fibroids with degeneration or sarcomatous transformation. Ectopic pregnancy is often the foremost consideration in reproductive-aged women presenting with acute abdominal pain and haemoperitoneum, particularly when accompanied by vaginal bleeding and adnexal tenderness. A positive serum β -hCG and ultrasonographic evidence of an adnexal gestational sac are key distinguishing features. Similarly, ruptured ovarian cysts, particularly haemorrhagic or functional types, may cause sudden pelvic pain and intra-abdominal bleeding, but are usually characterised by a collapsed cyst on ultrasonography and a negative β -hCG. Ovarian neoplasms, whether benign or malignant, can also mimic gastrointestinal tumours through mass effect, abdominal distension, or torsion, yet they typically demonstrate adnexal rather than bowel wall origin on imaging and may be associated with tumour marker abnormalities. Tubo-ovarian abscesses represent another important differential, especially in patients with fever, leucocytosis, or a history of pelvic infection, and they usually respond to antibiotic therapy. Finally, uterine fibroids - particularly when undergoing degeneration or sarcomatous transformation - may present as pelvic masses with pain and abnormal bleeding, but their uterine wall origin is typically demonstrable on MRI [10, 11]. In our case, the LMS of the cecal base initially mimicked an ectopic pregnancy or ruptured ovarian cyst due to the acute pelvic pain, haemoperitoneum, and mass effect. Only through endoscopic surgery and subsequent histopathological evaluation was the correct diagnosis established. This highlights the importance of considering gastrointestinal mesenchymal tumours in the differential diagnosis of young women presenting with acute pelvic symptoms, particularly when initial gynaecological evaluations are inconclusive.

In laparoscopic imaging, colonic leiomyomas may resemble mucosal adenomas, making diagnosis challenging. H.H. Choi, et al. (2016) [8] reported that only 46% of colonic leiomyomas are correctly identified

based on endoscopic appearance. For this type of lesion, en bloc resection and histopathological examination are required to confirm the diagnosis. Leiomyomas of the colon wall can be visualised via laparoscopy when they develop into the colorectal lumen. Some grow externally in the colonic lumen and, as in this case, are only visible on ultrasonography and CT scan. Unfortunately, our patient did not undergo a CT scan because she was misdiagnosed with a ruptured ovarian follicular cyst and taken for emergency surgery. Colonic leiomyomas at the cecal base can cause symptoms similar to gynaecological tumours, such as rectal bleeding and lower abdominal pain. The limited literature on the clinical characteristics of colonic LMS makes diagnosis challenging. Due to its malignant nature and high recurrence rate, it is essential to distinguish it from GIST, the most common mesenchymal neoplasms of the gastrointestinal tract. IHC staining results showed positivity for smooth muscle markers actin and desmin, but negativity for CD34 and CD117 proteins. These findings supported the diagnosis of colonic LMS. By contrast, GISTs are typically positive for CD117 (C-Kit), CD34, and/or DOG-1 [2, 12, 13]. These features help distinguish leiomyomas from GISTs, which may appear similar under a microscope.

Intraoperative exploration, particularly via endoscopic surgery, serves not only as a therapeutic approach but also as a crucial diagnostic tool. Literature reports confirm that several rare intestinal pathologies - including LMS, gastrointestinal stromal tumours, and atypical inflammatory lesions - have been identified unexpectedly during surgical procedures initially undertaken for suspected gynecologic conditions [14]. This highlights the importance of maintaining a broad differential diagnosis when evaluating young female patients presenting with acute pelvic symptoms. Moreover, the intraoperative discovery of intestinal neoplasms underscores the limitations of imaging modalities in distinguishing between gynaecological and gastrointestinal pathologies in the pelvis. Surgical exploration, therefore, remains indispensable in cases where imaging results are equivocal or inconsistent with clinical findings. Such an approach ensures timely and accurate diagnosis, enabling appropriate surgical management and reducing the risk of misdiagnosis or delayed treatment.

Surgery is the most effective treatment for LMS, with complete resection offering the highest chance of cure. Any residual malignant cells can significantly increase the risk of local recurrence or metastasis. Therefore, an accurate diagnosis and adequate resection margins are essential. However, achieving a correct diagnosis before surgery is extremely difficult, and very few cases are confirmed through histology. Our patient underwent emergency

surgery without sufficient preoperative information, such as CT imaging, laparoscopy, or histological evaluation. Moreover, because she was a young woman, doctors initially suspected a gynaecological cause rather than LMS, which is extremely rare. Fortunately, the surgeon performing the operation, who specialised in oncology, requested an immediate biopsy and histological testing, which confirmed a leiomyoma. The surgical team then proceeded with a wide resection and mesenteric lymph node dissection. Postoperative histopathology, including H&E and IHC staining, further confirmed the diagnosis of colonic LMS. Ten days after the operation, a contrast-enhanced CT scan of the chest and abdomen revealed normal organs and no free fluid. The treatment strategies and the extent of resection depend on the tumour's nature, size, location, and mitotic count. G. Fujimoto, et al. (2019) [7] suggest that wide resection should be performed due to the difficulty of distinguishing benign from malignant tumours intraoperatively. Tumour size is an important prognostic factor, with tumours larger than 5 cm being suggestive of malignancy [8]. Although colonic leiomyomas generally have a good prognosis after complete resection, LMS is aggressive due to its malignant nature and high recurrence rate. For this reason, patients require close follow-up and adjuvant chemotherapy after surgery.

4. Conclusions

This rare case highlights the difficulty of diagnosing colonic LMS preoperatively, especially in young women. Most cases are identified incidentally or upon presentation with bleeding complications, often leading to misdiagnosis as a ruptured ovarian cyst or an ectopic pregnancy. Current guidelines recommend surgery as the primary treatment for colonic LMS, with intraoperative radiation and adjuvant chemotherapy following surgery or in cases of metastasis. In our case, a cecal base LMS was accurately diagnosed through an immediate intraoperative biopsy. This report emphasises the critical role of intraoperative and postoperative histopathology in diagnosing and distinguishing LMS.

CRedit author statement

Anh Vu Hong: Conceptualisation, Writing original draft; Ha Vu Thi: Writing - Reviewing and Editing; Co Ve Van, Trung Nguyen Cong, Nam Trinh Thi Hoai, Thuy Nguyen Thi: Investigation, Data curation; Trung Le Thanh: Visualisation, Methodology.

COMPETING INTERESTS

The authors declare that there is no conflict of interest regarding the publication of this article.

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Multiple renal artery reconstruction in a high-volume living donor kidney transplant centre

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Abstract:

Kidney transplantation (KT) is the most effective treatment for end-stage renal disease; however, certain challenges (e.g. multiple renal arteries) may increase technical complexity and perioperative risk. We aimed to describe a single-centre experience with reconstruction techniques and outcomes. This retrospective study included 82 patients who underwent KT with multiple renal arteries out of a total of 762 cases in the period from April 2018 to August 2022, with demographic data and renal vessel characteristics collected. The main outcomes were operation time, graft function, complications, and graft survival, and these were compared with a single-artery control group. Most patients had two arteries (82.9%). There were significant differences in warm ischemic time, reconstruction time for arterial anastomosis, and overall operation time compared with the control group ($p < 0.05$). One patient (1.2%) developed a pseudoaneurysm requiring reoperation, with no grade 4 or higher complications. Graft function remained stable, and no patients experienced graft failure. The efficacy and safety of KT in patients with multiple renal arteries were acceptable.

Keywords: kidney transplantation, multiple renal arteries, outcomes, reconstruction.

Classification numbers: 3.2, 3.6

1. Introduction

Kidney transplantation has significantly enhanced survival rates and quality of life for patients with end-stage renal disease (ESRD) [1]. The increasing demand for kidney transplants has made living donor KT (LDKT) a favourable solution, particularly prevalent in Asian countries. The advent of minimally invasive living donor nephrectomy has revolutionised this field. Recent data indicate that graft survival rates can reach 90% at five years and 70% at ten years post-transplantation [2]. Our centre has performed KT since 2000, with laparoscopic intraperitoneal nephrectomy introduced in 2016. Annually, we conduct 200-250 kidney transplants, with 90% sourced from living donors, classifying us as a high-volume centre [3]. Multiple renal arteries (RAs), present in 18-25% of donors, pose significant challenges due to the need for intricate vascular reconstruction, prolonged warm ischaemic time, and extended operative duration [4, 5]. Inadequate experience may cause thrombosis or stenosis and adversely affect long-term graft survival. Several techniques have been well described in the literature, demonstrating promising short- and long-term graft survival [6-9]. This study aims to delineate

our systematic approach to managing up to four RAs, evaluating surgical techniques and immediate post-transplant outcomes.

2. Materials and methods

2.1. Study population

This retrospective study included patients who underwent KT with multiple renal arteries from living donors at Viet Duc University Hospital between April 2018 and August 2022. The study received ethical approval from the Institutional Ethical Review Board (No. 01.2024.NCVĐ).

2.2. Study design

A retrospective cohort study was conducted, recruiting patients who underwent KT with multiple renal arteries (MRA) and comparing their outcomes with those who underwent KT with a single renal artery (control group). The study excluded deceased-donor KT, KT with venous reconstruction, and patients with severe comorbid conditions. The kidney with higher scintigraphy values was preserved for the donor. Data were compared with a control group of single renal

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artery KT cases performed between January and May 2019 by the same surgeon. All procedures were performed by a single surgeon with ten years of experience in vascular surgery. For HLA matching <3/6, basiliximab was used for induction. Maintenance immunosuppression included prednisolone, mycophenolate mofetil (MMF), and tacrolimus, with target trough levels maintained at 8-10 ng/ml. Colour Doppler ultrasound was routinely performed on postoperative days 2 and 4, and additionally if clinically indicated. If serum creatinine levels increased and ultrasound revealed abnormal findings, corticosteroid bolus therapy or biopsy was considered. Anticoagulation was not routinely applied.

2.3. Data collection, outcomes, and definitions

Baseline characteristics collected included age, gender, haemodialysis status, graft site, and history of previous KT. Technical parameters included vessel characteristics (number, length, and diameter), type of reconstruction in cases with multiple vessels (single common orifice or separate implantation), with the first vessel defined as the largest main artery and subsequent vessels numbered from top to bottom. Warm ischaemic time (from removal from cold storage to reperfusion), vessel reconstruction time, and total operation time were recorded. Complications were documented and graded using the Clavien-Dindo classification, including ureteric stricture, vascular complications (bleeding, pseudoaneurysm, thrombosis), and medical complications (acute allograft rejection, slow graft function, delayed graft function). Postoperative outcomes, including length of hospital stay, postoperative kidney function, and graft survival, were also documented.

2.4. Surgical technique

The management algorithm for multiple renal arteries is detailed in Fig. 1. During bench surgery, the perfusion zone of each artery was assessed, and the diameter and length of each vessel were measured. Side-to-side reconstruction was preferred when arterial diameters and lengths were comparable (Fig. 1). For small-diameter arteries, even after post-dilatation, the inter-arterial distance was evaluated; reconstruction was performed if the distance permitted safe anastomosis, otherwise separate anastomoses were performed. In rare instances, when the upper pole artery diameter was minimal, and its perfusion area

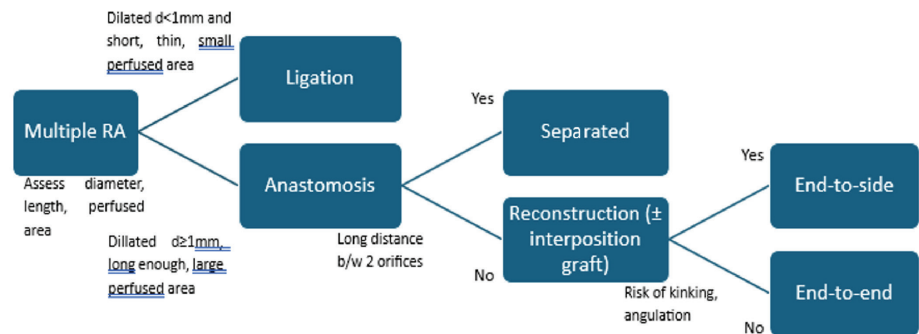


Fig. 1. Management algorithm for multiple renal arteries.

was less than 10%, ligation was undertaken (Fig. 1). Anastomoses were performed using continuous 6/0 or 7/0 Prolene sutures under 2.5× magnification surgical loupes to ensure precision.

2.5. Data analysis

The data were collected and analysed using IBM SPSS version 20.0 software. Percentages were used for categorical variables and mean±SD for continuous variables. A two-tailed p-value<0.05 was considered statistically significant. Graft survival was analysed using the Cox regression model.

3. Results

Of the 762 kidney transplantations (KTs) performed, 95 patients (12.5%) with multiple renal arteries (MRAs) underwent KT, with 82 patients providing comprehensive data for analysis. The mean follow-up duration was 58±33.9 months, with no graft loss observed. A total of 75.6% of patients were in the 18-50 age group, with a male-to-female ratio of 1.93:1. In addition, 82.9% of patients were on haemodialysis before transplantation, with no cases of retransplantation; there was no significant difference compared with the control group (Table 1).

Table 1. Baseline characteristics.

Characteristics	MRA (n=82)	Control (n=59)	p-value
Age			
- <18	1 (1.2)	1 (1.7)	0.034
- 18-50	62 (75.6)	54 (91.5)	
- ≥50	19 (23.2)	4 (6.8)	
Sex			
- Male	54 (65.9)	42 (71.2)	0.50
- Female	28 (34.1)	17 (28.8)	
Haemodialysis (%)	68 (82.9)	49 (83.1)	0.98
Retransplant (%)	0 (0)	0 (0)	-
Donor graft site			
- Right kidney	57 (69.5)	33 (55.9)	0.1
- Left kidney	25 (30.5)	26 (44.1)	

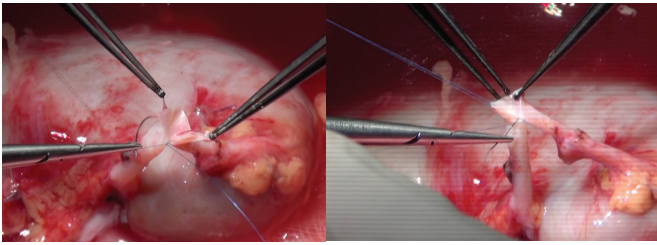


Fig. 2. Reconstruction technique in benchwork.

Regarding graft vessels, most patients (82.9%) had a single renal vein, with a smaller subset presenting two (15.9%) or more veins (1.2%). There was no significant difference in the mean lengths and diameters of the first renal vein (2.43 and 1.27 cm vs 2.17 and 1.17 cm) or the second renal vein (1.77 and 0.89 cm vs 1.5 and 1.0 cm), respectively ($p>0.05$). For cases with two arteries, a single reconstructed orifice was preferred, while for three arteries, one reconstructed and one separate orifice was more common (Fig. 2, Table 2). Two patients had four arteries, in whom reconstruction was performed using two anastomoses (Fig. 3).

Table 2. Operation characteristics, complications, and long-term graft survival.

Characteristics	MRA (n=82)	Control (n=59)	p-value
No. of renal vein			
- 1 vein	68 (82.9)	57 (96.6)	-
- 2 veins	13 (15.9)	2 (3.4)	
- >2 veins	1 (1.2)	0 (0)	
Renal vein length (mean±SD) (cm)			
- 1 st RV	2.43±0.98	2.17±0.65	0.08
- 2 nd RV	1.77±0.67	1.50±0.0	0.59
- 3 rd RV	4.0±0.0	-	-
Renal vein diameter (mean±SD) (cm)			
- 1 st RV	1.27±0.34	1.17±0.20	0.06
- 2 nd RV	0.89±0.40	1.0±0.0	0.80
- 3 rd RV	0.4±0.0	-	-
Renal artery length (mean±SD) (cm)			
- 1 st RA	3.10±0.61	3.61±0.66	<0.001
- 2 nd RA	3.10±0.79	-	-
- 3 rd RA	2.75±1.03	-	-
- 4 th RA	3.75±0.25	-	-

Characteristics	MRA (n=82)	Control (n=59)	p-value
Renal artery diameter (mean±SD) (cm)			
- 1 st RA	0.44±0.10	0.44±0.09	0.71
- 2 nd RA	0.25±0.10	-	-
- 3 rd RA	0.29±0.22	-	-
- 4 th RA	0.20±0.10	-	-
No. of renal arteries and reconstruction (%)			
- Two arteries (n=68)			-
o Common orifice	42 (61.8)		
o Separated	26 (38.2)		
- Three arteries (n=12)			-
o Common orifice	2 (16.7)		
o One common orifice, one separated	10 (83.3)		
- Four arteries in two common orifices (n=2)	2 (100)		-
Iliac atherosclerosis	1 (1.2)	0 (0)	-
Inverted KT	18 (21.95)	0 (0)	-
Warm ischemic time (mins)	42.76±10.01	30.93±7.27	<0.001
Arterial reconstruction time (mean±SD) (mins)	28.84±10.05	25.2±8.87	0.04
Total reconstruction time (mean±SD) (mins)	34.25±7.74	26.72±6.34	<0.001
Operation time (mins)	201.22±48.38	171.10±34.94	<0.001
Complications (%)			
- Slow graft function	13 (15.8)	9 (15.3)	-
- Delayed graft function	0 (0)	0 (0)	
- Acute rejection	2 (2.4)	2 (3.4)	
- Graft loss	0 (0)	0 (0)	
- Pseudoaneurysm, requiring reoperation	1 (1.2)	0 (0)	
- RA stenosis	0 (0)	0 (0)	
- Surgical site infection	1 (1.2)	0 (0)	
Clavien-Dindo classification			
- Grade 1, 2	3 (3.7)	2 (3.4)	-
- Grade 3	1 (1.2)	0 (0)	
- Grade 4, 5	0 (0)	0 (0)	
Post-op creatinine (μmol/l) (median (IQR))			
- Day 1	600 (400)	568.3 (333)	0.69
- Day 3	147.4 (115)	122.8 (81)	0.013
- Day 5	120.2 (56)	110.4 (55)	0.30
- Day 7	113 (47)	108 (51)	0.64
Hospital stays (days)	16.06±8.69	19.85±14.80	0.06
Graft survival	82 (100)	59 (100)	-

RV: renal vein; KT: kidney transplantation.

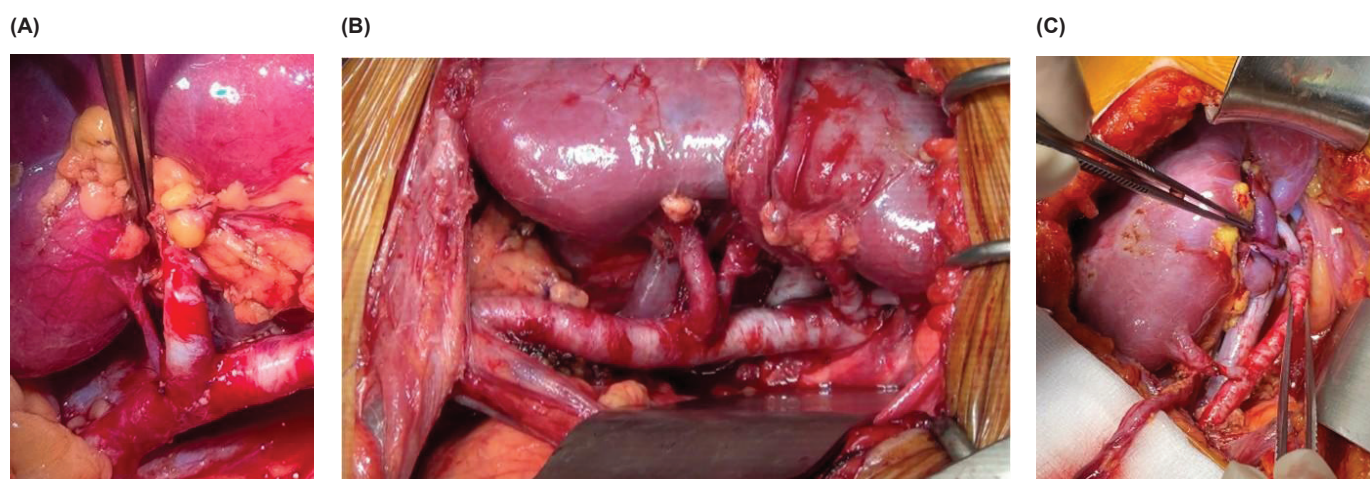


Fig. 3. Reconstruction for multiple renal arteries. (A) Two arteries, (B) Three arteries, (C) Four arteries.

The mean warm ischaemic time was 42.76 ± 10.01 minutes, and the mean operation time was 201.22 ± 48.38 minutes, ensuring graft viability, although both were significantly higher than in the control group (30.93 ± 7.27 and 171.1 ± 34.94 minutes, respectively). Reconstruction times for arterial anastomoses were also longer (28.84 ± 10.05 vs 25.2 ± 8.87 minutes, $p < 0.05$).

Complication rates were low, with no delayed graft function or graft loss reported. Acute rejection (treated with bolus corticosteroids, without biopsy confirmation) occurred in 2.4% of cases, while pseudoaneurysm requiring reoperation and surgical site infection were each observed in 1.2% of patients. A total of 3.7% of patients experienced Grade I-II complications, with no severe complications documented. Postoperative serum creatinine levels showed a significant decrease over the first week, although improvement was slower on day 3 compared with the single-artery group, and remained stable thereafter. There was no difference in postoperative creatinine levels between the separate and common orifice groups (Table 3). The average postoperative hospital stay was 16.06 ± 8.69 days. No graft failure occurred during outpatient follow-up.

Table 3. Renal function classified by reconstruction techniques.

Post-op creatinine ($\mu\text{mol/l}$) (median (IQR))	Two arteries (n=68)		Three arteries (n=12)		Four arteries (n=2)
	Common	Separated	Common	Common + Separated	
Day 1	630.8 (509)	600 (266)	843.5	463.1 (735)	281.9
Day 3	156.4 (118)	138.3 (85)	553.5	136 (266)	140.7
Day 5	125.8 (50)	119.3 (48)	411.5	114.4 (107)	83.8
Day 7	120 (53)	110.5 (35)	231.5	107.9 (77)	83.9

* $p > 0.05$.

4. Discussion

Historically, MRAs were considered a relative contraindication for KT due to technical complexities. Recent studies have elucidated strategies to address these challenges, demonstrating favourable outcomes. We provide insight into the efficacy of these surgical techniques and their implications for graft survival. The observed graft survival rates suggest that, with meticulous surgical planning, the presence of multiple arteries does not compromise short- or long-term success. However, the risk of vascular complications highlights the need for ongoing advancements in surgical techniques and postoperative care protocols. These findings emphasise the importance of individualised patient assessment and tailored surgical approaches to optimise outcomes. The exact benchwork time was not fully collected; however, in the case involving four arteries, the time reached 45 minutes. We favour bench reconstruction over separate anastomoses when vessel anatomy permits. However, there are no data demonstrating the superiority of one technique over another [10, 11]. In cases of significant vessel calibre disparity, separate anastomoses were preferred, aligning with practices reported by other centres. The complication rate was slightly lower compared with other studies, and our data also showed comparable outcomes relative to conventional KT. Owing to the renal blood supply, ligation of an artery may cause ischaemia in the corresponding region. Therefore, this was performed only when the artery was very small (< 1 mm), of insufficient length for reconstruction, and supplied less than 10% of the renal parenchyma [12].

Because of the segmental nature of the renal blood supply, ligation of small accessory arteries may risk segmental ischaemia in the corresponding renal parenchyma. There is concern that ligation of an inferior artery could cause infarction or urinary leakage due to inadequate ureteral blood supply; however, this has rarely been reported in the literature [13]. Comprehensive preoperative imaging and preservation of peri-ureteric tissue are critical to minimising risks such as urinary leakage [14]. Although no arteries required ligation in our study, this approach was considered only when the artery was too small (<1 mm) after dilatation, had insufficient length for reconstruction, and the affected area was minimal. Doppler ultrasound and serial postoperative creatinine monitoring were employed to assess graft perfusion, despite our hospital stay (16.06 ± 8.69 days) exceeding global benchmarks due to extended rehabilitation and follow-up protocols.

In our study, no cases of transplant renal artery stenosis (TRAS) were observed, whereas D. Choudhary, et al. (2024) [9] reported an overall TRAS incidence of 1.14% in cases where *ex vivo* vascular reconstruction was performed. Vascular complications were minimal in our cohort (1.2% pseudoaneurysm, no thrombosis), lower than the 5.6% partial arterial thrombosis reported in end-to-side reconstructions [15]. Mechanisms contributing to higher risks in prior studies include intimal hyperplasia in reconstructed vessels, as well as thrombus propagation leading to chronic ischemia and fibrosis in end-to-side approaches [9].

There may be concern that prolonged operation time and warm ischaemic time could adversely affect outcomes; however, advances in vascular techniques have largely mitigated these effects, resulting in comparable outcomes. A meta-analysis of MRA KT revealed that, although MRA grafts are associated with higher complication rates and delayed graft function compared with single renal artery (SRA) grafts, long-term graft and patient survival are comparable. Specifically, MRA grafts demonstrated a 13.8% complication rate, compared with 11% for SRA grafts, and a delayed graft function rate of 10.3%, compared with 8.2% in the single-artery group. Despite these challenges, 5-year graft survival rates were similar, underscoring the importance of advanced surgical techniques and individualised patient care in achieving successful outcomes [8, 16]. Nevertheless, MRA grafts

should not be routinely preferred owing to longer nephrectomy, benchwork, and surgical times.

Our study proposes a management algorithm for KT involving multiple renal arteries. Although many studies have been published, most focus on individual techniques rather than a comprehensive algorithm for these scenarios [7, 17-19]. These findings support the broader adoption of MRA grafts in clinical practice, potentially improving the quality of life for patients with end-stage renal disease. Limitations of this study include its retrospective design, which may introduce bias, and the modest sample size ($n=82$), limiting generalisability. Future prospective studies with larger cohorts and randomised controlled trials are warranted to validate these findings and further elucidate factors influencing outcomes in MRA transplantation.

5. Conclusions

Multiple renal artery grafts, when managed with meticulous bench reconstruction by experienced surgeons in specialised centres, can provide acceptable short-term outcomes. The efficacy and safety of KT in patients with multiple renal arteries were satisfactory. Although the procedure can be successfully performed, it should be undertaken in specialised centres. Long-term outcomes, particularly regarding the incidence of TRAS and rejection, require ongoing surveillance and reporting.

CRedit author statement

Khai Ninh Viet: Conceptualisation, Study design, Writing - Original draft preparation, Follow-up; Dang Do Hai: Data collection, Writing - Original draft preparation, Follow-up; Tuan Hoang: Surgical assistance, Data collection, Formal analysis, Writing - Reviewing and Editing; Trung Nguyen Duc: Formal analysis, Writing - Reviewing and Editing; Hung Duong Duc: Surgical procedure, Conceptualisation, Methodology, Writing - Reviewing and Editing.

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COMPETING INTERESTS

The authors declare that there is no conflict of interest regarding the publication of this article.

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