Journal of Neonatal Surgery
ISSN(Online): 2226-0439
Vol. 14, Issue 21s (2025)
https://www.jneonatalsurg.com

OPEN ACCESS

Trans-Catheter Interventions in the Management of Renal Vascular Injuries

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Cite this paper as: Shady Arafa El-dweamer , Tarek Mohsen Abd-El- Fattah, Osama El saeid Ghieda, Mahmoud Abd-El-Aziz Dawoud, Mohamed El-sayed Hegazy, (2025). Trans-Catheter Interventions in the Management of Renal Vascular Injuries. *Journal of Neonatal Surgery*, 14 (21s), 1388-1396.

ABSTRACT

Background: Iatrogenic renovascular injuries have risen due to the growing prevalence of interventional procedures, including renal artery angioplasty, stenting, and percutaneous techniques. The aim of this work was to evaluate the role of trans-catheter interventions in the management of renal vascular injuries.

Methods: This prospective interventional work had been conducted on 46 individuals, aged from 19 to 65 years old, diagnosed with renal vascular injuries by computed tomography (32 cases) or ultrasonography (35cases), symptomatic patients who present with flank pain, hypertension, hematuria, and acute hemorrhage as life-threatening retroperitoneal hemorrhage. All patients were subjected to catheter angiography and embolization.

Results: Comparing the number of cases scheduled for procedure and outcome of management, three cases show persistent hematuria post catheterization, indicating proper control with significant p value (0.001). Only six cases presented by impaired renal functions postembolization, which were normalized /reduced to perinormal values within short period post procedure with satisfactory follow up. Follow up of patients using different imaging modalities, to assess renal function and morphology, among 6 cases underwent renal scan (renogram), Perfusion abnormalities were seldom recorded. The degree of Scar tissue was assessed according to the embolized region of the kidney and selectivity of procedure. In our studied cases, due to super selective embolization, mild scar tissue was noticed in 12 cases, 9 of them lower pole segmental branch of renal artery was embolized.

Conclusions: Endovascular management is an effective minimally invasive and safe procedure in the management of renal vascular injuries with preservation of renal functions and low minor and major complication.

Keywords: *Trans-Catheter Interventions, Management, Renal Vascular, Hematuria*

INTRODUCTION

The kidney is the most often damaged genitourinary organ in instances of external abdominal trauma. The primary causes that cause kidney injuries include acute trauma, iatrogenic factors during interventional procedures, and intraoperative events. The majority of injuries resulting from blunt trauma are of lower severity and non-life-threatening. Renal injuries might be categorised as renal laceration, contusion, and vascular damage [1].

Iatrogenic renovascular injuries have risen due to the growing prevalence of interventional procedures, including renal artery stenting or angioplasty, as well as percutaneous operations like nephrostomy, biopsy, nephro-ureter lithotomy, and nephron-sparing surgery [2].

The rising prevalence of minimally-invasive kidney surgery has led to a notable increase in haematuria and renal damage as common urologic consequences. Recent advancements in imaging, increased expertise in interventional radiology, and the availability of superior embolic materials have led to the widespread implementation of renal angioembolization (RAE). The method has shown efficacy in addressing urgent patients for many causes, including iatrogenic and traumatic injuries [3].

Potential radiographic findings in iatrogenic vascular lesions include arteriovenous fistula, arterial dissection, pseudoaneurysm, or contrast extravasation. The majority of these lesions resolve spontaneously. Nonetheless, they might lead to significant haemorrhaging, life-threatening haematuria, or a decline in renal function, necessitating urgent intervention [4].

Currently, conservative or minimally-invasive techniques, such as transcatheter arterial embolisation (TAE) and the insertion of stents/stent grafts, are increasingly preferred over surgical interventions [5].

Endovascular therapy is a recognised nonsurgical technique for renal artery injuries, offering several benefits, including expedited healing, reduced hospital duration, and prompt return to physical activity [5].

Conventional surgical methods like partial and total nephrectomy are suboptimal for preserving renal function; consequently, selective arterial embolisation (SAE) has become increasingly preferred in recent years, owing to the accessibility of micro-catheters and enhanced diagnostic imaging quality as well as being able to preserve normal renal parenchyma (nephron-sparing procedure) which is the main goal of treatment. SAE is also an alternative option to partial nephrectomy in individuals deemed unsuitable due to comorbidities or those who refuse surgical intervention [6].
The aim of this work was to evaluate the role of trans-catheter interventions in managing of renal vascular injuries.

Patients and Methods:
This prospective interventional work had been conducted on 46 individuals, aged from 19 to 65 years old, diagnosed with renal vascular injuries by computed tomography (CT) (32 cases) and/ or ultrasonography (US) (35cases), symptomatic patients who present with flank pain, hypertension, hematuria, and acute hemorrhage as life-threatening retroperitoneal hemorrhage.
The work had been conducted from May 2022 to May 2024 following approval from the Ethics Committee Tanta University Hospitals, Tanta, Egypt. Each participant provided a written informed consent.
Criteria for exclusion were general contraindications such as severe renal failure, severe respiratory insufficiency, severe anemia, congestive heart failure, chronic liver insufficiency and uncontrolled Bleeding and coagulation disorders.
Each participant had been exposed to complete taking of history, clinical examinations, laboratory tests [full blood picture (CBC), coagulation profile (international normalized ratio (INR), prothrombin time (PT) and partial thromboplastin time (PTT)), renal function test (creatinine level and blood urea level), urine analysis (for erythrocyte count in urine) and liver function test] and radiological imaging [US, CT and catheter angiography].

Catheter angiography.
DSA, which stands for digital subtraction angiography, was carried out. A standard right common femoral arterial puncture was carried out, and a 6F arterial sheath was used to secure the access. For the purpose of cannulating the affected side main renal artery, a renal double-curve (RDC) catheter with a diameter of 5F was used. Using bone subtraction, standard posterior to anterior projection renal angiograms were created at three frames/second. These angiograms were then analysed to determine whether or not there were any arterial injuries (pseudoaneurysm, AVF, or extravasation). Visibility of overlapping arteries was achieved by the acquisition of oblique images. In 24 instances, super selective catheterisation was performed using a 2.7 F microcatheter in order to reach as far away from the lesion as feasible. Additionally, super selective runs were acquired, and flow dynamics were assessed in order to choose the embolic material that would be utilised.

Embolization: All patient preparation were fasting for at least 8 hours before the procedure. Prophylactic antibiotic (ceftriaxone 1 gm IV). Venous access (wide bore cannula; 20- gauge 22-gauge in size) was fixed. Blood transfusion was done in 25 unstable cases, in which hemoglobin level <10 gm/dl (1 patient needed 1 unit, 8 patients needed 2 units, 6 patients needed 3 units, 4 patients needed 4 units, 2 patients needed 5 units, and 4 patients needed >10 units). IV fluids (Normal saline) 1000-1500 cc were sufficient in 21 cases.
An infiltration of 5 cc of lidocaine hydrochloride (xylocaine) solution at a concentration of 2% was performed beneath the skin surrounding the puncture site and superficial to the femoral artery in each and every patient included. The anesthesia was performed by a trained anesthesiologist.
The technique of trans-catheter renal artery embolization was straight forward. The renal artery was accessed by a femoral catheterisation.
A vascular sheath was introduced into the targeted artery via the modified Seldinger method, followed by the direct insertion of a 4 or 5 F C2 Cobra catheter into the renal artery or after doing flush aortography to reveal the origin of the renal artery in difficult cases. Super-selection of the targeted vascular lesion was achieved using micro catheters, the vascular lesion was then embolized using different embolic agents, each suited to a different type of vascular pathology where vascular coils were used in pseudoaneurysms and in proximal occlusion of extravasating arteries as well as AV fistulae at the arterial side. Push coils of the 018 system, namely sizes 18-3-2, 18-3-3, 18-5-2, and 18-5-3, have been employed in 38 instances. Verify that angiograms were acquired following 10 minutes to permit enough thrombus development in the coil, hence confirming lesion resolution. Permanent particles PVA were used in 4 cases to embolize vascular lesions with multiple collateral arterioles and vascular beds especially with tumors. Gelatin sponge “Gel Foam” pledges were used in 5 cases with small temporary iatrogenic bleeders.

Post-embolization: Medical therapy and medical instructions, antibiotics, anti-inflammatory and analgesic drugs and every patient was advised to drink a lot of water and to immobilize the catheterized lower limb after the procedure.
Follow up: (3-6 months) helped to assess any residual lesion, urine erythrocyte counts, and serum creatinine of all patients by comparing pre- and post- embolization data.

Clinical follow up during hospitalization: Regular palpation of Dorsalis pedis pulse to assess peripheral circulation and regular observation of the site of catheter enters at upper thigh to detect any sizable hematoma formation and regular measurement of blood pressure and body temperature.

Radiological follow up after one month: By routine post-interventional Ultra-sonography and Triphasic CT&MRI. in forty-one cases (CT in 39 cases &MRI in 2 cases) and renogram and DMSA scan in twenty cases.

Statistical analysis

Statistical analysis was conducted employing SPSS v26 (IBM Inc., Chicago, IL, USA). Shapiro-Wilks test and histograms had been utilised to assess the data distribution normality. Quantitative parametric data had been displayed as mean and standard deviation (SD). Quantitative non-parametric data had been displayed as median and interquartile range (IQR). Qualitative parameters had been displayed as frequencies and percentages (%). P-value < 0.05 was considered statistically significant.

Results:

Demographic data, symptoms, pre-arteriography diagnostic imaging and cause of renal vascular injury were displayed in this table. **Table1**

Table 1: Demographic data, symptoms, pre-arteriography diagnostic imaging and cause of renal vascular injury of the studied patients

		N=46
Age		**48.0 ± 11.36**
< 30		**8(17.3%)**
30-40		**4(8.7%)**
40 – 60		**20(43.5%)**
> 60		**14(30.4%)**
Sex	**Male**	**32(69.6%)**
	Female	**14(30.4%)**
Symptoms	**Gross hematuria**	**40(86.9%)**
	Flank pain	**32(69.5%)**
	Hypovolemic shock	**4(8.6%)**
Diagnostic imaging modalities	**Pelvi-abdominal US andDoppler**	**35(76.0%)**
	Non contrast CT and MRI	**32(69.5%)**
	Renal CECT and CTA	**30(65.2%)**
	Renal MRA	**2(4.3%)**
Cause of injury	**Iatrogenic post PCNL**	**32(69.6%)**
	Post biopsy	**4(8.7%)**
	Post trauma	**6(13.0%)**
	Hemorrhagic angiomyolipoma	**4(8.7%)**

Data are presented as mean ± SD or frequency (%). US: Ultrasonography, CT: Computed tomography, MRI: magnetic resonance imaging, CECT: contrast-enhanced computed tomography, CTA: computed tomography angiography, MRA: magnetic resonance arteriography, PCNL: percutaneous nephrolithotomy.

Indications of transcatheter angiography, pre-management Imaging findings, embolization sessions, types of the used catheters data and embolic agents used were presented in this table. **Table 2**

Table 2: Indications of transcatheter angiography, pre-management Imaging findings, embolization sessions, types of the used catheters data and embolic agents used of the studied patients

		N=46
Indications of transcatheter angiography	Gross hematuria	40(87.0%)
	Hypovolemic shock, intraperitoneal and Perinephric hemorrhage	6(13.0%)
Imaging findings	pseudoaneurysm	30(65.2%)
	pseudoaneurysm and AVF	14(30.4%)
	Negative angiographic findings	2(4.3%)
Embolization session	One session	35(85.3%)
	Three sessions	2(4.9%)
	Two sessions	4(9.8%)
Type of the used catheters	Pre-embolic flush aortography	10(21.7%)
	Selective angiography	46(100.0%)
	Cobra catheter	22(47.8%)
	Microcatheter	24(52.2%)
Embolic agent	Coils	32(78.0%)
	Particles	3(7.4%)
	Combined	6(14.6%)

Data are presented as frequency (%). AVF: arteriovenous fistula.

Comparing the number of cases scheduled for procedure and outcome of management, three cases show persistent haematuria post catheterization, indicating proper control with significant (P=0.001). **Table 3**

Table 3: Assessment of hematuria pre and post catheterization

	Pre	Post	X^2	P
Hematuria	40(87.0%)	3(6.8%)	54.480	0.001*
No hematuria	6(13.0%)	41(93.2%)		

Data are presented as frequency (%). significant p value<0.05. X^2: chi square test.

Only six cases presented by impaired renal functions postembolization, which were normalized /reduced to perinormal values within short period post procedure with satisfactory follow up. **Table 4**

Table 4: Laboratory markers of the studied patients

	Pre-embolization (n=46)	Post-embolization (n=41)
Normal renal functions	38(82.6%)	35(85.3%)
Impaired renal functions	8(17.4%)	6(14.6%)

Data are presented as frequency (%).

Follow up of patients using different imaging modalities, to assess renal function and morphology, among 6 cases underwent renal scan (renogram), Perfusion abnormalities were seldom recorded. The degree of Scar tissue was assessed according to the embolized region of the kidney and selectivity of procedure. In our studied cases, due to super selective

embolization, mild scar tissue was noticed in 12 cases, 9 of them lower pole segmental branch of renal artery was embolized. **Table 5**

Table 5: Imaging follow up

	N	Findings
Functional and morphological follow up (scar tissue)	**41**	
CT/MRI with contrast	**41**	**All cases show good function** **All cases show scar**
Renogram (dynamic renal scintigraphy)	**6**	**Good perfusion and excretory function (n=5)**
		Hypoperfusion (n=1)
DMSA (static renalscintigraphy)	**14**	**Grade of scar** **12 < % 25 mild**
		2 % 25- % 50 moderate

CT: Computed tomography, MRI: magnetic resonance imaging, DMSA: Dimethyl Sulfoxide.

Causes of failure of embolization, complications and overall success rate of catheterization were presented in this table. **Table 6**

Table 6: Causes of failure of embolization, complications and overall success rate of catheterization of the studied patients

		N=3
Failure causes		
Technique factors	**Short stem artery and multiple kinking**	**1(33.3%)**
	Multiple aneurysms and distal location	**1(33.3%)**
Patient factors	**Clinically unstable patient**	**1(33.3%)**
Complications		
		N=40
Minor complications (n=28)	**Pain**	**20(43.5%)**
	Fever	**8(17.4%)**
Major complications (n=12)	**PES**	**10(21.7%)**
	Coil migration (non-target embolization)	**2(4.3%)**
		N=46
Overall success rate of Trans catheterprocedures	**Success**	**43(93.5%)**
	Failure	**3(6.5%)**

Data are presented as frequency (%). PES: Post-embolic syndrome.

Case 1: A 6-year-old child, presented with hypovolemic shock (preceded with gross hematuria and severe flank pain) after falling from height. **Figure 1**

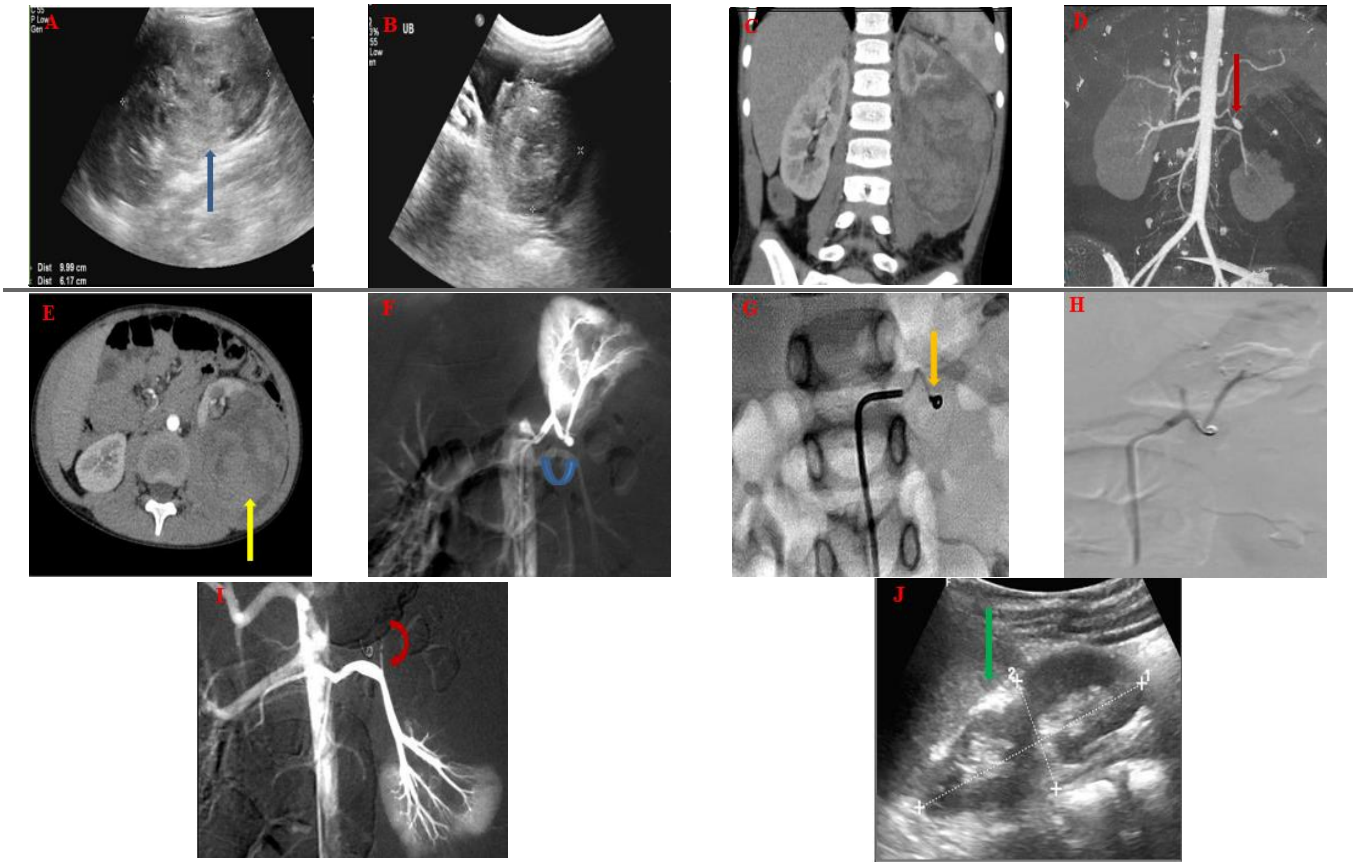
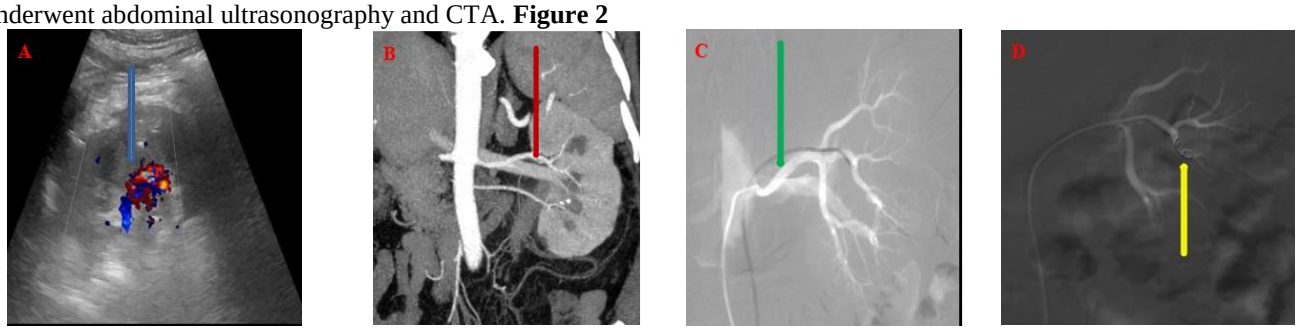


Figure 1: (A and B) abdominal ultrasound revealed enlarged left kidney with evidence of large heterogeneous lesion (10x6cm) at mid zone with no detected internal vascularity likely hematoma with preserved shape of upper and lower poles (blue arrow). Also, hyper echoic blood clot is seen in urinary bladder, CTU and CTA of renal vessels (C)coronal image, (D) coronal MIP image and (E) axial image revealed distorted left kidney with complete separation of the upper and lower part and double left renal arteries with aneurysm seen arising at the superior branch supplying upper part(red arrow) . In addition to presence of large perinephric and intra renal hematoma(yellow arrow) and evidence of contrast material inside the hematoma, (F) diagnostic selective left renal angiography revealed double left renal arteries then selective catheterization of upper branch was done, revealed small pseudo aneurysm from lower segmental branch (curved yellow arrow), (G) Coiling of aneurysm with microcoil by microcatheter under fluoroscopic control (orange arrow), (H and I) post-embolization control angiography revealed successful embolization with no further opacification with completer occlusion aneurysm(curved red) and (J)follow up by abdominal U/S scan 6 months after coiling

Case 2: A 55-year-old male patient, presented with gross hematuria and left flank pain after left PCNL, the patient underwent abdominal ultrasonography and CTA. **Figure 2**



(A) **(B)** **(C)** **(D)**

Figure 2: Abdominal ultrasound and color Doppler was done (A), revealed area of focal aliasing noted at left renal hilum with broad spectral flow and high PSV reaching 139cm/sec and decreasing blood flow at periphery of kidney suggesting Arteriovenous fistula (AVF) (blue arrow), then CTA of renal vessels was done, (B) revealed Double left renal arteries, Evidence of arteriovenous fistula (feeding artery middle segmental branch from main renal artery) associated with early filling of ipsilateral renal vein and IVC).(red arrow), Diagnostic selective left renal artery angiography (C) revealed Double left renal arteries, evidence of arteriovenous fistula (feeding artery middle segmental branch from main renal artery) associated with early filling of ipsilateral renal vein and IVC).(green arrow), Then super selective catheterization

&embolization of feeding artery was carried out using Single micro-coil, Post-embolization control angiography (D) revealed Successful closure of the fistula with no further filling of vein with contrast.(yellow arrow)

Discussion:

Renal trauma may be life-threatening; however, most renal injuries are mild and may be handled conservatively. Improvements in trauma imaging and staging, together with advancements in treatment approaches over the last two decades, have reduced the requirement for surgical intervention and enhanced kidney preservation [7].

In our study, the most presenting symptoms were gross hematuria (86.9%) then flank pain (69.5%) then hypovolemic shock (5.6%), these results agree with Jain et al.[8].

Post-traumatic persistent or intermittent haematuria was the predominant symptom in all of our participants (n=40), this agreed with series done by Fornazari et al. [9] showed that the predominant symptom was macroscopic haematuria, and during the initial postoperative period, three patients had severe flank discomfort.

In our study, ultrasonography was the primary diagnostic tool, followed by contrast-enhanced CTA for diagnosing RAAs. MRA was used in cases where CT was contraindicated, including renal impairment and pregnancy, with two cases undergoing MRA. This agreed with Klausner et al. [10] and Chaer et al. [11] who stated that The predominant imaging modality utilised is CTA, (which is the preferred method for assessing individuals with a suspected RAA or AV fistula), followed by non-contrast enhanced CT, then magnetic resonance angiography MRA, then catheter angiography.

In the present study, Doppler Ultrasonography detected vascular lesions in 35 patients (76%), CT Angiography detected vascular lesions in 30 patients (65.2%) and diagnostic angiography (DSA) detected vascular lesions in 44 patients (95.6%), this agreed with the series done by Richstone et al. [12] concluded that in 95% of instances, conventional angiography showed a demonstrable and treatable aetiology.

In our study, the etiology and risk factors in 36 cases were iatrogenic causes such as (post PCNL) then post trauma (6 cases), these results supported by Fornazari et al. [9] reported that there was a series of iatrogenic renal vascular complications following PCNL.

In our study we noticed the high percentage of iatrogenic renal injury (78.6%) more commonly after PCNL (69.9%), and biopsy (8.7%). The result of our study was not agreed with series which were done by Esparaz et al. [13] showed that the most prevalent iatrogenic kidney injuries are vascular. These complications can occur during procedures like renal biopsy, nephrostomy, nephrolithotomy, endopyelotomy, and partial nephrectomy.

In the present work, selective angiography (DSA) showed pseudoaneurysm only in 30 participants (65.2%), combined pseudoaneurysm and arteriovenous fistula in 14 participants (30.4%), and no vascular lesion was in 2 patients (4.3%). This agreed with Farg et al. [14] reported that pseudoaneurysm was the most prevalent finding on renal angiography (54%). This corresponded to the results of Giurazza et al. [15] found at DSA, nine participants displayed with active bleeding, 15 had a pseudoaneurysm.

In the current study, the target vessels of all cases 46 (100%) lesions were accessed by Cobra catheter (selective), while in 10 (21.7%) lesions, the target vessels were reached by preembolic flush aortography.

In the present study, distal locations of the vascular lesions were found in 24 patients (52.2%). We agreed with Farg et al.[14] who reported that the renal artery was selectively catheterised via 5 Fr cobra head catheter and 18% cases had no lesions.

In the present study, metallic coils were used to embolize vascular lesions in most angiographically positive patients, either alone or with particles. Coils were used in 78% of cases, particles alone in 7.4%, and a combination of coils and particles in 14.6%. This corresponded with the study that was done by Alwarraky et al. [16] who showed that coils were used in 23/45 patients (51.1%) in selective renal artery embolization to control renal bleeding.

In the present study 6 patients (14.7%) treated with single coil presented with recurrent bleeding occurred 2-11 days after the first embolization. We agreed with the findings of Rosemary et al. [17] who stated that micro-coils are the most often utilised embolic agent and a combination of coils and gelatine sponges are less commonly utilised to stop bleeding.

In the present study, the average parenchymal tissue loss after embolization was less than 30% of the total renal parenchyma., this agreed with Dos Reis et al. [18] who revealed that the super selective renal embolization technique performed to control hemorrhage following a urological procedure is efficient.

In the present study, intra lesional fat tissue and perinephric hematoma were recognized in all patients with bleeding AML. This agreed with Pacella et al. [19] found that the CT scan at the completion of the surgery revealed a perirenal haematoma devoid of active bleeding, with sporadic adipose tissue, with increasing enhancement seen in a significant portion of the tumour.

In the current work, intratumoral aneurysms were the most prevalent angiographic finding in patients with bleeding AMLs (75%). This agreed with Tajiri et al. [20] who found that there were ruptured AML and CECT revealed a retroperitoneal hematoma with intratumoral aneurysm.

In the present study, all patients were presented with bleeding AMLs, the embolization was carried out urgently to stop bleeding in all cases. This agreed with Tajiri et al. [20]found that there were bleeding due to ruptured AML. Also, Kikuchi et al. [21] showed that the TAE is the first-choice therapy to control bleeding.

In the present study the size of bleeding renal AMLs ranged from 4 to 12 cm with the mean size was 7cm. This agreed with Vaggers et al. [22] who found that R-AMLs <4 cm in low risk of hemorrhage, 4–6 cm in medium risk of hemorrhage and >6 cm high risk of hemorrhage. However, Vos et al. [23] found that AMLs was larger than 3 cm.

In our study, we did not report ischemia induced hypertension or renal failure during the follow up period in any of our patients. This agreed with Dong et al. [24] who reported that 46 patients received SRAE to prevent renal damage and success rate was 100%.

In the present study, 21.7% of our patients had experienced post embolization syndrome to varying degree, they were presented by flank pain, fever, increased white blood cell count, vomiting, nausea, and/or paralytic ileus. Alwarraky et al. [25] identified that medical problems including post-embolization syndrome, characterised by back discomfort, fever of unknown origin, and nausea. Also, Roehlen et al. [26] showed that post-embolization syndrome complications were fever, nausea and abdominal pain

Non target embolization was seen only in 2 cases (4.3%) in our study. This agreed with Sédat et al.[27] reported that the nontarget embolization was found in 10% of patients.

In our patients, only 6 cases (13%) show post embolization elevated serum creatinine levels, which gradually returned to their baseline levels over the follow up period, this matched with the findings of a workthat was done by Liu et al.[28] found that 4 weeks following embolisation, serum creatinine level revealed a substantial rise.

In the current work, an overall success rate of 93.5% was achieved as 41 RAAs had been successfully embolized with no recurrence on follow-up visits. While 3 (6.5%) cases were recurrent or not successfully embolized, these results were favourable compared with those reported by Gong et al.[29] found that TAE yields 99.1% technical success rate. Also, Palmerola et al. [30] reported that in their study the recurrence rate of endovascular management was (3.8%).

Limitations of this study included that small group of patients. Different indications of management. The pre-arteriography images of some individuals were acquired from various hospitals using technology distinct from that accessible in our facility. Our research was a prospective investigation with a brief follow-up duration. This should not impact the findings of our study as the majority of patients show good clinical and radiological improvement within the first months following endovascular management. However, long-term monitoring is necessary to ascertain sustained effectiveness following successful endovascular management.

Conclusions:

Endovascular management is an efficient minimally invasive and safe procedure in managing renal vascular injuries with preservation of renal functions and low minor and major complication.

Financial support and sponsorship: Nil

Conflict of Interest: Nil

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