Original Article

Diagnostic accuracy of computed tomography angiography in detection of post traumatic renal vascular injury

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ABSTRACT

Objectives: To evaluate accuracy of computed tomography angiography (CTA) in evaluation of post traumatic renal vascular injury.
Patients and methods: 38 patients were presented with post traumatic intermittent or persistent hematuria. Renal CTA and digital subtraction angiography (DSA) were done for all patients.
Results: CTA demonstrated pseudoaneurysm (PA) in 30 patients (78.9%) and no vascular lesions in 8 patient (21.1%). CTA had 86.11% sensitivity and 50% specificity in detection of post traumatic renal pseudoaneurysms, CTA missed diagnosis of renal arteriovenous fistula (RAVF) in 10 patients which discovered later by DSA.
Conclusion: CTA with MIP as non invasive technique widely replaced renal DSA in detection of posttraumatic renal pseudoaneurysm. Renal DSA is still best modality in detection of RAVF and also has the upper hand in planning of selective renal artery embolization for the management of persistent or delayed hemorrhage from renal vessels.

1. Introduction

Trauma can be defined as any damage to the body caused by external violence. From all abdominal trauma, renal vascular injuries represent 1-5%. Renal vascular lesions are usually caused by blunt or penetrating accidental trauma or iatrogenic injuries [1,2].

Penetrating injuries are most often caused by gunshot and stab wounds. These penetrating traumas have an inclination to be more vigorous with less inevitable course than those from blunt trauma [3].

Iatrogenic injuries are the main causes of renal vascular lesions (> 50%) as open and endoscopic procedure, percutaneous nephrolithotomy and renal biopsy [4].

After complete or partial renal artery injury, early due to hypotension and pressure exerting by surrounding tissue leading to stoppage of bleeding then recanalization between intra and extravascular spaces occur leading to pseudoaneurysm formation [5].

Blood clot may retained within the collecting system leading to renal obstruction and renal insufficiency and commonly causing hematuria which is the most common presenting symptom in renal trauma [6].

Multi Detector Computed Tomography (MDCT) angiography is the method of choice for evaluation of the abdominal vascular injury. Use of conventional angiography in setting of renal vascular injuries was greatly replaced by CTA because conventional angiography is not specific for renal parenchymal injury and more invasive [7,8].

Pseudoaneurysm, active extravasation, arteriovenous shunting and arteriocaliceal fistula are the most common angiographic finding by digital subtraction angiography suggestive of renal vascular injury [9].

The evolution of multi-row CT scanners and CT angiography has an invulnerable role in increasing its accuracy for detection of renal vascular lesions. It is also considered a non invasive technologic advance in evaluating the renal arteries, however, definitive diagnosis of renal artery pathology is still depending on visualization of renal artery anatomy with angiographic techniques [10,11].

The aim of this work is to assess accuracy of CTA in evaluation of post traumatic renal vascular injury.

2. Patients and methods

2.1. Patients

Thirty-eight patients with post traumatic persistent or intermittent hematuria underwent renal CTA for evaluation of renal vascular injury throughout the period from October 2014 to September 2016. Informed consent were taken from all patients; they were informed about expected complications of the procedure.

Inclusion criteria were: patients with post –traumatic persistent or intermittent hematuria, both sexes were included, no age predilection. Exclusion criteria included contraindications to radiation as pregnancy, or to administration of iodinated contrast agents.

2.2. Methodology

All patients were subjected to the following:

1. **Full history taking and clinical examination:**
   (a) **Personal history included** age, sex and special habits as smoking, alcoholism.
   (b) **History of the present illness**.
   (c) **Past history** with special concern on renal trauma, known urolithiasis, or recent medical intervention in which percutaneous instrumentation was used.
   (d) **Clinical examination included:** general examination and local abdominal and pelvic examination.
2. **Laboratory investigations included: renal function** and **coagulation profile** of the patients to assure proper renal function and exclude coagulation defects as cause of the hematuria.
3. **Ultrasonography:** Grey scale Ultrasonography followed by color Duplex examination were done for all patients (n = 38) for assessment of:
   - Blood clots in renal calyces, pelvis and/or urinary bladder.
   - Perinephric hematoma.
   - Intra abdominal free fluid.
   - Vascular lesions as aneurysm and/or arteriovenous fistula.
4. **Computed Tomography:** Renal CTA with post processing techniques as MIP and 3D volume rendered study was done for all patients.
   - **CT machine:** Toshiba Aquilion 16.
   - **Patient preparation and initial scanning:**
     - Fasting for 4–6 h before scanning.
     - A 20-gauge needle placed in a superficial vein at antecubital fossa.
     - All patients were placed supine, feet first with head fixation and arms above head.
     - Scout image (tube voltage, 120 KV; tube current, 50 mAs) was obtained.
     - Scan range covering the abdominal aorta from its diaphragmatic hiatus to its bifurcation.
   - **Spiral acquisition and contrast medium administration:**
     - For excellent abdominal aorta and its branches contrast enhancement, a bolus tracking was obtained as a technologist set a region of interest within the lumen of descending thoracic aorta.
     - Then a nonionic iodinated contrast media; Omnipaque 350 mgI/mI was administrated (80–120 ml; 1 ml\kg body weight) with an automated injector at a flow rate of 4–5 ml\s and followed by a saline flush.
     - Data acquisition was performed in a craniocaudal direction.
     - A nominal section thickness of 1 mm.
     - A 0.5-s gantry rotation time (pitch, 1.5) and a table feed of 18 mm per rotation.

- **Image reconstruction:**

All CT angiographic data were post processed using a dedicated remote workstation that allows generation of multiplanner reformatting, volume rendering and maximum intensity projection.

5. **Diagnostic angiography procedure**

   Angiographic machine:
   XIDF-PON 801, Toshiba, Shimoishigami, Japan.
   Contrast media:
   Non ionic contrast media (Omnipaque 300 mgI/ml, GE Healthcare, Cork, Ireland) was used in all patients (n = 38), and the dose was 8–10 ml of contrast media for every injection, manual injection was used in selective and superselective angiography.
   Diagnostic angiography:

   - All patients were asked to fast for 6 h before the procedures.
   - Local anesthesia (5cc xylocaine 2% solution) was infiltrated under the skin around the puncture site and superficial to the femoral artery.
   - The right femoral artery puncture approach was done for all patients.
   - Selective renal DSA was performed using cobra C5 catheter which was advanced over 0.035 in. hydrophilic guidewire.
   - Angiographic data were obtained as type, number, site of the renal vascular injury and its feeding arteries.

6. **Statistical analysis**

The data were collected, tabulated and statistically analyzed. The Statistical Package for the Social Sciences (SPSS) Version 21 was used for statistical analysis. Descriptive statistic was performed in a form of number and percentage for qualitative data. Chi-squared test ($\chi 2$) was used to assess the significance of association between CT and conventional angiographic findings. Sensitivity, specificity, and diagnostic accuracy were used for CTA diagnostic evaluation. P-value ≤ 0.05 was considered significant.

3. Results

Thirty-eight patients were in this study, 32 of them were male while 6 were female, ranged from 4 to 63 years old (mean age = 39.4 years). The most affected age group was from 30 to less than 40 years (11 cases) representing 28.95% of the cases. The causes of trauma were: percutaneous nephrolithotomy (PCNL) in 15 patients, surgical nephrolithotomy in 5 patients, true cut needle biopsy in 4 patient, blunt trauma in 7 patients and penetrating trauma in 7 patients. Clinically, 38 patients presented with gross hematuria, 4 had combined fever and hematuria, 5 had combined hematuria and loin pain and 3 had combined hematuria and oliguria. Demographic and admission characteristics of studied patients are listed in Table 1.

Grey scale and duplex sonogram showed blood clots in the renal calyces, pelvis and\or urinary bladder in 19 patients and perinephric hematoma in 9 of them. Color duplex examination identified the vascular lesions in 14 patients (14 pseudoaneurysms). Variable degrees of hydronephrosis of the injured kidney were reported.

Computed Tomography characterized the lesions as regard location, type and flow pattern, also it showed the condition of both kidneys. Renal CTA was done for all patients. Thirty patients had pseudoaneurysm and 8 patients showed no positive angiographic findings. 32 vascular lesions were detected in 30 patients, 2 patients had two pseudoaneurysms. CTA disclosed vascular lesions as upper polar site in 4 patients, a mid polar site in 14 patients, and a lower polar site in 10

Table 1
Demographic and admission characteristics of studied patients.

Characteristics	No. of Patients (Total = 38)	(%)
Gender:		
• Male	32	84.22
• Female	6	15.78
Age in years:		
• < 20	4	10.52
• 20- < 40	16	42.11
• 40- < 60	13	34.21
• ≥ 60	5	13.16
Mean of age ± SD	**39.4 ± 8.35**	
Causes of post traumatic hematuria:		
• Post PCNL	15	39.5
• Surgical nephrolithotomy	5	13.2
• True-cut needle biopsy	4	10.5
• Blunt trauma (car accident)	7	18.4
• Penetrating trauma (stab)	7	18.4
Clinical presentation:		
• Hematuria	38	100.0
• Loin pain	5	13.2
• Fever	4	10.5
• Oliguria	3	7.6

SD[*] standard deviation.

patients, while combined mid and lower polar vascular lesions were seen in 2 patients. All vascular lesions were fed by segmental and interlobar arteries except two patient in which pseudoaneurysm was fed by accessory renal artery. Mid polar arterial tree was the most common site of injury in this study (n = 14).

All patients were examined by DSA as part of embolization technique. Only two patient showed no positive angiographic findings one of them was positive by CTA that had small pseudoaneurysm, on follow up spontaneous improvement was achieved. The other 36 patients were angiographically positive, 32 patients had a pseudoaneurysm only, 4 patients had both arteriovenous fistula and pseudoaneurysm. Pseudoaneurysms were by the most common type of renal vascular injury in this study. It represents 84.2% if considered alone and 94.7% if we add the pseudoaneurysm associated with arteriovenous fistula. Forty-eight vascular lesions were detected in 26 patients; 44 pseudoaneurysms (two patients had two pseudoaneurysms) and 4 arteriovenous fistulas.

Digital subtraction angiography disclosed vascular lesions as upper

Table 3
Sensitivity, specificity and diagnostic accuracy of CT angiography in post-traumatic renal vascular injury.

CT Angiographic findings	Sensitivity (%)	Specificity (%)	Accuracy (%)
The presence of vascular lesions	80.56	50.00	78.94
Pseudoaneurysm	86.11	50.00	84.21

polar site in 6 patients, a mid polar site in 16 patients and a lower polar site in 12 patients while combined mid and lower polar vascular lesions were seen in 4 patients. All vascular lesions fed by segmental and interlobar arteries except two patient in which pseudoaneurysm fed by accessory renal artery. Mid polar arterial tree was the most common site of injury in this study (n = 16). Number and percentage of renal vascular lesions among the studied cases are listed in Table 2. Sensitivity, specificity and diagnostic accuracy of CT angiography in post-traumatic renal vascular injury are listed in Table 3 (see. Figs. 1–4).

4. Discussion

Most of renal injuries are mild and may need only conservative management but it may be life threatening. The development of imaging modalities and forward movement in the staging of trauma have reduced the possibility of surgical intervention and increased the chance of renal safety [12].

Digital subtraction angiography (DSA) is more specific for assessment of the definite location of the vascular injuries as well as its degree and also it has the upper hand in setting the strategy of selective embolization for the management of persistent or delayed hemorrhage from renal vessels and its branches. Digital subtraction angiography is preferred when CT findings are not conclusive in good assessment of pedicle injury in stable patients [13].

In the current study, the high percentage of iatrogenic renal injury (63.2%) occurs after PCNL (39.5%), the mechanism of injury is about direct damage to the parenchyma, excretory system, or vascular structures and even peritoneal invasion. These results were attributed to the frequent daily use of these procedures at our center within the permissible limit.

Post traumatic persistent or intermittent hematuria was the main symptom in all the studied patients (n = 38). This matches with the fact that gross hematuria and shock are basic symptoms in adult patients
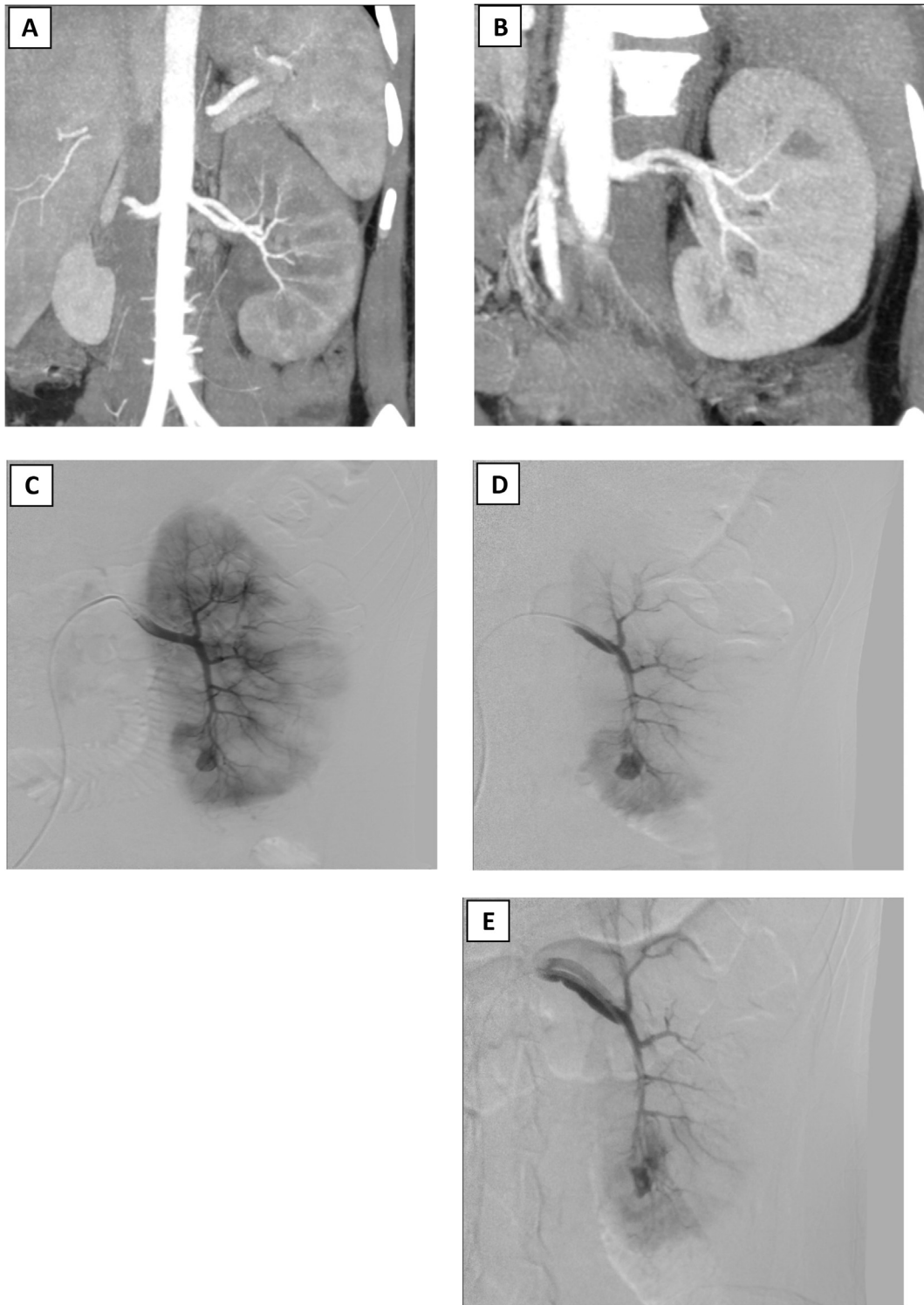
Table 2
Number and percentage of renal vascular lesions among the studied patients.

Radiological findings	CT angiography	Renal DSA	Chi-square- value (χ2)	P-value
Vascular lesions:				
• Present	30 (78.9)	36 (94.7)	4.1455	0.0417[*]
• Absent	8 (21.1)	2 (5.3)		
• Total	38 (100.0)	38 (100.0)		
Type of Vascular lesions:				
• Pseudoaneurysm only	30 (100.0)	32 (88.9)	7.317	0.006831[*]
• Pseudoaneurysm and arteriovenous fistula	0 (0.0)	4 (11.1)		
• Total	30 (100.0)	36 (100.0)		
Site of Vascular lesions:				
• Upper polar	4 (13.3)	6(16.7)	0.1711	0.982
• Mid polar	14 (46.7)	16(44.4)		
• Lower polar	10 (33.3)	12(33.3)		
• Combined mid and lower polar	2 (6.7)	2 (5.67)		
• Total	30 (100.0)	36 (100.0)		

* Statistically significant difference.

Fig. 1. A 40-year-old male patient had history of blunt abdominal wound two months ago, he had recurrent attacks of painless hematuria since two weeks, rapid decline of HB reaching to 9 g\dl. Renal CTA (A and B): revealed normal study, no evidence of renal vascular injury. Selective and super selective left renal artery angiography (C–E): revealed small pseudoaneurysm supplied by lower segmental renal artery with evidence of small arteriovenous fistula and early filling of the left renal vein.
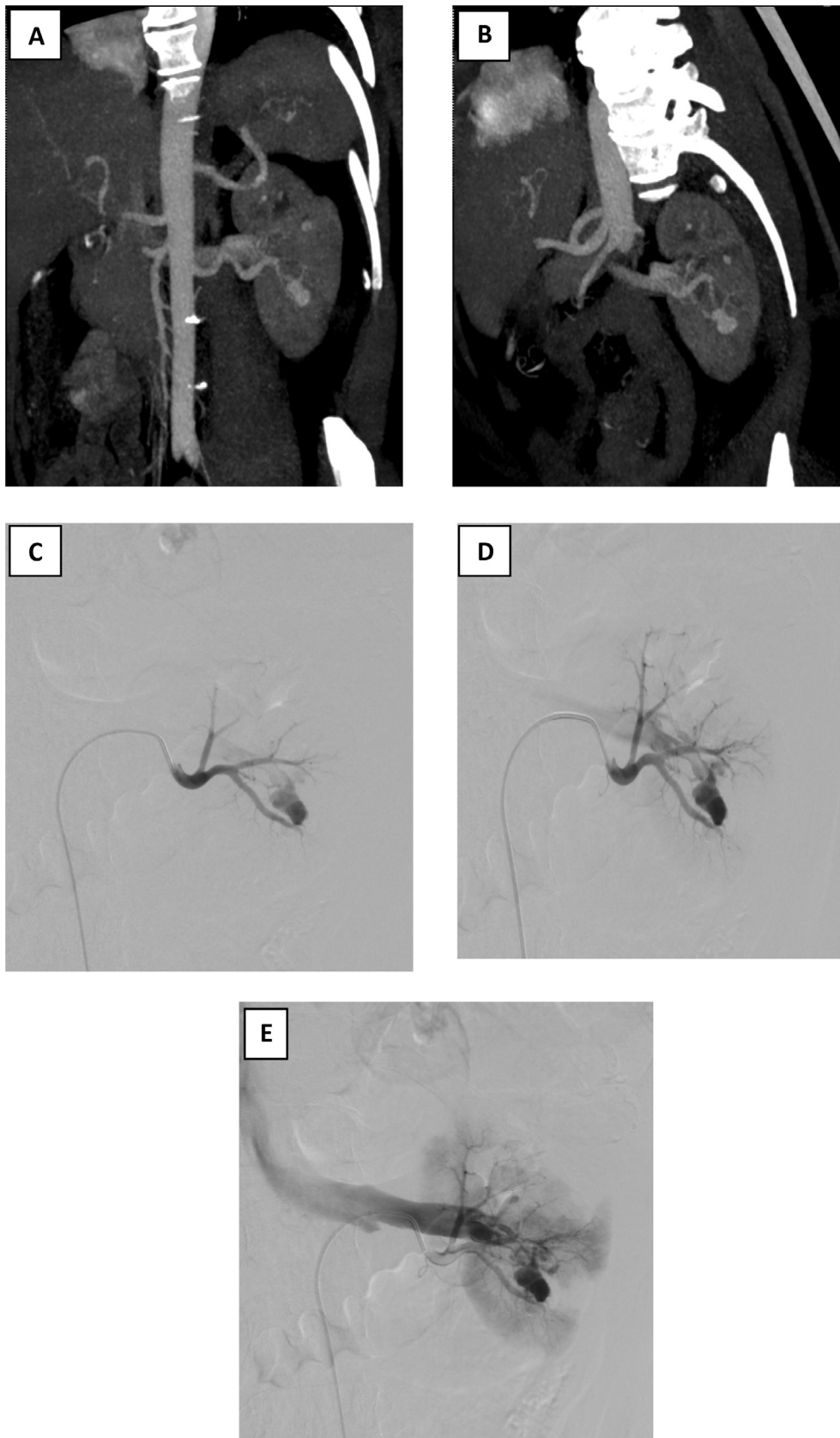
Fig. 2. A 20-year-old male patient had history of penetrating abdominal trauma (stab injury) 10 days ago, he had recurrent attacks of painless hematuria and rapid decline of HB reaching to 9 g\dl. Renal CTA (A and B) revealed small pseudoaneurysm supplied by lower segmental renal artery of the left kidney. Selective and super selective left renal angiography (C–E): revealed pseudoaneurysm supplied by lower segmental renal artery with evidence of AVF and early filling of the renal vein.
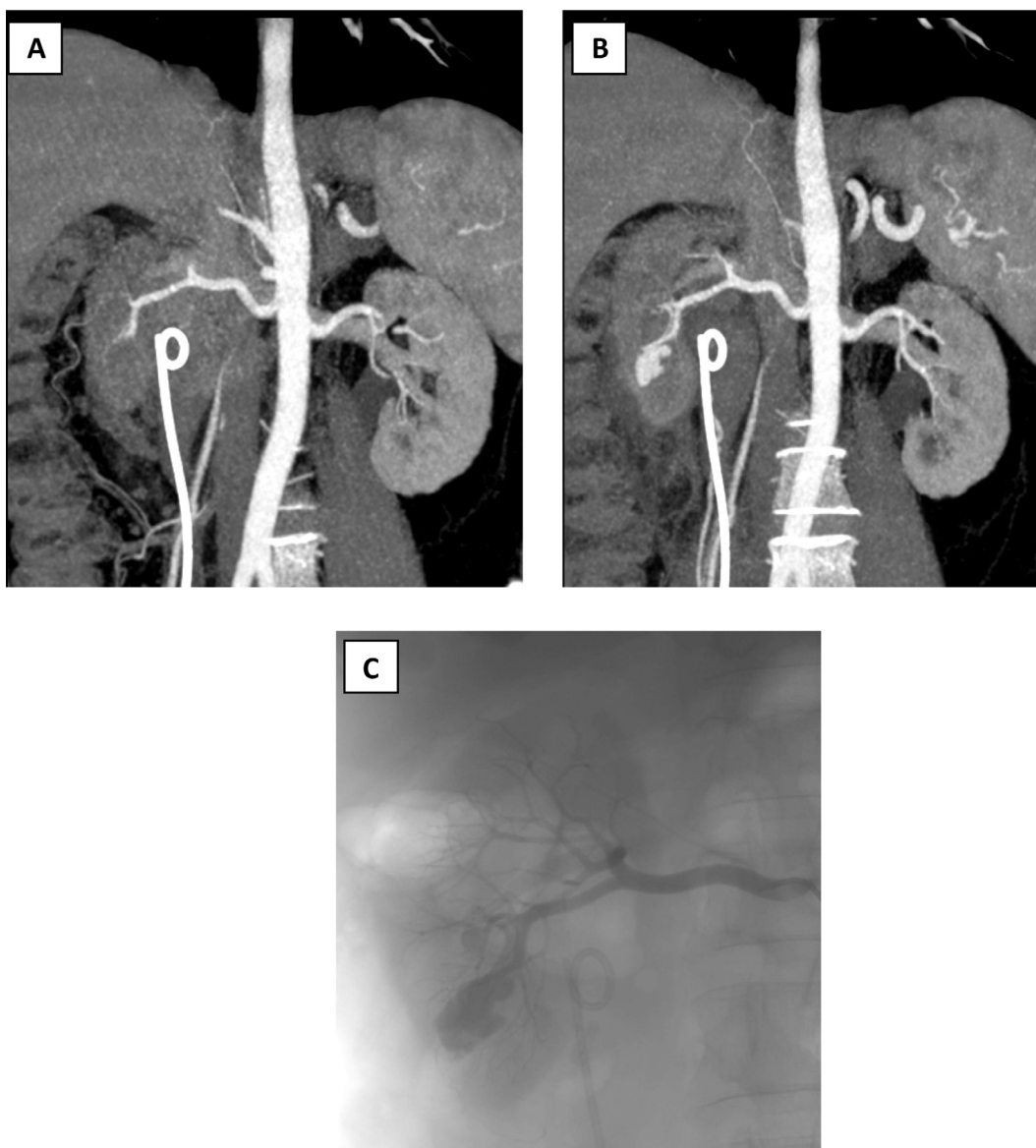
Fig. 3. A 44-year-old female patient had history of PCNL 7 days ago, she had recurrent attacks of hematuria and rapid decline of HB reaching to 8 g\dl. Renal CTA (A and B) revealed pseudoaneurysm supplied by lower segmental renal artery of the right kidney. Selective and super selective right renal artery angiography (C): revealed two pseudoaneurysm supplied by middle and lower segmental renal artery.

with considerable urinary tract injury.

In the present study, CTA demonstrated pseudoaneurysm in 30 patients (78.9%) and no vascular lesion was in 8 patient (21.1%). 32 PA were detected in 30 patients, two patients had two pseudoaneurysms. CTA have diagnosed 81.6% of pseudoaneurysms, however, five cases were missed and discovered later by conventional angiography.

Also, CTA missed diagnosis of renal AVF in 4 patients which were discovered later by renal DSA, this result can be explained by delayed development of the RAVF. In the study done by Vignali et al., (2004) [14]A, selective renal arteriography was found to be a perfect method when compared to others in diagnosis of RAVF. It can confirm the presence of fistula, assess its volume, location in relation to the afferent artery and state of the venous or efferent system.

In this study, selective renal DSA demonstrated pseudoaneurysm alone in 32 patients (84.2%), combined pseudoaneurysm and arteriovenous fistula in 4 patients (10.5%), and no vascular lesion was in 2 patient (5.3%). Pseudoaneurysms were the most common type of injury in this study representing 84.2% if considered alone and 94.7% if associated with arteriovenous fistula. This copes with the results of Richstone et al. [15] who found that 53% of the patients in their study had pseudoaneurysm, 25% of them had contrast extravasation from a lacerated renal vessel in, another 25% had arteriovenous fistula and 10% of the patients had renal arterial dissection.

Renal DSA failed to detect any vascular lesion in two patient. On follow up, spontaneous improvement was achieved. In a series done by Vikas et al. [16], angiography could not detect any lesion in 6 patients (14.6%), and in another study done by Richstone et al. [15], 5% of their patients were angiographically negative. They attributed their results to the venous origin of bleeding that was self limiting and responded to conservative management.
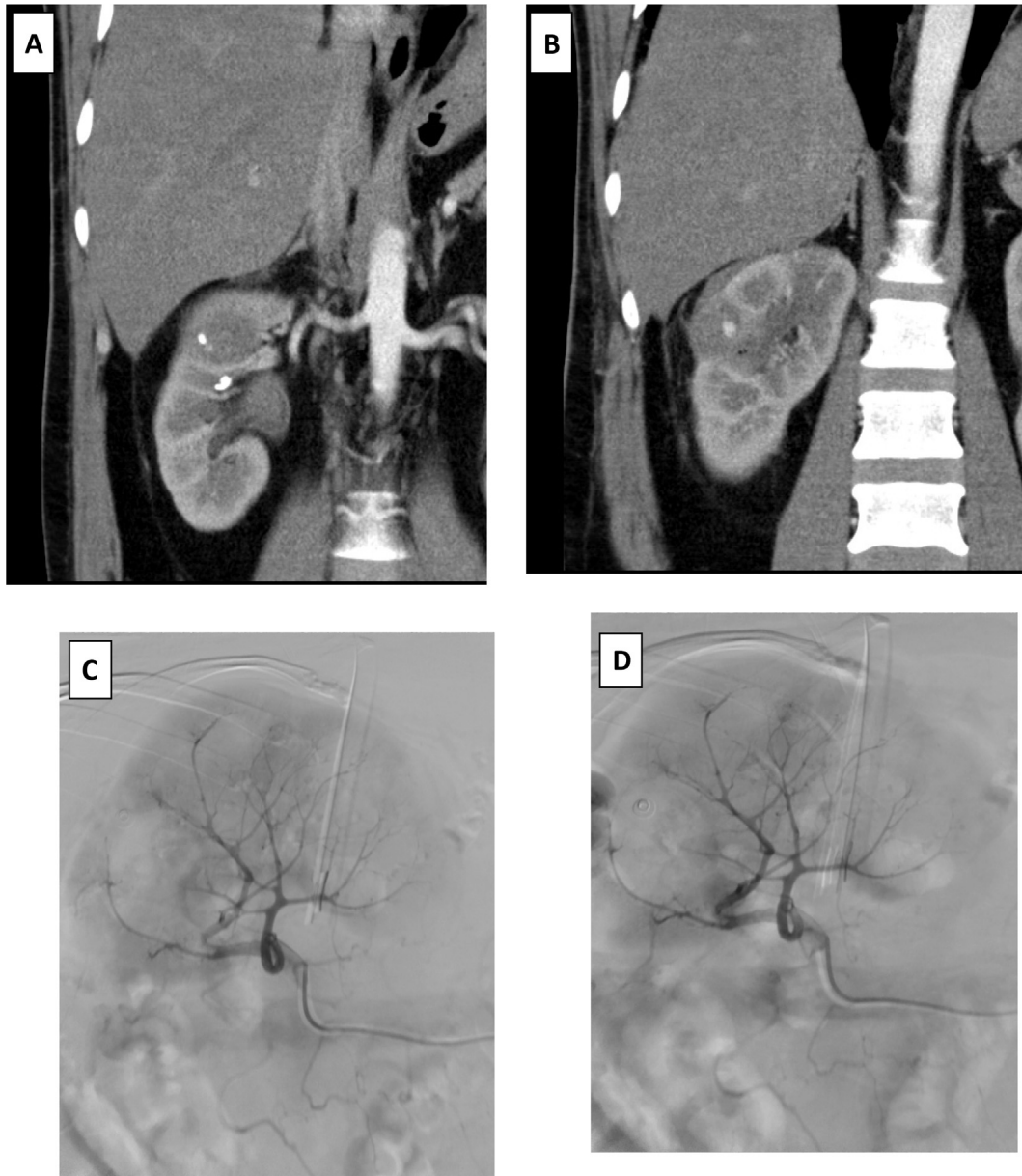
Fig. 4. A 31-year-old female patient had history of stab abdominal wound two weeks ago, she experienced recurrent attack of painless hematuria. Renal CTA (A–C) revealed small pseudoaneurysm at mid zone of the right kidney. Selective and super selective right renal artery angiography (C): revealed normal DSA study, no vascular lesions. Spontaneous improvement was achieved on follow up.

5. Conclusion

CTA has been shown to be effective for evaluating renal vascular injury, CTA performed with MIP is extremely accurate and widely replaced DSA in detection of renal vascular injury especially pseudoaneurysm but renal DSA is still best modality in detection of RAVF.

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