Acute Flank Pain: Multi-detector Computed Tomographic Evaluation in the Emergency Room

Yeliz Aktürk, Serra Özbal Güneş, Baki Hekimoğlu
Clinic of Radiology, Dışkapı Yıldırım Beyazıt Training and Research Hospital, Ankara, Turkey

Abstract

Acute nontraumatic pathological conditions of the kidneys include frequent hematuria, renal colic, and acute renal failure. Infections and renal vascular problems are frequently encountered in an emergency department. In this pictorial review, we aim to discuss patterns of acute renal pathologies and explain hints for differential diagnosis with computed tomographic findings.

Keywords: Renal, tomography, flank pain

Introduction

Various renal pathologies can be detected by computed tomography (CT) in patients referring to the emergency room with acute abdominal pain. Emergency physicians and radiologists often play an important role in the evaluation and management of acute renal diseases.

In the diagnosis of acute renal pathologies, anamnesis, clinical and laboratory findings, and physical examination are of primary importance. Imaging methods are of equal importance as these diagnostic methods. Often, ultrasonography is the first choice for imaging. However, there are clinical limitations with ultrasonography. Some of these limitations are: the need for patient cooperation, the presence of artifacts due to intestinal gases, and some technical disadvantages in diagnosing the vascular pathologies. It is also easier to exclude other non-kidney causes such as acute appendicitis, psoas abscess, diverticulitis, which cause abdominal pain with CT. Although CT involves radiation exposure, contrast agent allergy, and contrast nephropathy risks (in some patients), it is a fast performing modality with a high diagnostic value that should be preferred when ultrasonography is insufficient. It provides more anatomical details than ultrasonography. Renal perfusion defects and parenchymal vascularization problems can also be demonstrated using contrast media.

Early recognition, diagnosis, and management of renal disease have important implications for long-term morbidity and mortality.

Acute pathological conditions of the kidneys may be classified as traumatic and non-traumatic. The non-traumatic admissions to the emergency department are frequent hematuria, renal colic, and acute renal failure. Infections and renal vascular problems are also frequently encountered in the emergency department. In this pictorial review, we aim to discuss patterns of acute non-traumatic renal pathologies and explain hints for differential diagnosis with findings from CT imaging.

Hematuria

Hematuria is commonly seen in a wide spectrum of urinary diseases (1). The causes of gross hematuria are urinary system infections, urolithiasis, and neoplasms of genitourinary system (2).

Hematuria may be evaluated by multi-detector CT (MDCT) of nephrographic, excretory phase, or without contrast. MDCT without contrast helps evaluate nephrolithiasis which is one of the main reasons of hematuria and allows imaging from the kidney to the bladder (3).

A typical CT urography procedure obtains non-contrast images, and nephrographic phase images are obtained 90-100 s after intravenous nonionic contrast injection (100-150 mL of 300 mg I/mL at 2-4 mL/s, 2.5- to 5-mm slice thickness) (4).

Correspondence to: Yeliz Aktürk e-mail: yelizakturk@yahoo.com
Received: 21.06.2016 • **Accepted:** 15.01.2017

DOI: 10.5152/eajem.2017.02986

Renal parenchymal abnormalities, especially masses, are best visualized via nephrographic phase images by which other abdominal organs can also be evaluated. Delayed thin slice images from the kidneys to the bladder reveal contrast distended urinary system and are used to detect uroepithelial diseases (3). Pyelographic phase images are obtained 5-15 min after contrast administration and are used to evaluate uroepithelium. However, economical analyses reveal that MDCT are most cost-effective in patients with persistent hematuria and normal ultrasonographic findings (4).

Renal cell carcinoma and transitional cell carcinoma have typically higher density than urine and their densities are measured to be 5-30 Hounsfield units (HU) in CT without contrast administration. Malignant renal and urothelial tumors show early contrast enhancement and washout (4, 5). Thus, in the nephrographic phase, contrasted urothelial lesions may be detected in urine with low density (Figure 1).

Increase in density up to more than 20 HU after contrast administration is a sign of malignancy (4, 6). Infiltration may cause focal delays in contrast enhancement. Ureteric obstruction maybe best visualized in nephrographic phase and can be easily distinguished from a stone. The other findings of transitional cell carcinoma are thickening of the wall, stenosis, and infiltration of periurethral fat tissue (4).

Figure 1. The axial abdominal computed tomography (CT) images of a patient obtained in the nephrogram phase because of hematuria. The lesion was diagnosed as transitional cell carcinoma (white arrow) which fills the left renal sinus and shows contrast enhancement, solid lesion with a density higher than urine

Renal colic and urolithiasis

Acute flank pain and renal colic are commonly encountered in emergency departments. The lifetime incidence of urolithiasis is approximately 12% (7, 8). The patients are generally between 30 and 60 y, and the occurrence is three times more common in men (7). It has been shown in many studies that abdominal CT without contrast administration has a higher specificity and sensitivity for detecting stones in the urinary system compared with other modalities (9).

Multi-detector CT without contrast is a fast and reliable diagnostic method for urinary stones. There is no requirement of intravenous contrast administration and thus allergic--anaphylactic reactions and nephrotoxicity risks do not exist. The analysis maybe performed in a very short time and has a high sensitivity for distinguishing stones and other causes of renal colic (7). However, there is radiation exposure in CT. Thus, nowadays low-dose tomographic studies are gaining importance. Researchers have reported that in patients with acute abdomen who refer to the hospital with urinary colic CT examinations with low-dose radiation (25 mAs) have the same diagnostic sensitivity as the examinations with standard radiation dose (100 mAs) (10). McLaughlin and colleagues stated that the use of iterative reconstruction techniques increases diagnostic ability (11).

However, on some occasions of renal anomaly and variations such as duplication of renal collective system, CT urographic study, which includes excretory phase after intravenous contrast administration, may be useful for diagnosis (Figure 2).

Increase in kidney dimensions may be observed because of swelling and edema in acute obstructions. This has been reported at an incidence of 36%-71% in different studies. Perinephritic edema has been reported in 36%-82% of the patients. Decrease in renal density due to obstruction may be seen in patients with kidney stone (9). Hydronephrosis, hydroureter, and perinephritic fat stranding have a predictivity of 90% for obstruction of the urinary system due to stone disease (4, 12).

Urinary tract infections

Bacterial nephritis has a wide spectrum ranging from acute pyelonephritis (APN) to renal abscess and emphysematous pyelonephritis (EPN) (13). Recent reports imply the importance of early imaging. Shen and Brown stated that early imaging is cost-effective and advocate imaging in people who are going to be hospitalized by APN (14, 15). Yoo et al. (14) reported that there are clinically significant findings in 16% of the patients. MDCT is important for the detection of abscess and APN. It is superior to ultrasound in renal abnormalities such as perinephric stranding, inflammatory masses, delayed or diminished contrast enhancement, kidney enlargement, or gas formation (13).

Contrasted studies are needed to demonstrate the changes in renal parenchymal perfusion and contrast excretion. The most common findings of APN are areas of wedge shape, focal or global diminished attenuation with unclear borders. Linear bands of hyper- or hypoattenuation parallel to the axis of tubules and collecting ducts may be seen.

The other findings are loss in corticomedullary distinction in early arterial phase and delay in cortical nephrogram. Occasionally, focal pyelonephritis areas may mimic renal tumors (14).

Renal abscess is accumulation of purulent material in renal parenchyma and is caused by hematogenous gram-positive bacteria or ascending gram-negative microorganisms (Figure 3). On MDCT, hypodense lesion due to necrosis and hyperdense peripheral border, which holds contrast, may be encountered (16).

Emphysematous pyelonephritis is a rare, necrotizing infection characterized by gas production in the renal parenchyma (17). Most patients are diabetic, and obstructive uropathy is reported as a risk factor in 90% in different series. It is unilateral in 90% of the cases. The most common pathogens are *Escherichia coli*, *Klebsiella pneu-*

Figure 2. a, b. (a) Ureterolithotomy was performed on a 42-year-old male patient because of a ureter stone seen in his radiogram. The stone could not be found endoscopically in the operation and hence a catheter was placed. Postoperatively, a multi-detector CT (MDCT) in the pyelogram phase was performed. On coronal imaging, urethral duplication, urethral stone in the superior part of the superior ureter (white arrow), and the catheter extending from the collecting structures to the internally located ureter were seen, (b) Coronal image in excretory phase shows dilatation in superior collecting structures and the filling defect in superior ureter (black arrow)

Figure 3. A 53-year-old female patient was admitted to the emergency with fever and flank pain. Axial computed tomography (CT) images in nephrogram phase reveal a lesion in the posterior middle section of the right kidney. Fluid density and minimal peripheral contrast enhancement are consistent with abscess (white arrow). In addition to that, fluid accumulations in the perirenal area (black arrow), perirenal stranding, and thickening of Gerota fascia are visible

moniae, *Proteus mirabilis,* and *Pseudomonas aeruginosa* (18). The prognosis may be mortal if evaluated by X-ray graphy, because the gas in the renal parenchyma may be confused with the intestinal gas (19). CT is useful in detecting the extension of the infection, parenchymal gas formation, and the evaluation of complications (18, 19). There are subtypes of EPN according to the images on the CT. In Type 1, there is parenchymal destruction but no fluid collection or gas extension from medulla to cortex. Subcapsular or perinephral crescentic gas formation may be seen. The nonexistence of fluid collection is the result of a weak immune response. Mortality rate is high (66%). However, in type 2, there exist confined, bubbly, intrarenal gas pattern, renal and perirenal fluid collections, and gas formation in renal pelvis. Mortality rate is nearly 18% (19). Formation of gas may reach perirenal region, renal vein, and inferior vena cava (Figure 4, 5).

Renal vascular pathologies

Arterial dissections are frequent in malignant hypertension, atherosclerosis, trauma, fibromuscular dysplasia, connective tissue diseases such as Marfan syndrome, Ehler-Danlos syndrome (20-22). Cocaine abuse and extracorporeal shock wave lithotripsy cases were also reported (22). The most common localization of primary dissection of perinephric arteries is renal arteries (20). The extension of false lumen may cause a narrowing in the true lumen, and diminished renal blood flow may cause renal infarct. Less than 25% of renal artery dissections occur spontaneously and frequently in men of fourth

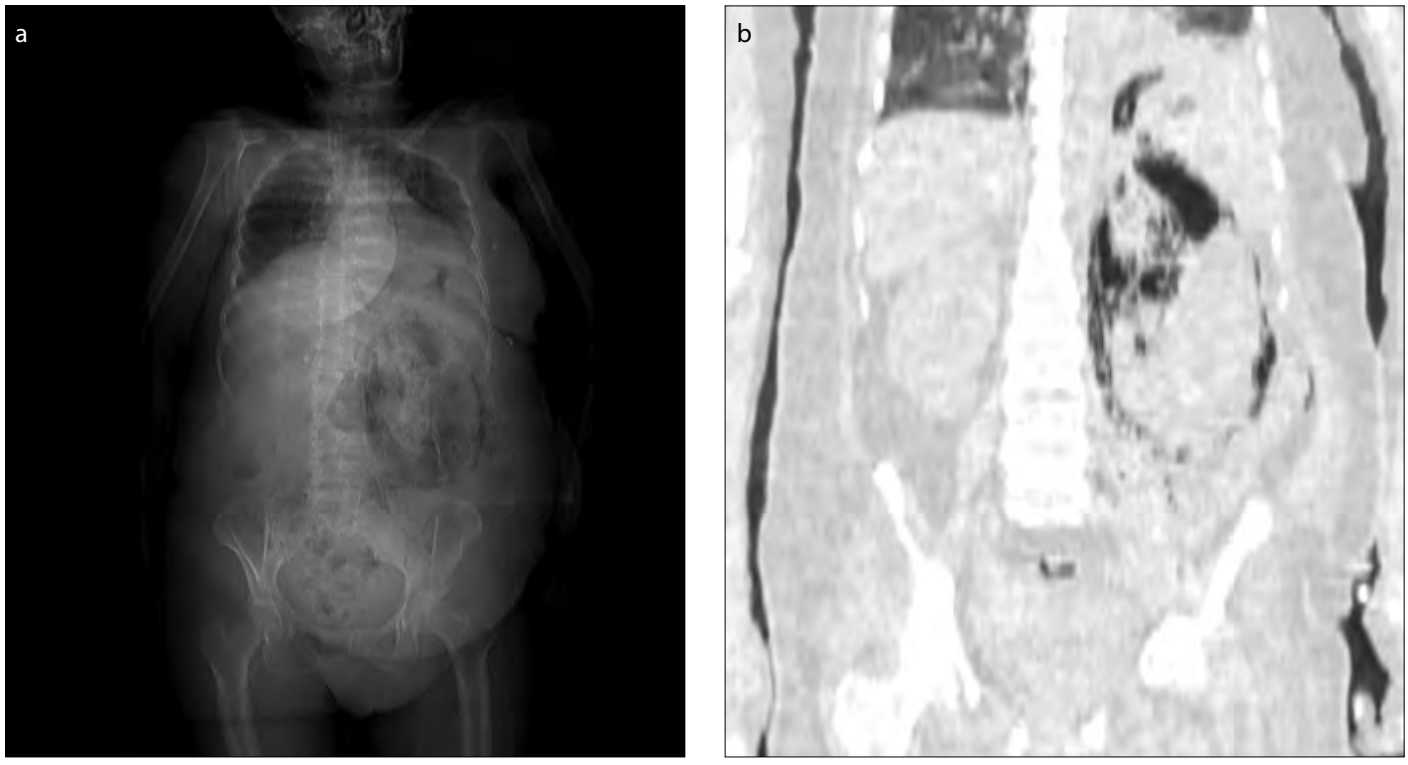

Figure 4. a, b. (a) Abdominal scans of a 56-year-old female patient who was admitted to the emergency department with high fever and flank pain and (b) reconstructed image in coronal lung window. In the upper left quadrant, in the left renal region, there is abundant air which can be differentiated from the intestinal gas

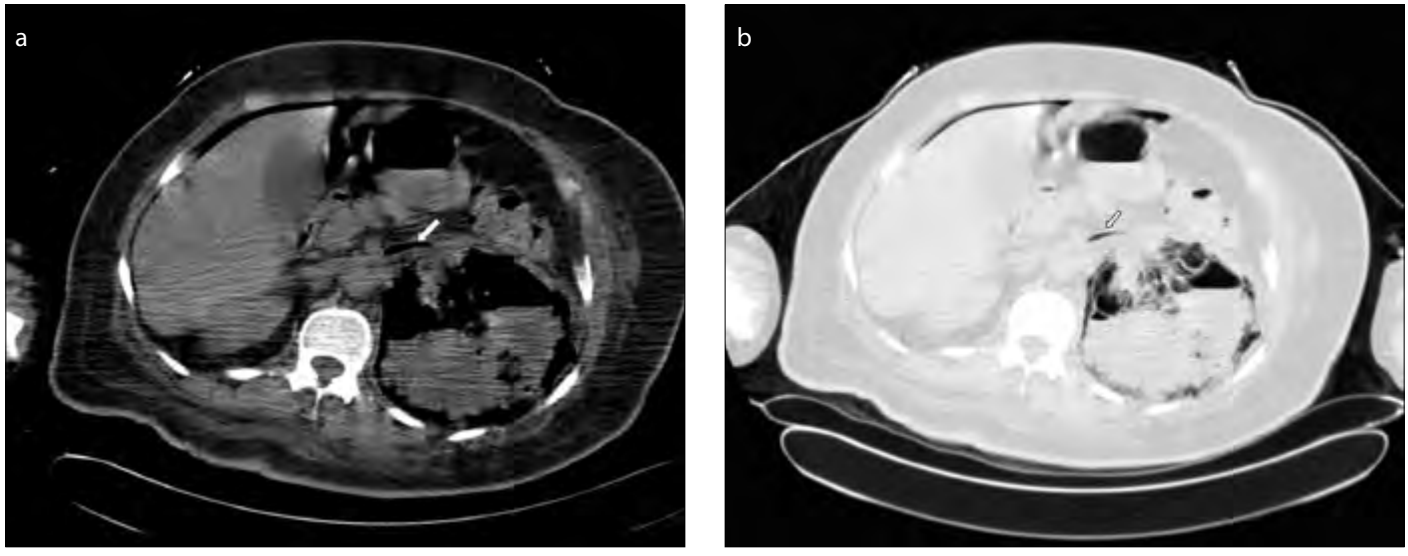

Figure 5. a, b. (a) Axial images after contrast administration: parenchymal and (b) lung window. Left renal dimensions are enlarged. In the renal cortex, renal pelvis, and perirenal region, there is abundant air density and the borders of renal cortex and medulla are lost. Air density extends into the left renal vein (arrow)

and fifth decades with no previous health problems (20, 23). The most common clinical presentation is persistent and severe hypertension with an acute onset. However, severe upper abdominal pain resembling a renal colic may also be seen (24). Because of this, even if there is no history of trauma in a patient with acute flank pain and hypertension, isolated renal artery dissection may also be taken into consideration (20, 25). Angiography with catheter is a gold standard in diagnosis; however, it is possible to evaluate by CT angiography noninvasively (22, 25). In CT renal perfusion defects, areas without contrast enhancement and hypodense image in renal artery may be seen (Figure 6).

Conclusion

Acute renal pathologies are a wide spectrum of diseases which may be life-threatening. Early diagnosis is important in prognosis,

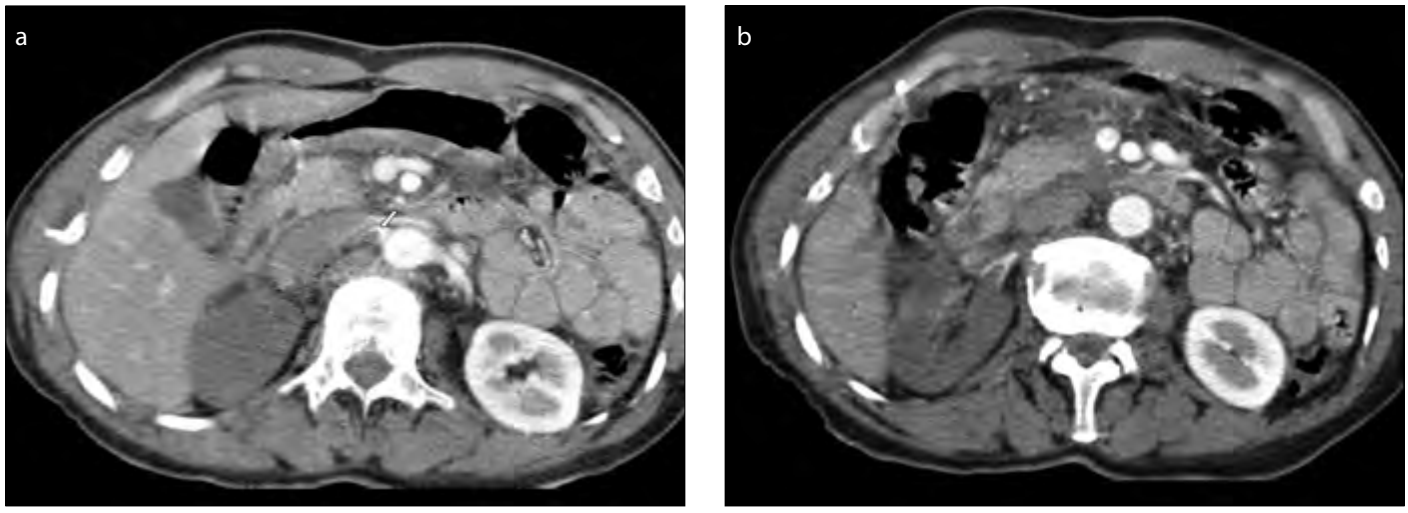

Figure 6. a, b. (a) Axial abdominal computed tomography (CT) of a patient after contrast administration. The patient is 45- years-old and he has right flank pain with hematuria and hypertension with no history of trauma. The sign of a false lumen without contrast filling at the level of the right renal artery orifice (arrow) and delay in the nephrogram phase in the right renal parenchyma, (b) There is no contrast enhancement in the right kidney even if the left kidney is in nephrogram phase

early onset of therapy, and in decreasing complications. MDCT is an important modality in acute renal pain.

Informed Consent: Written informed consent was obtained from patients who participated in this study.

Peer-review: Externally peer-reviewed.

Conflict of Interest: No conflict of interest was declared by the authors.

Financial Disclosure: The authors declared that this study has received no financial support.

References

1. Song JH, Beland MD, Mayo-Smith WW. Incidental clinically important extraurinary findings at MDCT urography for hematuria evaluation: Prevalence in 1209 consecutive examinations. AJR AM J Roentgenol 2012; 199: 616-22. [CrossRef]
2. Dames EL, Ng LG, Tay KH. Congenital renal arteriovenous malformation presenting with gross hematuria after a routine jog: a case report. J Med Case Rep 2014; 8: 65-70. [CrossRef]
3. Joffe SA, Servaes S, Okon S, Horowitz M. Multi-detector row CT urography in the evaluation of hematuria. Radiographics 2003; 23: 1441-55. [CrossRef]
4. O'Connor OJ, McLaughlin P, Maher MM. CT Urography. AJR Am J Roentgenol 2010; 195: 201-6. [CrossRef]
5. Lang EK, Macchia RJ, Thomas R, Watson RA, Marberger M, Lechner G, et al. Improved detection of renal pathologic features on multiphasic helical CT compared with IVU in patients presenting with microscopic hematuria. Urology 2003; 61: 528-32. [CrossRef]
6. Silverman SG, Leyendecker JR, Amis ES Jr. What is the current role of CT urography and MR urography in the evaluation of the urinary tract? Radiology 2009; 250: 309-23. [CrossRef]
7. Patatas K, Panditaratne N, Wah TM, Weston MJ, Irving HC. Emergency department imaging protocol for suspected acute renal colic: re-evaluating our service. Br J Radiol 2012; 85: 1118-22. [CrossRef]
8. Kirpalani A, Khalili K, Lee S, Haider MA. Renal colic: comparison of use and outcomes of unenhanced helical CT for emergency investigation in 1998 and 2002. Radiology 2005; 236: 554-8. [CrossRef]
9. Akay H, Akpınar E, Ergun O, Ozmen CA, Haliloğlu M. Unenhanced multidetector CT evaluation of urinary stones and secondary signs in pediatric patients. Diagn Interv Radiol 2006; 12: 147-50.
10. Licheng J, Yidong F, Ping W, Keqiang Y, Xueting W, Yingchen Z, et al. Unenhanced low-dose versus standard-dose CT localization in patients with upper urinary calculi for minimally invasive percutaneous nephrolithotomy (MPCNL). Indian J Med Res 2014; 139: 386-92.
11. McLaughlin PD, Murphy KP, Hayes SA, Carey K, Sammon J, Crush L, et al. Non-contrast CT at comparable dose to an abdominal radiograph in patients with acute renal colic; impact of iterative reconstruction on image quality and diagnostic performance. Insights Imaging 2014; 5: 217-30. [CrossRef]
12. O'Connor OJ, McSweeney SE, Maher MM. Imaging of hematuria. Radiol Clin North Am 2008; 46: 113-32. [CrossRef]
13. Lim SK, Ng FC. Acute pyelonephritis and renal abscesses in adults--correlating clinical parameters with radiological (computer tomography) severity. Ann Acad Med Singapore 2011; 40: 407-13.
14. Yoo JM, Koh JS, Han CH, Lee SL, Ha US, Kang SH, et al. Diagnosing acute pyelonephritis with CT, Tc-DMSA SPECT, and doppler ultrasound: a comparative study. Korean J Urol 2010; 51: 260-5. [CrossRef]
15. Shen Y, Brown MA. Renal imaging in pyelonephritis. Nephrology (Carlton) 2004; 9: 22-5. [CrossRef]
16. Piccoli GB, Consiglio V, Deagostini MC, Sera M, Biolcati M, Ragni F, et al. The clinical and imaging presentation of acute non complicated pyelonephritis: a new profile for an ancient disease. BMC Nephrol 2011; 12: 68. [CrossRef]
17. Arsene C, Saste A, Arul S, Mestrovich J, Kammo R, Elbashir M, et al. A case series of emphysematous pyelonephritis. Case Rep Med 2014; 2014: 587926. [CrossRef]
18. Nasr AA, Kishk AG, Sadek EM, Parayil SM. A case report of emphysematous pyelonephritis as a first presentation of diabetes mellitus. Iran Red Crescent Med J 2013; 15: e10384. [CrossRef]
19. Saxena D, Aggarwal L, Tudu SK, Thomas S. Emphysematous pyelonephritis-a rare surgical emergency presenting to the physician: a case report and literature review. Indian J Surg 2013; 75: 272-4. [CrossRef]
20. Bayram Y, Turgut F, Kırbas I, Kanbay M. Idiopathic spontaneous renal artery dissection: a rare case. Turk Neph Dial Transpl 2010; 19: 206-8. [CrossRef]

21. Alamir A, Middendorf DF, Baker P, Nahman NS Jr, Fontaine AB, Hebert LA. Renal artery dissection causing renal infarction in otherwise healthy men. Am J Kidney Dis 1997; 30: 851-5. [CrossRef]
22. Afshinnia F, Sundaram B, Rao P, Stanley J, Bitzer M. Evaluation of characteristics, associations and clinical course of isolated spontaneous renal artery dissection. Nephrol Dial Transplant 2013; 28: 2089-98. [CrossRef]
23. Lok SY, Chalvardijan A, Common AA. Primary renal artery dissection. Can Assoc Radiol J 1995; 46: 54-6.
24. Kanofsky JA, Lepor H. Spontaneous renal artery dissection. Rev Urol 2007; 9: 156-60.
25. Tandon G, Sukhija R. Isolated spontaneous renal artery dissection: a case report and review. Int J Angiol 2012; 21: 99-102. [CrossRef]