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RESEARCH ARTICLE

IMAGING EVALUATION OF IATROGENIC RENAL VASCULAR INJURIES AND THEIR ENDOVASCULAR MANAGEMENT

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Abstract

Objective: To study the role of USG Doppler, CT renal angiography in evaluation of iatrogenic renal vascular injuries and to assess the effectiveness & safety of endovascular intervention of Iatrogenic Renal Vascular Injuries (IRVIs).

Materials and methods: A total of 23 patients with IRVIs were initially evaluated with USG Doppler followed by CT angiography and DSA was performed in 20 patients. Four out of 23 patients showed spontaneous resolution as confirmed by preprocedural USG Doppler. Endovascular embolization of IRVIs was performed using micro coils in 19 patients. Technical success was confirmed at the end of the procedure by a renal angiogram. The patients were followed up for a period of 6 months to assess the clinical success.

Results: The most common cause of IRVI in our study was PCNL seen in 16(70%) patients followed by Partial Nephrectomy and PCN. All patients presented to us within 10-14 days of the etiological event with hematuria flank pain or drop in hematocrit. USG was able to detect IRVIs in the form of RAPs in 17(74%) and perirenal/intrarenal hematoma in 2(7%) cases. CT angiography was able to detect IRVIs in all the patients, however, additional aneurysms in two patients were not detected which were later seen on DSA renal angiography. Embolization was performed for 21 aneurysms in 19 patients using micro coils and showed 100 % technical and clinical success.

Conclusion: USG Doppler and CT angiography play a very important role in diagnosis of iatrogenic renal vascular injuries. Endovascular embolization is an effective and safe method for management of injuries.

Introduction:-

Iatrogenic renal injuries account for 50% of renal injuries [1, 2]; 15% of all invasive surgical or percutaneous procedures cause vascular injuries. [3-5] Nephrolithotomy for higher urinary stones currently uses a percutaneous technique. [6] Patients experience severe haematocrit drops, ongoing hematuria, or growing perirenal bleeds that cause loin pain. [7] Moreover, between 70 and 80 percent of vascular injuries heal on their own [8]; only severe bleeding, declining renal function, or renal haemorrhage that lasts longer than 72 hours require treatment. [8,9] Pseudoaneurysm, arteriovenous fistula (AVF), active bleeding, etc. are examples of iatrogenic renal vascular injuries (IRVIs). According to reports, these renal arterial injuries can be treated with selective transcatheter artery embolization, a less invasive procedure (TAE). [10-13] The preferred course of treatment is endovascular, with

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angiography and targeted embolization anticipated to reduce renal tissue loss. [14-22] Iatrogenically-related renal vascular injuries: aetiology. They result from a range of surgical and endourological treatments, such as partial nephrectomy and percutaneous nephrolithotomy, percutaneous nephrostomy, percutaneous renal biopsy, and endopyelotomy. Other uncommon reasons include Double-J catheter insertion via the ureter for urine drainage and Percutaneous transluminal renal artery angiography. [23] Both PCNL and PCN are linked to particular difficulties with accessing the collecting system and the nephrostomy tract. Injuries that could result from puncturing and dilating the nephrostomy tract include lacerations, haemorrhage, parenchymal lesions, and vascular lesions, according to Michel et al. [24] Iatrogenically-related renal vascular injuries result from numerous surgical and endocrine procedures. Image-guided catheter placement and insertion into the renal collecting system is referred to as PCN. [18] If the catheter is large enough to allow drainage of the urine collecting system or if a nephrostomy tract is sufficiently dilated to allow a planned intervention through the tract itself, this will be successful (such as PCNL). During a percutaneous nephrolithotomy, a rigid nephroscope is inserted into a sufficiently dilated nephrostomy route to remove a renal or proximal ureteral calculus. Large stones may occasionally be broken up before being removed using a percutaneous access tract. PCN is indicated for urinary obstruction caused by intrinsic or extrinsic sources (stones, malignancy, iatrogenic), infected hydronephrosis/pyonephrosis, urinary leakage or fistulas, access for other interventional procedures such as PCNL or antegrade ureteral stent placement, foreign body retrieval, chemotherapy delivery, urinary diversion for hemorrhagic cystitis, and emergent drainage in settings of severe shock due to urosepsis. [18,23] Because to high technical success rates in the 90% range, PCNL has now largely supplanted open surgery for the extraction of practically all forms of renal calculi in patients of all ages [23, 25]. Although percutaneous renal procedures are increasingly being used as the first line of treatment for a variety of renal and ureteral diseases, problems are still a possibility with PCN and PCNL. To avoid vascular damage, interventional radiologists traditionally target Brödel’s line under fluoroscopic or ultrasound guidance for needle entry and access to the center of a posterior-facing, dorsolateral calyx.[36] The renal vein and renal artery lie in the central part of the kidney, with the renal pelvis located posteriorly to these vessels. If this central portion of the renal pelvis is punctured at any time during access or stone removal, a major vascular structure may be injured, resulting in bleeding and other potential vascular complications. In addition, urinary leakage could occur due to incomplete sealing of the catheter tract, as the renal pelvis may not be completely surrounded by renal parenchymal tissue.[23] An increased number of punctures and improper puncture site, for example, too medial of an approach, can be blamed for the development of vascular complications following percutaneous procedures. Therefore, it is of paramount importance to adhere to Brödel’s line during initial access.[36] Even correct technique can result in iatrogenic renal vascular injuries. [37] The most common cause of bleeding from renal vessels after these procedures is the formation of a pseudoaneurysm or AVF.[29] These vascular lesions form when the nephrostomy tract passes close to or directly posterior to the renal hilum, which can cause laceration of interlobar and lower-pole arteries. The resulting damage in a high-pressuresystem will cause leakage into a lower pressure venous system, forming an AVF, or into renal parenchyma or hilar tissue, forming a pseudoaneurysm. On the other hand, lacera-tion of larger anterior or posterior segmental arteries usually causes severe acute bleed-ing.[27] Several authors have identified factors associated with an increased risk of form-ing vascular lesions and hemorrhage after PCNL. [29,32,35] The presence of partial stag-horn calculi, multiple nephrostomy tracts, the Amplatz method of dilation and total stone burden/surface area of >1,000 mm2 are significant predictors of blood loss.[32] In one study, multiple nephrostomy tracts and the presence of staghorn calculi significantly pre-dicted severe bleeding, defined as hemodynamic instability requiring blood transfusion and super selective embolization for treatment.[35] The presence of a solitary kidney, in-experienced operator, and upper caliceal puncture are also significant risk factors for se-vere bleeding. [32] In their report, ElNahas et al [35] described physiologic compensatory hypertrophy and increased size of solitary kidneys leading to an increased risk of bleeding with more damage to renal tissue and vascular supply. In addition, upper caliceal punc-tures requiring a more oblique and longer nephrostomy tract often result in changes to the direction of the tract and a higher rate of injury to adjacent parenchyma and vasculature. Arteriosclerosis, diabetes mellitus, hypertension and advanced age also predispose a pa-tient to renal bleeding.[27] Finally, Srivastava et al concluded that mean stone size signif-icantly predicted severe vascular lesions following PCNL for symptomatic stone dis-ease.[29] Clinically, patients with iatrogenic renal vascular injuries present with non-resolving postoperative gross hematuria, unremitting unilateral flank and/or loin pain, continued hemorrhage from the nephrostomy site, acute increase in serum creati-nine, or a drop in hemoglobin/hematocrit that could manifest as hemodynamic instabil-ity.[25,26] Vascular injuries such as AVF and pseudoaneurysm may manifest even 3 weeks after the initial percutaneous procedure.[24]

Radiologists play a key role in the diagnosis of these injuries. Colour Doppler so-nography and Computed Tomography (CT) scan are usually the first imaging modalities in the evaluation of patients with suspected renal vascular injuries. CT scan provides in-formation similar to that of renal Doppler sonography, yet with more detail owing to its high spatial resolution. The advantage of Computed Tomography and Magnetic Reso-nance Imaging over US is the ability to provide a more comprehensive assessment of the renal vascular anatomy with multiplanar imaging and reconstruction, which is non-operator dependent. Digital Subtraction Renal angiography still remains the gold standard in imaging of renal vasculature, however it is rarely performed solely in a diag-nostic context due to its invasive nature so it is reserved mainly for cases aimed with therapeutic goal in mind or in cases where diagnosis is unclear. Ierardi et al suggested that a post-renal procedure patient presenting with acute flank pain or gross hematuria should undergo color Doppler sonography, Contrast Enhanced Computed Tomography (CECT), or Magnetic Resonance Angiography (MRA).[26] Some authors describe renal an-giography as the primary imaging study to evaluate those patients with significant post-operative hemorrhage because of the high likelihood of a positive angiogram and the op-portunity to intervene. [25] Colour Doppler sonography is important in non-invasivefol-low up of patients who have undergone percutaneous and vascular interventional proce-dures, and in patients who are at risk of developing renal vascular complications like pseudoaneurysm, artero-venous fistula etc. In pseudoaneurysm, Doppler sonography shows swirling, bidirectional blood fow within the lesion. Renal angiography confirms the finding and also helps in detecting the site of pseudoaneurysm and clearly displaying the renal artery branch from which it arises. In artero-venous fistula, colour Doppler sonography shows complex high frequency pulsatile flow. Retroperitoneal hematomas and AVFs can be detected using duplex ultrasound. However, Vignali et al reported that 4 of 10 pseudoaneurysms in their patient sample were not identified with duplex ultrasound.[27] The development of multislice CT scanners has increased both the sensitivity and specificity in identifying renal vascular lesions. CT has become the imaging modality of choice for the evaluation of renal trauma and other associated injuries, providing the essential anatomic and functional information necessary to determine the type and extent of parenchymal, vascular or collecting system injuries and associated abdominal injuries. In addition, CT can help detect active hemorrhage and urine leakage and is of great help in guiding transcatheter embolization and delineating preexisting disease entities that may predispose to post traumatic hemorrhage. In fact, CT may be the first choice to detect iatrogenic kidney injury.[28] CT confers the added advantage of imaging the entire genitourinary tract in addition to the kidneys. Moreover, CT angiography is very highly sensitive in revealing renal vascular injuries in even the most peripheral sites. On CT angiography, hemorrhage is seen as active extravasation of contrast [26] and AVFs can be detected during the arterial phase, during which there will be early or simultaneous opacification of one or several intrarenal arteries and veins. A pseudoaneurysm presents as an ovoid or round contrast-containing abnormality that communicates with a ruptured vessel wall. [38-41] With these developments, renal angiography now shares a more limited diagnostic role and should be used primarily when planning a percutaneous intervention. MANAGEMENT Most renal vascular injuries are minor and resolve spontaneously with conservative treatment[26] but some of these injuries are potentially life threatening and necessitate rapid clinical evaluation and treatment.[42] During PCNL itself, excessive bleeding is usually venous and easily controlled by noninvasivemaneuvers, such as clamping the nephrostomy tube, Kaye balloon tamponade, adequate hydration, mannitol administration or placement of a larger nephrostomy tube.[29] Conversely, arterial injuries result in significant bleeding, which may not only result in formation of AVF or pseudoaneurysm but may also require invasive procedures for bleeding cessation and prevention of loss of renal function. In the past, treatment of acute iatrogenic injury of the renal artery consisted of an open procedure with renal artery ligation followed by bypass graft placement or nephrectomy.[26] However, technological advances in minimally invasive endourological procedures and other conservative treatments have shifted the paradigm of management away from initial surgery. One of the most widely accepted treatment strategies is now Super selective Renal Artery Embolization (SRAE). In fact, SRAE is now accepted as the most appropriate treatment of iatrogenic renal vascular pseudoaneurysms that arise peripherally in the kidney and does not respond first to conservative maneuvers.[27,30] Emergency TAE is an effective treatment modality for management of hemodynamically unstable patients with renal pseudoaneurysm or renal arteriovenous fistula.[43] In addition, this presents a unique instance in which diagnostic and interventional radiologists are enmeshed in the cause of iatrogenic injury (e.g., by PCN,PCNL, or percutaneous renal biopsy) subsequent diagnosis and initial management. Multiple series havedemonstrated that SRAE for managing renal vascular injury has high technical and clin-ical success rates, with low complication rates. While surgery is generally fraught with more risk of tissue loss and other complications, SRAE often results in less parenchymal tissue sacrifice, when the alternative might be partial or complete nephrectomy. [30,31] SRAE involves the precise identification of the site of the bleeding renal vascular lesion and to provide the highest selectivity possible. Super selective access of the target renal ar-tery branch is achieved using hydrophilic catheters and low-profile microcatheters. An embolic agent is administered via the catheter to perform a distal and irreversible occlu-sion of the target bleeding vessel, with resulting complete hemostasis.[27] By eliminating the pressure head to a vascular lesion such as an AVF or RAP, selective embolization works similarly to surgical ligation of a bleeding vessel, with a lower risk of further parenchymal injury.[27] The choice of embolic agent varies widely in the published liter-ature and is oftentimes reported as dependent on the operator's preference. Sole use or a combination of gelatin sponges, micro coils, polyvinyl alcohol particles, n-butyl cy-anoacrylate, iodized oil mixture, or microspheres has been reported.[26] Each embolic material has its own advantages. Gelatin sponges are biodegradable and can be used re-peatedly until the target lesion is occluded, while micro coils are known for greater effica-cy and ability to be administered more distally and selectively to minimize parenchymal loss. Nevertheless, the embolic material should be chosen with consideration of the site, size and flow pattern of the target vasculature as well as institutional availability and ex-perience of operator.[32] The technique of trans-catheter renal artery embolization is usu-ally straight forward. The renal artery is catheterized using a femoral approach. A 6 French (6F) vascular sheath is placed in the desired vein using modified Selinger tech-nique and 4 or 5 F C2 Cobra catheter is inserted in renal artery directly or after doing flush aortography to reveal the origin of the renal vein in difficult cases. Super-selection of the targeted vascular lesion can be achieved using micro catheters.[33] The vascular lesion is then embolized using different embolic agents, each suited to a different type of vascular pathology, where vascular coils are used in pseudoaneurysms and in proximal occlusion of extravasating arteries as well as AV fistulae at the arterial side. Polyvinyl Alcohol parti-cles (PVA) are used to embolize vascular lesions with multiple collateral arterioles and vascular beds especially with tumors. Gelatin sponge "Gel Foam" pledges are used with small temporary iatrogenic bleeders; it also can be used when other agents are not availa-ble and on emergency basis.[33] Technical success in the majority of SRAE series is de-fined as complete occlusion of the targeted bleeding site or vascular lesion on angi-ography. Meanwhile, clinical success is described as the lack of clinical or imaging evi-dence of further bleeding after SRAE, such as the absence of hypotension, gross hematuria, or retroperitoneal hematoma. Two recent series illustrate the high technical and clinical success rates of SRAE. [26,30).

Materials and Methods:-

Type of study: It was a prospective study conducted in north India from Sept. 2018 for a pe-riod of two years. Ethical approval was obtained from the institutional ethics committee.

Subjects:

All suspected cases of renal vascular injury following renal intervention, irrespec-tive of age and gender, were included in the study. Renal vascular injury was suspected in the presence of persistent haematuria, flank pain, drop in haematocrit or continuous bleeding from the nephrostomy site. Patients who had history of allergy to iodinated con-trast were excluded from the study.

Clinical and Demographic profile:

Clinical data was acquired from the medical records. The type of procedure performed and clinical features were documented for each patient.

Imaging Technique:

All suspected cases of iatrogenic renal vascular injury were evaluated by a Doppler USG at the time of presentation followed by CT angiography in all patients. All CT angiographies were performed with non-contrast, arterial and venous phases us-ing Iodinated IV contrast agent.

Image Analysis:

The images were reviewed on a dedicated CT console along with recon-struction techniques like 3D, MPR, VRT for features of the IRVI including contrast en-hancement, contrast extravasation, size, the segmental branch of origin, and any renal ar-terial variations were noted. IRVI findings were described as follows: Evidence of contrast medium extravasation during the arterial phase, expanding in the venous phase, was used to define active bleeding [13] The presence of a perivascular contrast medium, with the same enhancement of the neighbouring artery and the same size during all phases, was used to identify pseudoneurysms [13] Early (arterial) opacification of renal vein indi-cates an arteriovenous fistula. Main and segmental artery-related IRVI were categorized as proximal, whereas interlobar, arcuate, and interlobular artery-related IRVI were catego-rized as distal. On CT, the degree of injury was identified, and confirmed by DSA diagnos-tic runs during the RAE procedure.

Endovascular Embolization technique:

Common femoral artery was punctured with a 18 gauge single wall puncture needle and vascular assess secured with a 6F vascular sheath. Initially DSA aortogram was obtained to visualize the vascular anatomy. Catheters like

RDC& COBRA were used for hooking the Renal vessel based on the type of origin as as-sessed on CT angiography. Selective/super selective renal arteriogram on the side of injury was obtained using a micro catheter (PROGREAT) to confirm the presence of injury, ob-tain size of the feeding vessel and look for additional pseudoaneurysms if any missed-on CT angiography. Embolization of the feeding vessel done in almost all patients, using mi-cro coils that were approx. 25% larger in size than the feeding vessel (Figure 1a-1f). Selec-tive renal angiogram was obtained in each case to as determine the technical success.

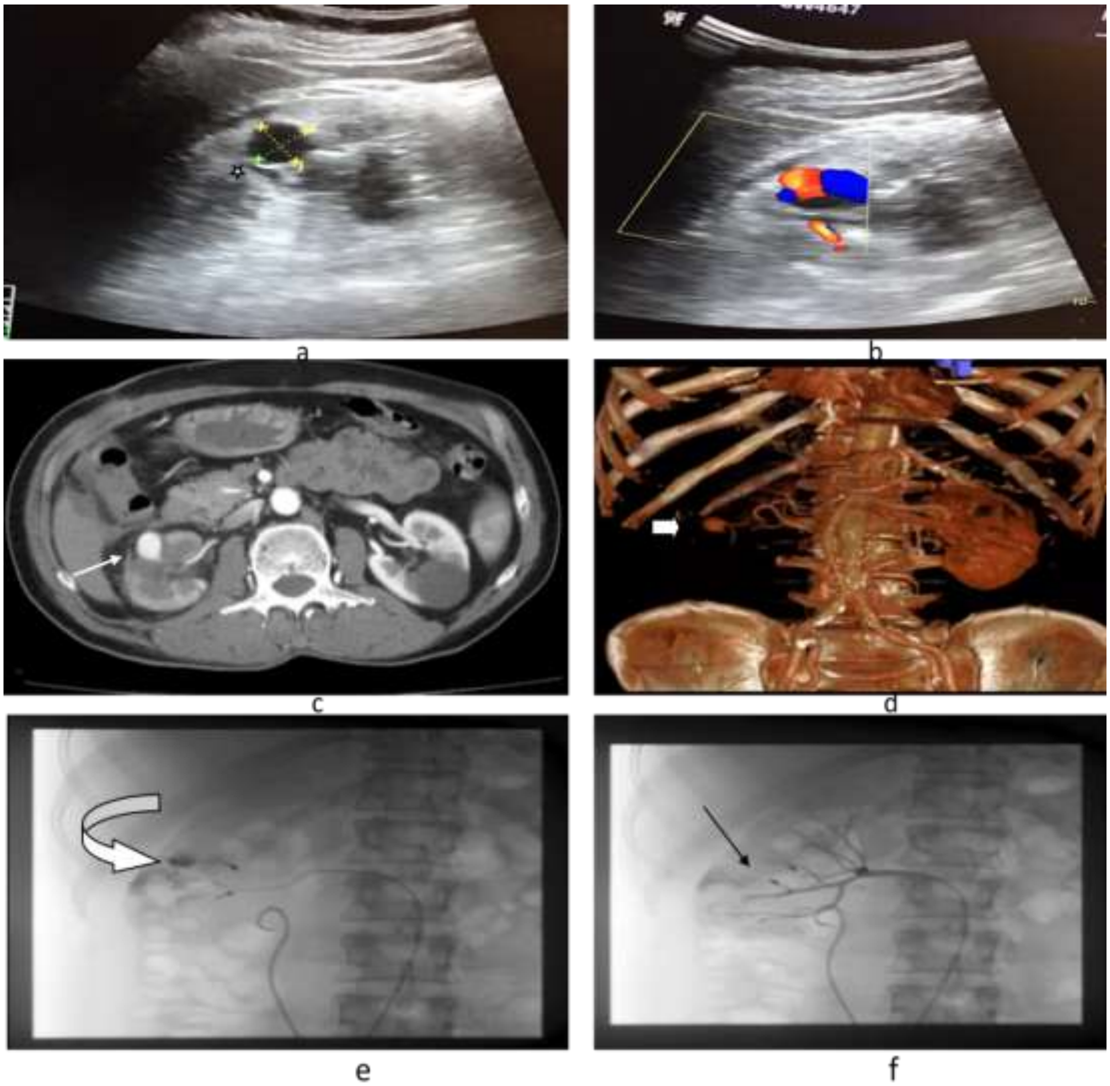

Figure 1(a-f): -Renal artery pseudoaneurysm: 37-year-old male presented with hematuria and decrease in haematocrit after PCNL. USG Doppler(a-b), CT angiography (single black arrow) and CT VRT (white arrow) angiography(d) shows typical features of RAP Yin yang(star)flow(b) at mid pole. DSA renal angiography (e) confirms the diagnostic suspect of RAP (curved arrow) involing interpolar artery which was subsequently embolized (two black arrows) with coils(f).

Results:-

A total number of 23 patients were included in our study. There were 18(78%) males and 5(21%) females. The mean age of the patients was 37.9 ± 4.73 years (range 21 to 64 years). (TABLE1) The causative procedures were percutaneous nephrolithotomy (PCNL) in 16(70%) of our patients, partial nepherectomy in 5(22%) cases and percutaneous nephrostomy (PCN) in 2(8%) cases. The clinical presentation was hematuria with drop in haematocrit in 12(52%), hematuria alone in 9(40%) patients, flank pain with drop in haematocrit and flank pain with bleeding from nephrostomy site in one patient each. Out of 23 patients, 18 (78%) presented between 7-14 days while 5(22%) presented between 14-21 days. The mean time of presentation in our study was 13.3 ± 3.1 days. Among the types of

IRVIs, renal artery pseudoaneurysm was seen in all 23 patients with associated arteriovenous fistula in only one patient.

Table 1:-

USG findings	Number	Percentage
No injury seen	4	17.4
Pseudoaneurysm seen	17	73.9
Arteriovenous fistula seen	0	0.0
Both pseudoaneurysm and AVF seen	0	0.0
Peri renal or Intrarenal haematoma	2	8.6
Total	23	100

USG Doppler was able to detect IRVI in the form of RAP in 17(74%) patients and perinephric haematoma in 2(9%) patients. (TABLE 2) USG findings of RAPs were noted in the form of anechoic area on gray scale and to and fro flow in the form of ying yang sign on color Doppler imaging

Table 2:-

CT Angiographic findings	Number	Percentage
No injury seen	0	0.0
Only Pseudoaneurysm seen	22	96
Both pseudoaneurysm and AVF seen	1	4
Active extravasation	0	0.0
Total	23	100

CT angiography was able to detect IRVI in the form of RAP in all 23(100%) patients. Asso-ciated AVF was seen in one patient. The mean size of the RAP in our study was 5.5 ± 1.5 mm (range 3mm to 10 mm) (TABLE 3)

Table 3:-

DSA renal angiography findings	**Number**	**Percentage**
No injury seen	0	0.0
Only Pseudoaneurysm seen	18	96
Both pseudoaneurysm and AVF seen	1	5.0
Active extravasation	1	5.0
Total	20	100

We performed DSA renal angiography in 20 out of the 23 patients based on hemodynamic instability and CT features. We found 21 RAPs in 19 patients on DSA due to detection of an additional RAPs in 2 patients not seen on CT angiography. One patient out of 19 showed an AVF in addition to RAP. One patient with evidence of RAP on CT showed no RAP on DSA. However, a large RP hematoma was noted in this patient suggesting rup-ture of the RAP (TABLE 4)

Table 4:-

Outcome	**Number**	**Percentage %**
Embolized and improved	19	83.0
Spontaneously improved	4	17.0
Total	23	100

Nineteen patients with IRVI in the form of RAPs and AVF were embolized in the same set-ting using micro coils. Four patients with RAPs resolved spontaneously and were man-aged conservatively. Completion angiography showed technical success with complete exclusion of RAP and AVF from the renal circulation in all the 19 patients (100%). No major complication was encountered in any of the patients. Post procedure renal function was maintained in all patients. All the patients showed improvement in hemodynamic stability and settling of hematuria over 5 to 12 days after embolization. Four patients who were managed conservatively showed spontaneous resolution of RAPs seen on follow up color Doppler USG. Clinical and imaging follow up with USG Doppler at 3 and 6 months revealed complete resolution of symptoms normal doppler study in all patients (TABLE 5)

Iatrogenic injury	Number	Percentage
PCNL	16	69.6
PCN	2	8.7
Partial Nephrectomy	5	21.7
Total	23	100

Discussion:-

Our study was carried out in a tertiary care institute of north India, in the Depart-ment of Radio diagnosis & Imaging for a period of 2 years during this period 23 cases were enrolled with features of Iatrogenic renal vascular injuries (IRVIs) which were sus-pected by Department of Urology and referred to Department of Radiodiagnosis &Imag-ing.

The most common Iatrogenic renal vascular injury (IRVI) was renal artery pseudo-aneurysm (RAP) seen in all the 23(100) % patients which were combine detected by mul-timodality imaging like Color Doppler USG and CT renal angiography evaluation of these patients and AVF is detected in one patient.

In our study we assessed 23 patients with post renal intervention IRVIs having a mean age 37.9 ± 4.73 years (range 21 to 64 years) with male to female ratio was 18(78%): 5(22%). These results are supported by previous studies conducted by Guo H et al [14] and Chiramel GK et al [1] 23 patients with features of iatrogenic renal vascular injuries were preliminary detected by USG which were confirmed by MDCT renal angiography. Among these 23 patients 19patients underwent interventional management, 4 were managed conservatively and shows spontaneous resolution. The common causes of iatrogenic renal vascular injuries among our patients were renal intervention in the form of percutaneous nephrolithotomy (PCNL) in 16(70%) of our patients, partial nepherectomy in 5(22%) cases and percutaneous nephrostomy (PCN) in 2(8%) cases. These results are concordant with previous studies conducted by Chiramel GK et al [1] who also found PCNL as the most common cause of IRVI. The patients presented with hematuria and drop in haematocrit 12(52%), 9(40%) patients had only hematuria, 1(4%) patient had drop in haematocrit and flank pain and 1(4%) patient had bleeding from nephrostomy site and flank pain. These results were also found in the study conducted by Guo H et al. [14]

The mean time of presentation in our study was 13.3 ± 3.1 days. The most common time of presentation was between 10-14 days post the etiological event. Of the 23 patients 18 (78%) presented between 7-14 days while 5(22%) others presented between 14-21 days. This time interval corresponds to findings in the literature which show that pseudoaneu-rysms or arteriovenous fistulas were detected from one day up to several months after surgery, with an approximate mean of between 8 and 15 days.[15,16]This is similar to the mean time of presentation in previous studies by Venkateswarlu J et al (11.5 days),[17]Cohenpour M et al(8-10days),[18] Li L et al(10.5 days)l[19] and Guo H et al(14 days).[14]In our study, all the patients who presented with hematuria and drop in haematocrit after post renal intervention were initially evaluated by a color Doppler USG (GE LOGIC P5) at the time of presentation followed by CT angiography irrespective of the presence or absence of any injury on color Doppler examination. USG Doppler was able to detect IRVI in the form of RAP 17 (74%) patients and perinephric haematoma in 2(9%) patients. USG findings of RAPs were noted in the form of anechoic area on gray scale and to and fro flow in the form of ying yang sign on color Doppler imaging. All CT angiographies were per-formed on CT SOMATOM SENSATION 64 and non-contrast, arterial phase and venous phases were obtained using iodixanol (visipaque 100 ml) as the contrast agent. The imag-es were viewed on a dedicated workstation and source, 3D MIP and VRT images were re-constructed and features of the IRVI including its contrast enhancement features, contrast extravasation, size, the segmental branch of origin, and any renal arterial variations were noted using MIP images. CT angiography was able to detect IRVI in the form of RAP in all 23(100%) patients. The mean size of the RAP in our study was 5.2 ± 1.5 mm (range 3mm to 10 mm). We also observed one AVF in one patient in addition to RAP.

Digital subtraction angiography was performed in 20 out of the 23 patients based on hemodynamic instability and CT features. We found 21 RAPs in 19 patients on DSA due to 1 additional RAPs in 2 patients in which only 1 RAP was found on CT angiography and subsequent embolization was performed in these 19 patients. One patient shows evi-dence of AVF in addition to RAP and one patient with evidence of RAP on CT showed no evidence of any RAP on DSA, however a large RP hematoma was noted in this patient suggesting rupture of the RAP. Similar results with angiography were observed by Guo H et al [14] and Venkateswarlu J et al [17] who in their studies found DSA to be 100% sensi-tive investigation for IRVI. Thus, angiographic studies although invasive in nature remain the gold standard for diagnosis of IRVI and may help in the diagnosis of the smallest of the pseudoaneurysm that may not be visible on USG or CT angiography. Nineteen pa-tients with IRVIs in the form of RAPs and AVF were taken up for endovascular manage-ment using common femoral artery access. It was achieved using a 6F vascular sheath was secured and followed by an abdominal aortogram to demonstrate the vascular anatomy. A RDC or COBRA catheter was used for hooking the renal artery based on the information regarding origin from CT angiography Selective/super selective renal arte-riogram on side of injury was obtained using micro catheter (PROGREAT/COBRA) for assessment of renal artery anatomy. The presence of IRVI was confirmed on a selective renal angiogram, size of the feeding vessel was obtained and a search for any other pseu-do aneurysm was made. All the patients underwent embolization of the feeding vessel using micro coils that were at least 20% larger in size than the feeding vessel. A comple-tion selective renal angiogram was taken in each case to ascertain the technical success. A technical success rate of 100 % was achieved in our study with post embolization comple-tion angiography showing no evidence of any RAP or contrast extravasation. Similar technical success rates were achieved by Guo H et al,[14] and Ierardi et al [10] in their studies. In our study, 4 patients were not taken up for intervention. However spontaneous resolution of small RAP's has been found by Takagi et al [20] who in his study of 117 CT angiographies post renal intervention found 17 Raps' out of which 5 showed sponta-neous resolution. The size of these aneurysms was less than 4mm in all the cases which is similar to our study.

No major complication was observed in our study after embolization procedures of IRVIs. These findings are similar to those of Guo H et al [14] with no major complication in their study and 4(15%) out of 27 patients developing post embolization syndrome. No major complication was noted by Angle JF et al,[21] Martin X et al,[22] Halloul Z et al [23] and AnT et al [24] in their studies.

Follow up in the form of clinical and USG Doppler evaluation was done at 3- and 6-months showing resolution of symptoms and no evidence of IRVIs. Clinical success was defined as absence of clinical and imaging evidence of bleeding as determined by resolu-tion of gross hematuria, retroperitoneal bleeding, further decrease in haematocrit and hy-potension after TAE. [25] Thus a clinical success rate of 100% was achieved in our study (Figure 2. This success rate is similar to those of Guo H et al. [14] and Ierardi et al. [10] having clinical success rates of 96.5% and 95% respectively. A success rate varying be-tween 80-100% has been described by other researchers in their study like Wang C et al [26] and Zakabrium et al [27].

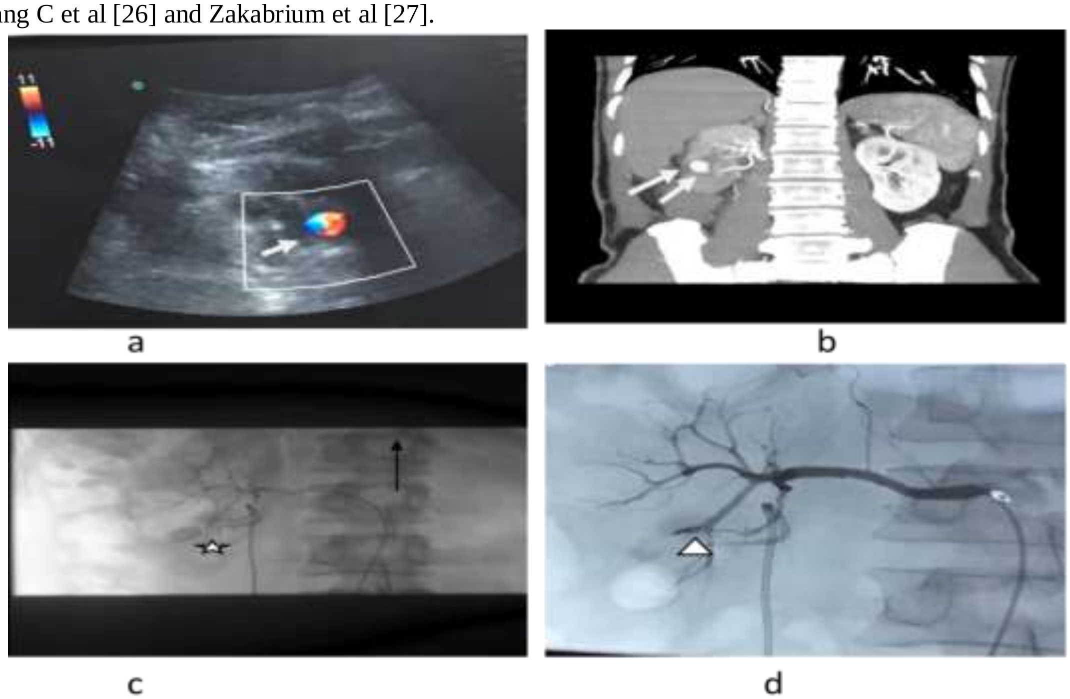

Figure 2a-d. Renal artery pseudoaneurysm: 37year old presented with gross hematuria on 7th day after PCNL with DJ stenting for nephrolithasis. USG Doppler Yin yang (white arrow) flow (a) and CT renal angiography(b) shows typical features of RAP (two white arrows) at lower pole. Selective DSA renal angiography(c) confirms the diagnosis of RAP (star) and subsequently embolized (d) with Nester coils (triangle)

Conclusions:-

Percutaneous renal intervention is the most frequent cause of IRVI in our setting. USG Doppler and CT plays very important role in Iatrogenic renal vascular injuries as USG Doppler was able to detect IRVIs in the form of RAPs in 73% of patients and CT renal an-giography is able to detect IRVIs in the form of RAPs in all (100%) the patients in our study. Endovascular angioembolization is effective and safe for the management of IRVIs with high technical and clinical success.

References:-

1. Poulakis V, Ferakis N, Becht E et al. Treatment of renal-vascular injury by transcatheter embolization: Immediate and long-term effects on renal function. J Endourol2006; 20:405-409.
2. Fisher RG, Ben-Menachem Y, Whigham C. Stab wounds of the renal artery branches: Angiographic diagnosis and treatment by embolization. AJR Am J Roentgenol1989; 152:1231-1235.
3. Orons PD, Zajko AB. Angiography and interventional aspects of renal transplantation. Radiol Clin North Am 1995; 33:461-469.
4. Hübsch PJ, Mostbeck G, Barton P et al. Evaluation of arteriovenous fistulas and pseudoaneurysms in renal allografts following percutaneous needle biopsy. Color- coded Doppler sonography versus duplex Doppler sonography. J Ultra-sound Med 1990; 9:95-98.
5. Sennet CA, Messersmith RN, Yousefzadeh DK et al. Percapsular and percutaneous embolization of renal transplant pseudoaneurysm and AV fistula. Cardiovasc InterventRadiol1989; 12:270-273.
6. Peene P, Wilms G, Baert et al. Embolization of iatrogenic renal hemorrhage following percutaneous nephrostomy. UrolRadiol 1990-12:84–87.
7. Maleux G, Messiaen T, Stockx L et al. Transcatheter embolization of biopsy-related vascular injuries in renal allografts. Long-term technical, clinical and biochemical results. Acta Radiol2003; 44:13-17.
8. Huppert PE, Duda SH, ErleyCM, et al. Embolization of renal vascular lesions: Clinical experience with microcoils and tracker catheters. Cardiovasc InterventRadiol1993; 16:361-367.
9. Dorffner R, Thurnher S, Prokesch et al. Embolization of iatrogenic vascular injuries of renal transplants: Immediate and follow-up results. Cardiovasc InterventRadiol1998; 21:129-134.
10. Gahan JC, Gaitonde M, Wadskier L et al. Renal function outcomes following selective angioembolization for iatrogenic vascular lesions after partial nephrectomy. Journal of endourology/Endourological Society 2013; 27: 1516–1519.
11. Ghoneim TP, Thornton RH, Solomon SB et al. Selective arterial embolization for pseudoaneurysms and arteriovenous fistula of renal artery branches following partial nephrectomy. The Journal of urology 2011; 185: 2061–2065.
12. Tinto HR, Di Primio M, Tselikas L et al. Selective arterial embolization of life- threatening renal hemorrhage in four patients after partial nephrectomy. Diagnostic and interventional imaging 2014; 95: 601–609.
13. Baumann C, Westphalen K, Fuchs H et al. Interventional management of renal bleeding after partial nephrectomy. Car-diovascular and Interventional Radiology 2007; 30: 828- 832
14. Somani BK, Nabi G, Thorpe P et al. Endovascular control of haemorrhagic urological emergencies: An observational study. BMC Urol2006; 6:27.
15. Mavili E, Dönmez H, Ozcan N et al. Transarterial embolization for renal arterial bleeding. DiagnIntervRadiol2009; 15:143-7.
16. Hellström PA, Mehik A, Talja MT, Siniluoto TM, Perala JM, Leinonen SS. Spontaneous subcapsular or perirenal haem-orrhage caused by renal tumours. A urological emergency. Scand J Urol Nephrol 1999; 33:17-23.
17. Bookstein JJ, Goldstein HM. Successful management of postbiopsy arteriovenous fistula with selective arterial emboli-zation. Radiology 1973; 109:535-536.
18. Ramchandani P, Cardella JF, Grassi CJ, et al; Society of Interventional Radiology Standards of Practice Committee. Quality improvementguidelines for percutaneous nephrostomy. J Vasc Interv Radiol 2003;14(9):277–281

19. Yeniyol CO, Zeyrek N, Parildar M, Selek E, Taşli F, Memiş A. Life-threatening hematuria in a patient with renal angi-omyolipoma and selective renal embolization prior to nephrectomy. Int Urol Nephrol 2002; 34:185-188.
20. Lovaria A, Nicolini A, Meregaglia D, et al. Interventional radiology in the treatment of urological vascular complications. Ann Urol (Paris) 1999; 33:156-167.
21. Hom D, Eiley D, Lumerman JH, Siegel DN, Goldfischer ER, Smith AD. Complete renal embolization as an alternative to nephrectomy. J Urol1999; 161:24-27.
22. Lupattelli T, Garaci FG, Manenti G et al. Giant high-flow renal arteriovenous fistula treated by percutaneous embolization. Urology 2003; 61:837.
23. Hausegger KA, Portugaller HR. Percutaneous nephrostomy and antegrade ureteral stenting: tech-nique-indications-complications. EurRadiol 2006;16(9):2016–2030
24. Michel MS, Trojan L, Rassweiler JJ. Complications in percutaneous nephrolithotomy. EurUrol 2007;51(4):899–906.
25. 25. Tan TJ, Teh HS, Pua U, et al. Endovascular management of iatrogenic renal vascular injuries complicating percu-taneousnephrolithotripsy: role of renal angiography and superselective coil embolisation. J HK Coll Radiol2008; 11:103–106.
26. 26 Ierardi AM, Floridi C, Fontana F, et al. Transcatheter embolisation of iatrogenic renal vascular injuries. Radiol Med 2014;119(4):261–268.
27. Vignali C, Lonzi S, Bargellini I, et al. Vascular injuries after percutaneous renal procedures: treatment by transcatheter embo-lization. EurRadiol 2004;14(4):723-729.
28. Kluner C, Rogalla P, Gralla O, Elgeti T, HammB, Kroencke T. Value of dual-phase multislice CT prior to minimally invasive therapy of iatrogenic renal injuries. J EndovascTher 2005;12(4):461–468.
29. Srivastava A, Singh KJ, Suri A, et al. Vascular complications after percutaneous nephrolithotomy: Urology 2005;66(1):38–40.
30. Sam K, Gahide G, Soulez G, et al. Percutaneous embolization of iatrogenic arterial kidney injuries: safety, efficacy, and impact on blood pressure and renal function. J VascIntervRadiol 2011;22(11):1563–1568
31. Chatziioannou A, Brountzos E, Primetis E, et al. Effects of superselective embolization for renal vascular injuries on renal parenchyma and function. Eur J VascEndovasc Surg 2004;28(2):201–206
32. Turna B, Nazli O, Demiryoguran S, et al. Percutaneous nephrolithotomy: variables that influence hemorrhage. Urology 2007;69(4):603–607
33. Muller A Olivier R. Renal artery embolization-indications, technical approaches and outcomes. Nature Reviews Nephrolo-gy2015; 11:288-301.
34. AbuRahma A and Yacoub M. Renal imaging: duplex ultrasound, computed tomography angiography, magnetic resonance angiography, and angiography. Seminars in Vascular Surgery.2013; 26(4):143-134.
35. El-Nahas AR, Shokeir AA, El-Assmy AM, et al. post-percutaneous nephrolithotomy extensive hemorrhage: a study of risk factors. J Urol 2007;177(2):576–579.
36. Lewis S, Patel U. Major complications after percutaneous nephrostomy-lessons from a department audit. Clin Radiol 2004;59(2):171–179.
37. Phadke RV, Sawlani V, Rastogi H, et al. Iatrogenic renal vascular injuries and their radiological management. Clin Radiol 1997;52(2):119–123
38 Urban BA, Ratner LE, Fishman EK et al. Three-dimensional volume-rendered CT angiography of the renal arteries and veins: normal anatomy, variants, and clinical applications. Radiographics 2001; 21:373-378.
39 Guo H, Wang C, Yang M et al. Management of iatrogenic renal arteriovenous fistula and renal arterial pseudoaneurysm by transarterial embolization: A single center analysis and outcomes. Medicine (Baltimore) 2017; 96: e8187.
40 Gahan JC, Gaitonde M, Wadskier L et al. Renal function outcomes following selective angioembolization for iatrogenic vascular lesions after partial nephrectomy. Journal of endourology/Endourological Society 2013; 27: 1516–1519.
41 Ghoneim TP, Thornton RH, Solomon SB et al. Selective arterial embolization for pseudoaneurysms and arteriovenous fistula of renal artery branches following partial nephrectomy. The Journal of urology 2011; 185: 2061–2065.
42 Venkateswarlu J, Sravan M, Ravindra P et al. Endovascular management of iatrogenic renal vascular injuries complicating percutaneous nephrolithotomy. Indian J Radiol Imaging 2017; 27:293-297.
43 Cohenpour M, Strauss S, Gottlieb P et al. Pseudoaneurysm of the renal artery following partial nephrectomy: imaging findings and coil embolization. Clinical Radiology 2007; 62: 1104–1109.
44 Li L, Zhang Y, Chen Y et al. A multicentre retrospective study of transcatheter angiographic embolization in the treatment of delayed haemorrhage after percutaneous nephrolithotomy. EurRadiol 2015; 25: 1140–1147.

45 BTakagi T, Kondo T, Tajima T, et al. Enhanced computed tomography after partial nephrectomy in early postoperative period to detect asymptomatic renal artery pseudoaneurysm. Int J Urol.2014; 21:880-5.
46 Angle JF, Siddiqi NH, Wallace MJ et al. Quality improvement guidelines for percutaneous transcatheter embolization: Society of Interventional Radiology Standards of Practice Committee. J VascIntervRadiol 1997; 21:1479-86.
47 Martin X, Murat FJ, Feltosa LC et al. Severe bleeding after nephrolithotomy: results of hyperselectiveembolization. Eur Urol2000; 37:136–139.
48 Halloul Z, Buerger T, Grote R, et al. Selective embolization of a renal artery aneurysm. Eur Jr Vasc Med 2000; 29:285–287.
48 A T, Zhang S, Xu M, et al. Transcatheter embolization of peripheral renal artery for hemorrhagic urological emergencies using FuAiLe medical glue. Sci Rep 2015; 5:9106.
49 Strobl FF, D'Anastasi M, Hinzpeter R, et al. Renal pseudoaneurysms and arteriovenous fistulas as a complication of neph-ron-sparing partial nephrectomy: technical and functional outcomes of patients treated with selective microcoil embolization during a ten-year period. FortschrRontgenstr 2016; 188:188–94.
50 Wang C, Mao Q, Tan F, et al. Superselective renal artery embolization in the treatmentof renal hemorrhage. Ir J Med Sci 2014; 183:59-63.
51 Ząbkowski T, Piasecki P, ZielińskiH, Wieczorek A, Brzozowski K, Zięcina P. Superselectiverenal artery embolization in the treatment of iatrogenic bleeding into the urinary tract. Med Sci Monit 2015; 21:333-7.