Endovascular Management of Iatrogenic Renal Vascular Injury: Experience in 28 Cases

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Abstract

Aim of the Work: To evaluate the feasibility and efficacy of endovascular techniques in the management of gross hematuria caused by iatrogenic renal vascular injury. Specifically, we aimed to assess different embolic agents, different methods of embolization and their impact on the renal parenchymal loss and renal function.

Patients and Methods: This is a single institutional study carried out between May 2004 to January 2011 and included 28 patients. Records of all patients who underwent postprocedural renal angiography were reviewed. Data on embolization technique and embolic agents, success rate, periprocedural complications, and the long-term morphological and functional outcomes of embolised organs was recorded.

Results: Twenty eight patients underwent angiography for diagnosis and treatment of gross hematuria caused by iatrogenic injury of renal vessels after surgical or percutaneous nephrolithotomy or renal biopsy. 96% were angiographically positive and underwent superselective embolization; of them pseudoaneurysm was noted 82%, AVF in 11%, and distorted renal branches in 7%. None of the 27 patients with successful embolisation developed recurrent bleeding or required post-procedural blood transfusion. There were no major procedure related post-embolisation complications.

Conclusion: The high success rate and low incidence of complications make endovascular management the first-choice treatment option in cases of severe postprocedural renal hemorrhage. Superselective embolization of the injured vessel minimizes the extent of renal parenchymal infarction and allows sparing of the renal parenchyma.

Key Words: Iatrogenic – Renal – Vascular injury – Endovascular.

Introduction

ALTHOUGH the incidence is very small, 1%-3% in various series [1-4], iatrogenic traumas represent more than 50% of all renal vascular injuries [5]. Traumatic injury to the renal vasculature is a well recognized complication after renal biopsy, percutaneous nephrostomy, percutaneous nephrolithotomy (PCNL), and open procedures [6]. Usually, renal bleeding is treated conservatively, but if continue, control of bleeding can be achieved either by open surgical procedure or minimally invasive transarterial embolization. Angiography is superior to surgical exploration as both a diagnostic and a therapeutic modality [7], rapid recovery, short hospital stay, and early resumption of physical activities [8]. We report our experience in treating 28 patients with iatrogenic renal vascular trauma, with superselective embolization using different permanent embolic agents, evaluating the efficacy of these procedures and their effect on the renal morphology and function.

Patients and Methods

This study was carried out throughout the period extending from May 2004 to January 2011 and included 28 patients (13 females and 15 males). Their ages ranged from 14 to 52 years (mean: 33 years). Post-procedural intractable (persistent or intermittent) hematuria was the leading symptom in all patients and all had experienced considerable renal blood loss requiring blood substitution (3-9 units). Three patients were hemodynamically unstable before angiography. The causes of iatrogenic trauma were; surgical nephrolithotomy (SNL) in 20 patients, percutaneous nephrolithotomy (PCNL) in 7 patients and tru-cut needle biopsy in 1 patient. All patients were referred for angiography and embolization 2-13 days after the first presentation (mean: 5 days).

We reviewed the clinical data, renal function tests, and coagulation profile of the patients to assure proper renal function and exclude coagulation defects as a cause of the hematuria. Ultrasound examination was done in all patients, followed by color duplex examination in 13 of the.

Selective, transfemoral renal digital subtraction angiography was performed with a 5-F cobra, renal or Simmonds catheters. After the source of the
bleeding was identified, the catheter was maneuvered into a more distal position with a hydrophilic 0.035-inch guide wire. Next, either a 4-F Cobra or multipurpose (MP) catheter was exchanged, or a 2.8-3F microcatheter was introduced coaxially, through the 5F catheter in the proximity of the bleeding site, or inside the pseudoaneurysm for doing superselective embolization. In one patient (Fig. 4), combined transarterial and transvenous approach was used to occlude a high flow AVF. We used only permanent embolic agents including: steel coils, polyvinyl alcohol particles (PVA), or N-Butyl Cyanoacrylate (NBCA) mixed with Lipiodol at a ratio of 1:3 or 1:2. (Table 1).

Postembolization renal angiogram was performed in all cases to assess the success of embolization and the size of ischemic area and to exclude inadvertent embolization of healthy branches. Repeated ultrasound examinations were used to evaluate the renal morphology, assess the degree of lysis of hematoma in the collecting system. Technical success of the procedure was defined as complete occlusion of all renovascular bleeding sites as documented with arterial angiography at the end of the procedure. Medical success was defined by the disappearance of gross fresh hematuria after embolization, absence of recurrent hematuria, absence of recurrent need for erythrocyte administration, and absence of need for angiographic reembolization or subsequent renal surgery.

Renal parenchymal loss (as percentage of the total renal parenchyma) was estimated by comparison of pre and post-embolization angiography during parenchymal phase. Ultrasound evaluation of renal size and echotexture of the embolized kidney was performed during the hospital stay and at least twice during the follow-up period with 3 months interval. Clinical follow-up includes 18 patients and ranged from 3-23 months (mean: 14 months) during which the blood pressure and renal function tests were estimated.

Results

A total of 28 patients with iatrogenic intractable hematuria were involved in this study. Preprocedural sonogram showed blood clots in the renal calices, pelvis and/or urinary bladder in all patients and perinephric hematoma was reported in two of them. Color duplex examination identified the vascular lesion in 5 of the examined 13 patients (2 AVF and 3 pseudoaneurysms). Variable degrees of hydronephrosis of the injured kidney were reported in 18 patients. Six patients showed variable degrees of renal function impairment; 5 of them due to associated hydronephrosis of the contralateral kidney and the sixth one that patient who had undergone renal biopsy for evaluation of chronic renal insufficiency.

Of the 28 patients, 13 had bleeding from the right kidney and 15 from the left. All patients were examined angiographically. Only one patient showed no positive angiographic findings and left without embolization. This patient underwent nephrectomy due to continued hematuria, two days after angiography. The other 27 patient (96%) were angiographically positive and underwent superselective embolization; of them pseudoaneurysm was noted in 22 patients (82%), AVF in 3 patients (11%), and the other 2 patients (7%) showed only distortion of small renal branches. The lesions were located at the level of a the lower pole segmental artery in 11 patients, interlobar arteries in 11 patients, and upper-pole segmental artery in 5 patients. Different permanent embolic materials were used; steel coils in 7 patients, polyvinyl alcohol PVA in 12 patients and NBCA in 8 patients. The postembolization parenchymal defect was less than 10% in 19 patients (70%), 10-20% in 5 patients (19%), and 20-30% in 3 patients (11%). (Table 1).

Embolization was technically successful in all angiographically positive patients. None of the patients needed any post-procedural blood transfusion and the hemoglobin level increased progressively after embolization. Follow-up ultrasound examination showed initial stabilization of the caliceal, ureteric and urinary bladder hematoma, followed by progressive dimensional reduction with total disappearance of the hematoma 7-20 days (mean: 13 days) after embolization. Urine cleared macroscopically within 13 days after embolization in all patients.

There were no major complications in our series. Minor complications in the form of post-embolisation syndrome (PES), in different degrees were reported in 16 patients (59%). These included fever, pain, nausea and vomiting or a combination them. All these symptoms were managed conservatively using analgesics, anti-pyretics and anti-emetics. The 5 patients with preprocedural transient renal failure due to associated contralateral hydronephrosis, showed progressive normalization in serum creatinine levels, and all returned to normal values within 11 days, with no need for hemodialysis.

When the ischemic area is small (<10%) on the angiogram, it was difficult to identify on early ultrasound examination. However, lager infarctions
were identified as hypoechogenic areas and some contained central air dots. There were no significant renal morphological changes (size and echotexture) on late ultrasound examination (after 6 months), apart from surface depression which may be a surgical scarring. None of our patients developed hypertension or long term renal function impairment after embolization.

Table (1): Angiographic procedures; including angiographic findings, catheters and materials and percentage of postembolization parenchymal defect.

<table>
<thead>
<tr>
<th>Patient No.</th>
<th>Angiographic findings</th>
<th>Catheter used for embolization</th>
<th>Embolizing material</th>
<th>% parenchymal defect</th>
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<tbody>
<tr>
<td>1</td>
<td>PA</td>
<td>4F Cobra</td>
<td>COIL</td>
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<td>2</td>
<td>PA</td>
<td>MC</td>
<td>PVA</td>
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<td>3</td>
<td>PA</td>
<td>4F MP</td>
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<td>PA</td>
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<td>6</td>
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DV : Distorted vessels.  MP : Multipurpose.
AVF : Arteriovenous fistula.  NBCA : N-Butyl cyanoacrylate.
PVA : Polyvinyl Alcohol.

Fig. (1): A 14-year-old girl presented by gross haematuria 2 days after SNL. Angiography (AI) showed a 7mm pseudoaneurysm of a lower pole interlobar artery. This branch was catheterized superselectively using the multipurpose 4F catheter and embolized with PVA particles (250-350µm). Control angiogram (1B) shows occlusion of the parent artery with exclusion of the pseudoaneurysm from the renal circulation.
Fig. (2): A 17-year-old girl presented by haematuria after PCNL. Color duplex examination (2A) showed two pseudoaneurysms near the lower pole. After 3 days, angiogram was performed. The parenchymal phase (2b) showed the pseudoaneurysms. The injured branch was catheterized using cobra 4F catheter (2C) and embolized with PVA particles (250-350 µm). Control angiogram (2D) demonstrated obliteration of the injured branch with subsequent small wedge-shaped perfusion defect.

Fig. (3): A 25-year-old male patient presented 3 days after surgery by recurrent gross hematuria. Angiography on the 5th day (3A), showed a pseudoaneurysm at the inferior interlobar branch. The supplying branch was catheterized and embolized with platinum coil 3mm x 3cm (3B). Control angiogram (3C) demonstrated obliteration of the parent artery and the pseudoaneurysms.
Fig. (4): A 31-year-old male patient presented by hematuria after SNL. CT examination (4A) showed a pseudoaneurysm-like lesion at the renal hilum with poor parenchymal enhancement. Angiography (4B,4C), showed a high flow AVF at the superior segmental branch. A balloon catheter was introduced through the femoral vein to arrest the flow through the fistula during injection of 50% NBCA (4D,4E). Control angiogram (4F) demonstrated obliteration of the fistula with preserved flow through the superior division.

**Discussion**

Surgery was the sole method of treatment of upper urinary tract calculi till the development of less invasive approaches such as ESWL and PCNL in 1980s [9]. Nowadays, the role of open stone operations has certainly diminished. However, it remains a treatment option for calculi with infundibular stenosis, staghorn stone with small intrarenal pelvis and calculi in patients who prefer a single procedure versus multiple less invasive procedures [10]. Severe acute bleeding usually arises from the injury of the anterior or posterior segmental arteries, whereas postoperative delayed complications (0.3% of cases) are usually caused by interlobar and lower-pole artery lesions mainly represented by arteriovenous fistulas or post-traumatic aneurysm development [11]. Renal hemorrhage is also the most worrisome complication of percutaneous nephrolithotomy [12] that can arise both from venous and arterial lesions. Bleeding from venous
vessels could be profuse at the end of procedure but is generally controlled by simple maneuvers, such as placing the patient supine to reduce the abdominal compression, positioning a nephrostomy catheter, and forcing diuresis through hydration and parenteral administration of mannitol after clamping of the nephrostomy [11,13]. Nevertheless, these maneuvers are insufficient in several cases of arterial damage and cannot be performed in arteriovenous fistulas or post-traumatic aneurysms; therefore, renal angiography and selective renal embolization is required [14]. Bleeding after renal biopsy has been well recognized and most of these injuries are small and heal spontaneously with nonoperative measures. Severe uncontrollable gross hematuria or expanding perirenal hematomas, necessitate either surgical management (heminephrectomy or nephrectomy) or transcatheter embolization. The presence of underlying renal disease makes superselective embolization the treatment of choice, as it results in lesser renal parenchymal tissue loss and a lesser degree of functional decompensation [15].

Postprocedural renal artery injury to its branch can be accurately diagnosed using angiography as 96% (27/28) of our patients showed positive signs on angiogram. Also this technique has high success rate as all patients who showed positive angiographic signs were treated successfully without recurrence of the bleeding. The reported success rate in the literatures ranged from 71-100% [16-19]. In this series both the technical and clinical success are equal; however they do not always parallel each other in prior published series, due to recurrent bleeding from the initially embolized lesions [20-22].

The described angiographic signs in the literatures include: pseudoaneurysm, contrast extravasation, arteriovenous fistula, arterial dissection, hypervascular area, a vascular “cut-off” sign, and a fistula between an arterial branch and the percutaneous tract. Pseudoaneurysm was seen in 82% of our patients on a pre-embolisation angiography. Superselective embolization of this lesion is rather easy and could be successfully performed by PVA (Figs. 1,2), coils (Fig. 3) or NBCA. Small and slow flow AVF at the level of interlobar arteries could be managed by coils or NBCA through transarterial approach. On the contrary, large and high flow AVF carries the risk of passage of embolic agents to the venous side with subsequent pulmonary embolism, so temporary occlusion of the venous flow with balloon catheter during injection of embolic agent (NBCA) is a solution and we uses it in one of our cases (Fig. 4).

In a series done by Vikas, et al., [6] angiography failed to demonstrate any lesion in 6 patients (14.6%), and in another study done by Richstone et al., [23] 5.3% of their patients were angiographically negative. They explained that by venous injuries that are often underdiagnosed by angiography. However, hemorrhages of a venous origin are usually self-limiting and respond well to conservative management, so we could not explain our negative case by the same way, as the patient continued bleeding that required nephrectomy to safe his life.

Few studies were reported on the unintentional parenchymal infarction [18,20,24,25], and the effects of embolization on renal function. Two series [18,24] postulated that the embolization procedure resulted in further deterioration of renal function, as a consequence of inadvertent parenchymal infarction. So using superselective technique is mandatory to reduce the risk of ischemia-related renal impairment. We noted that injection of PVA through the diagnostic 4F catheter is the only technique causing parenchymal defect larger than 20% in our series that occurred in 3 patients. This is due to reflux of the PVA particles into the proximal normal branches after partial occlusion of the injured one with increased pressure inside.

The presence of blood clots-related obstructive uropathy is a major cause of development of renal function impairment which was reported in 5 of our patients, as all of them returned to normal after dissolution of the blood clots and resolution of obstructive changes on ultrasound examination. Also, blood clots in the renal pelvis or the urinary bladder may extend the period of hematuria few days after embolization depending on the degree of lysis of the blood clot and the efficiency of urinary bladder wash before and after the procedures. Clinical follow-up of the patients, hematocrit value assessment, ultrasound follow-up of the pelvic and bladder blood clots and the absence of fresh blood in urine may help to exclude recent hematuria.

Postembolization syndrome may be presented by flank pain, fever, an elevated white blood cell count, nausea, vomiting, and/or paralytic ileus. 59% of our patients, had experienced this syndrome to varying degrees. Vikas, et al., [6] described this syndrome in 63.4% and Somani, et al., [26] in 50% of their patients.

Chatziioannou, et al., [8] used contrast enhanced renal CT to follow-up patients after embolization, and noted that the subsequent infarcted area was smaller at a mean 6% when compared to the initial
ischemic area, mean of 12%. They explained this finding by the presence of intrarenal collateral supply, which retransfuses the initial ischemic area and prevents total infarction from occurring. Although the renal arteries have been considered end arteries, intrarenal Anastomoses do exist via the perivascular plexuses of segmental, interlobar and arcuate arteries [27]. These findings simulate our ultrasound finding as the areas of infarction that could be identified on early examination were no longer distinguishable on later examination (after 6 months).

Martin et al., [28] reported that partial renal ischemia and subsequent infarction can cause a change in renal function and an emergence or exacerbation of hypertension. However, we did not report ischemia-induced hypertension or renal failure during the follow-up period in any of our patients, even those with area of initial parenchymal defect >20%. Superselective embolization of the injured vessel, minimizes the extent of renal parenchymal infarction and allow sparing of the renal parenchyma.

Conclusion:

Our results confirm safety and efficacy of renal artery embolization in patients suffering from iatrogenic arterial injuries, with a resulting immediate and long lasting resolution of the symptoms. High success rate and low incidence of complications make this technique the first-choice treatment option in cases of severe postprocedural renal hemorrhage.

References

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