Clinical outcomes of endovascularly managed iatrogenic renal hemorrhages

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Abstract

Objective: To evaluate the effectiveness of endovascular management in iatrogenic renal injuries with regard to clinical status on follow‑up and requirements for repeat angiography and embolization. Materials and Methods: This retrospective study included patients who were referred for endovascular management of significant hemorrhage following an iatrogenic injury. Data was recorded from the Picture Archiving and Communication system (PACS) and electronic medical records. The site and type of iatrogenic injury, imaging findings, treatment, angiography findings, embolization performed, clinical status on follow‑up, and requirement for repeat embolization were recorded. The outcomes were clinical resolution, nephrectomy, or death. Clinical findings were recorded on follow‑up visits to the clinic. Statistical analysis was performed using descriptive statistics. Results: Seventy patients were included in this study between January 2000 and June 2012. A bleeding lesion (a pseudoaneurysm or arteriovenous fistula) was detected during the first angiogram in 55 patients (78.6%) and was selectively embolized. Fifteen required a second angiography as there was no clinical improvement and five required a third angiography. Overall, 66 patients (94.3%) showed complete resolution and 4 patients (5.7%) died. Three patients (4.3%) underwent nephrectomy for clinical stabilization even after embolization. There were no major complications. The two minor complications resolved spontaneously. Conclusions: Angiography and embolization is the treatment of choice in iatrogenic renal hemorrhage. Upto 20% of initial angiograms may not reveal the bleed and repeat angiography is required to identify a recurrent or unidentified bleed. The presence of multiple punctate bleeders on angiography suggests an enlarging subcapsular hematoma and requires preoperative embolization and nephrectomy.

Key words: Bleeding; embolization; endovascular management; iatrogenic renal hemorrhages; iatrogenic renal vascular injuries

Introduction

Fifty percent of renal injuries are iatrogenic in etiology,[¹,²] and 15% of all invasive procedures, either surgical or percutaneous, would result in a vascular injury.[³‑⁵] Patients develop a significant drop in hematocrit, persistent hematuria, or an enlarging perirenal bleed causing loin pain. Some could develop altered renal function, urinary obstruction, hypertension, or cardiac failure.[⁶] Also, 70‑90% of vascular injuries resolve spontaneously[⁷] and treatment is indicated for a massive bleed, deteriorating renal function, or renal hemorrhage which persists for more than 72 h.[⁷,⁸] The treatment of choice is endovascular, with angiography and selective embolization expected to minimize the loss of renal tissue.[⁹‑¹⁷]

Materials and Methods

This was a retrospective study that included patients referred
for endovascular management of severe hemorrhage following an invasive renal procedure. Institutional ethics committee clearance was obtained, and informed consent taken from all patients for the procedure. Data was retrieved from the Picture Archiving and Communication System (PACS), patients’ charts, and electronic medical records. The information collected included the findings of angiography and embolization, technical details, clinical status, and findings on subsequent angiography, if performed. Technical success of embolization was defined as the complete occlusion of the target vessel with no residual bleed on angiography. Resolution was defined as clinical improvement with a stable hematocrit and no recurrence of bleed for at least 30 days. Adverse outcomes were nephrectomy and death. The clinical status and serum creatinine values were evaluated using the electronic health records of the patients, as they were followed up in the outpatient clinic. Statistical analysis was performed using descriptive statistics to calculate the means, proportions, and percentages.

Protocol followed for management of renal hemorrhage

The clinical algorithm for managing these patients is shown in Figure 1. Digital subtraction angiography was performed on an emergency basis in all patients (Multistar DSA; Siemens, Erlangen, Germany). The contrast agent used in patients with a normal serum creatinine value was iohexol (Omnipaque; GE Amersham Health, Princeton, NJ, USA). If the serum creatinine level was between 1.5 and 3 mg%, Iodixanol (Visipaque; GE Amersham) was used. Carbon dioxide was used as the contrast agent in one patient who had a serum creatinine higher than 3.5 mg%. Computed tomography (CT) angiography was not performed routinely prior to endovascular treatment. A contrast-enhanced CT of the abdomen was also not part of the routine protocol, but was performed in a few patients if their condition did not resolve after embolization. An initial aortogram was performed to study the renal anatomy, identify anatomic variations, and detect a bleed from an intercostal or lumbar artery. Anteroposterior projections were used as a standard during the initial angiogram. An oblique projection was used if there was a doubt regarding the origin of the vessel leading to the bleeding lesion. Selective renal angiography of the suspected side of bleed was performed with a 4F hydrophilic cobra catheter (Terumo; Target Therapeutics, San Francisco, CA, USA). Additional selective angiography of the adjacent lumbar or lower intercostal arteries was also performed if an intrarenal bleed was not identified. If a bleeding vessel was identified, embolization was performed in the same session. The vessel was superselectively cannulated as close as possible to the site of bleed using a coaxially placed 2.7F microcatheter (Progreat; Terumo, Target Therapeutics, San Francisco, CA, USA). Embolization with coils (0.035”) was performed through the cobra catheter itself in a few cases, if it was placed very close to the site of bleed. The embolization agents used depended on the site and characteristics of the bleeding lesion. Either 0.035” embolization coils (Cook, Bloomington, IN, USA) or 0.018” coils (Fibred microcoils, Target therapeutics, USA) were used. Polyvinyl alcohol particles (Contour; Boston Scientific, Marlborough, MA, USA) or gelfoam were used as adjuvants along with embolization coils in a few cases to reduce the blood flow through the vessel. If an arteriovenous fistula was visualized, n-butyl cyanoacrylate glue (Histoacryl; Bbraun, Tuttingen, Germany) was the embolization material of choice [Table 1]. The management of these patients and the decisions were based on the clinical status and the clinical management protocol. During emergency angiography, if no obvious cause for the bleeding was identified and the patient remained hemodynamically unstable despite good supportive care, empirical embolization was performed at the iatrogenic trauma. If the patient was hemodynamically stable, supportive care with close monitoring was continued without empirical embolization.

Results

Over a period of 12 years, 70 patients (51 males and 19 females) were referred for endovascular management of a severe bleed secondary to an iatrogenic injury during various procedures. There were 18 percutaneous biopsies, 50 percutaneous nephrolithotomies, and 2 surgeries (a surgical renal biopsy and a partial nephrectomy) [Table 2]. These

Figure 1: Protocol followed for the management of iatrogenic renal injuries
procedures were on the native kidney in 67 patients and on an allograft kidney in 3 patients. The average age was 41 years, the youngest being 7 months and the oldest being 70 years [Table 3]. The results of the angiography procedures and embolization are described as flowcharts [Figure 2a-c]. The first angiogram revealed an abnormality in 55 patients (78.6%). Embolization could not be performed in two as the segmental branch developed spasm during superselective cannulation. The spasm was persistent and the branch vessel became thrombosed. Both patients showed complete clinical resolution. Embolization was performed in the rest of the 53 patients of which 38 (71.7%) showed clinical resolution. Two patients died immediately after angiography before further treatment could be done. The angiograms in both these patients had shown multiple punctate bleeding vessels overlying the whole affected kidney for which the main renal artery was embolized with polyvinyl alcohol particles to reduce the bleeding. Thirteen patients (24.5%) who did not resolve hemodynamically after the first angiogram underwent a second angiogram the following day. One patient showed no abnormality and resolved spontaneously. Another showed a bleeding capsular artery but could not be selectively cannulated, and the patient expired before further treatment could be initiated. A second embolization procedure was carried out in 11 patients, of which 6 (54.5%) resolved. The condition of the remaining five did not resolve even though nephrectomy was performed in two patients. Also, all five patients underwent a third angiography. In the two post-nephrectomy patients, there were no abnormalities in both patients. One resolved spontaneously, while the other stabilized after empirical embolization of the overlying intercostal and lumbar arteries but expired in a month. Of the other three patients who underwent a third angiogram, one showed no abnormality and recovered completely while another patient developed persistent spasm of the segmental vessel during superselective cannulation, but recovered completely. In the third patient, as the bleeding vessel could not be superselectively cannulated, nephrectomy was done after embolizing the renal artery with Histoacryl glue. This patient recovered completely after nephrectomy. Overall, no abnormality was revealed in the first angiogram in 15 (21.4%) patients. Of these, 12 (80%) recovered with conservative management. One patient underwent a second angiogram which revealed a pseudoaneurysm, and the condition resolved after selective embolization of the vessel. In two patients, empirical embolization with polyvinyl alcohol particles of the segmental branch leading to the site of injury was performed and both recovered completely. Follow-up was in the outpatient clinic. There was no recurrence of bleed on follow-up and no significant rise in serum creatinine levels. Overall, 66 (94.3%) out of 70 patients in this study showed complete resolution. Three (4.3%) underwent nephrectomy and four (5.7%) died. There were two minor complications - a subintimal dissection of a segmental branch and migration of a coil, both of which spontaneously resolved. There were no major complications.

**Discussion**

A prior knowledge of the suspected site of renal injury helps to plan the imaging and treatment. The presence of hematuria indicates an intrarenal bleed with calyceal communication. In a patient with no hematuria, the bleed may be either within or outside the kidney. USG and color Doppler can demonstrate the presence of active bleeding into a perinephric hematoma and can be used as follow-up. The use of microcatheters for superselective cannulation and embolization of bleeding vessels helps to minimize the loss of renal tissue. A bleed can sometimes be detected on the initial aortogram itself [Figure 3]. It may be visualized as an active extravasation of contrast, a pseudoaneurysm [Figure 4], or an arteriocalyceal or arteriovenous fistula [Figure 5]. Oblique projections and selective renal angiography can help identify the specific arterial branch [Figure 6] and rule out other lesions. Selective cannulation can help detect even subtle lesions. A limited amount of contrast agent is used as the renal function may already be compromised. An iso-osmolar contrast agent is preferred in a patient with raised serum creatinine. Other studies that have evaluated the efficacy of endovascular embolization in iatrogenic renal injuries have included fewer patients and describe only one angiography session, except one study that reports a 67% resolution rate with two angiography sessions. The rate of resolution ranges from 85 to 98%. Though none of these studies have described clinical outcomes on long-term follow-up or included patients who required a third angiography, their results were comparable to the 94.3% resolution achieved in our patient population. The

### Table 1: Different types of bleeds and the preferred embolic agent for management

| Angiographic finding suggesting type of bleed | Preferred embolic agent |
|---------------------------------------------|------------------------|
| Pseudoaneurysm                               | Embolisation coils      |
| Pseudoaneurysm with active extravasation    | Coils and/or histoacryl glue |
| Multiple punctate bleeding vessels over the whole kidney | PVA particles |
| Arteriovenous or arteriocalyceal fistula    | Histoacryl glue         |

PVA: Polyvinyl alcohol

### Table 2: The number and type of cases with iatrogenic injury in this study requiring angiography for embolization

| Gender | Cause of iatrogenic injury | Total |
|--------|---------------------------|-------|
|        | Biopsy | PCNL | Surgery |       |
| Male   | 10     | 39   | 2       | 51    |
| Female | 8      | 11   | 0       | 19    |
| Total  | 18     | 50   | 2       | 70    |

PCNL: Percutaneous nephrolithotomy

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### Table 3: Details of all the patients included in this study who presented with an iatrogenic injury requiring angiography for potential embolization

| Patient details | Iatrogenic injury | Underlying disease/coagulopathy | Clinical presentation | Angiography findings | Embolisation material | Results | Further course in hospital | Final outcome |
|----------------|-------------------|----------------------------------|-----------------------|----------------------|-----------------------|---------|----------------------------|---------------|
| 57/M Biopsy    | Renal failure     |                                  | Hypotension and drop in hematocrit on the same day | Pseudoaneurysm       | PVA particles and coils | Embolised | Improved                   | Stable on follow up |
| 59/F Biopsy    | Renal failure     | Hematuria for ten days           | AVF                   | Coils                |                        | Embolised | Improved                   | Stable on follow up |
| 20/M Biopsy    | Renal failure     | Hematuria for five days          | AVF                   | PVA particles and coils | Embolised          | Improved | Stable on follow up        |               |
| 51/M Biopsy    | Renal failure     | Hematuria for two days           | Pseudoaneurysm and an AVF | Coils                | Embolised          | Improved | Stable on follow up        |               |
| 47/M Biopsy    | Renal failure and diabetes | Dropping hematocrit for three days | AVF                   | Histoacryl glue      |                       | Embolised | Improved                   | Stable on follow up |
| 29/M Biopsy    | Renal failure and diabetes | Dropping hematocrit on the same day | No extravasation seen. Suspected pseudoaneurysm from an interpolar branch | PVA particles        | Embolised but continued dropping hematocrit | Repeat angiogram did not show any abnormality | Improved after a day and stable on follow up |
| 57/M Biopsy    | Renal failure     | Dropping hematocrit on the same day | Pseudoaneurysm        | PVA particles and coils | Embolised          | Improved | Nephrectomy done           | Developed DIC and aspiration pneumonia. Died after a month |
| 30/M Biopsy    | Renal failure     | Dropping hematocrit for a day    | Pseudoaneurysm        | Histoacryl glue      | Embolised but bleeding continued. Two more embolisations of overlying intercostal and lumbar vessels with PVA particles and glue | Nephrectomy done and hematocrit stabilised | Stable on follow up |
| 58/M Biopsy    | Renal failure     | Dropping hematocrit for six days | Multiple punctate subcapsular bleeders. Suspected extravasation | PVA particles        | Embolised but significant bleed on same day | Developed seizures | Died |
| 21/F Biopsy    | Renal failure and polyarteritis nodosa | Dropping hematocrit on the same day | Pseudoaneurysm        | PVA particles and coils | Persistent bleed. Embolised overlying lumbar and capsular arteries with PVA and Histoacryl glue | Improved after second embolisation session | Stable on follow up |
| 17/M Biopsy    | Renal failure     | Dropping hematocrit for one day  | Pseudoaneurysm from a capsular branch | Histoacryl glue      | Did not improve. Second angiogram showed persistent bleed Could not cannulate | Planned for nephrectomy on the same day but developed DIC | Died |
| 41/F Biopsy of graft kidney | Protocol biopsy | Dropping hematocrit. Enlarging swelling on anterior abdominal wall for a day | AVF in the lower pole of the graft. Pseudoaneurysm from inferior epigastric artery | Coils, PVA, Histoacryl glue | Embolised circumflex iliac artery. But persistent bleed | Second angiography to embolised superior epigastric artery. Then stabilised | Stable on follow up |
| 47/F Biopsy    | Renal failure     | Dropping hematocrit on the same day | No bleeders found | None                | No embolisation done | Stabilised spontaneously | Stable on follow up |
| 23/F Biopsy    | Renal failure     | Dropping hematocrit on the same day | AVF                  | None                | Vasospasm on selective cannulation | Spontaneously thrombosed | Stable on follow up |
| 36/M Biopsy of graft | Protocol | Dropping hematocrit for a week | Pseudoaneurysm        | PVA, coils          | Embolised            | Stabilised | Stable on follow up        |               |

Contd...
| Patient details | Iatrogenic injury | Underlying disease/coagulopathy | Clinical presentation | Angiography findings | Embolisation material | Results | Further course in hospital | Final outcome |
|----------------|------------------|----------------------------------|-----------------------|----------------------|----------------------|---------|---------------------------|--------------|
| 52/F           | Biopsy           | Renal failure                    | Dropping hematocrit on the same day | Pseudoaneurysm       | PVA particles and coils | Embolised | Stabilised                | Stable on follow up |
| 53/F           | Biopsy           | Renal failure                    | Dropping hematocrit for one day | No bleeder found     | PVA particles into lower pole | Embolised | Stabilised after a few days | Stable on follow up |
| 50/M           | Biopsy of graft  | Protocol                         | Dropping hematocrit for one day | No bleeder found     | None                  | No embolisation done | Stabilised | Stabilised on follow up |
| 42/F           | PCNL             | Nephrolithiasis                  | Hematuria and dropping hematocrit for two days | Pseudoaneurysm from a lower pole branch | PVA particles and coils | Embolised | Stabilised after a few days | Stable on follow up |
| 37/M           | PCNL             | Nephrolithiasis                  | Hematuria and dropping hematocrit for two days | No bleeder seen      | None                  | No embolisation done | Stabilised | Stable on follow up |
| 50/F           | PCNL             | Nephrolithiasis                  | Hematuria and dropping hematocrit for a day | No bleeder seen      | None                  | No embolisation done | Stabilised | Stable on follow up |
| 41/F           | PCNL             | Nephrolithiasis                  | Hematuria and dropping hematocrit on the same day | Pseudoaneurysm from a lower pole branch | Gelfoam and coils but did not stabilise | Second embolisation with PVA and coils. Third angiography showed spasm of intrarenal vessels and bleed from cortical branches | Stabilised after a few days | Stable on follow up |
| 44/F           | PCNL             | Nephrolithiasis                  | Hematuria on the same day | No bleeder seen      | None                  | No embolisation done | Stabilised | Stable on follow up |
| 28/M           | PCNL             | Nephrolithiasis                  | Hematuria for sixteen days | Pseudoaneurysm from a segmental artery | Coils                | Embolised | Stabilised | Stable on follow up |
| 55/M           | PCNL             | Nephrolithiasis                  | Hematuria for fifteen days | First angiogram did not show any bleeder. Second angiogram showed a pseudoaneurysm | Coils                | Embolised in second angiography session | Stabilised | Stable on follow up |
| 48/M           | PCNL             | Nephrolithiasis                  | Hematuria for three days | Pseudoaneurysm from an interlobar artery | Coils                | Embolised | Stabilised | Stable on follow up |
| 41/M           | PCNL             | Nephrolithiasis                  | Hematuria for four days | Pseudoaneurysm from an interlobar artery | Gelfoam and coils | Embolised | Stabilised | Stable on follow up |
| 26/F           | PCNL             | Nephrolithiasis                  | Dropping hematocrit for one day | Pseudoaneurysm and an AVF | Coils | Did not stabilise. Second angiography showed a pseudoaneurysm from another intrarenal artery. This was embolised with coils | Stabilised | Stable on follow up |
| 38/M           | PCNL             | Nephrolithiasis                  | Hematuria on the same day | Pseudoaneurysm       | Coils, PVA, Histoacryl glue | Embolised | Stabilised | Stable on follow up |
| 49/M           | PCNL             | Nephrolithiasis                  | Dropping hematocrit for two days | Pseudoaneurysm and an AVF | Gelfoam and coils | Embolised | Stabilised | Stable on follow up |
| 43/M           | PCNL             | Nephrolithiasis                  | Hematuria for seven days | Pseudoaneurysm       | Coils | Embolised | Stabilised | Stable on follow up |
| 53/M           | PCNL             | Nephrolithiasis                  | Bleeding from nephrostomy tube for four days | Pseudoaneurysm       | Gelfoam and coils | Embolised | Stabilised | Stable on follow up |

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| Patient details | Iatrogenic injury | Underlying disease/coagulopathy | Clinical presentation | Angiography findings | Embolisation material | Results | Further course in hospital | Final outcome |
|----------------|------------------|----------------------------------|-----------------------|----------------------|----------------------|---------|-----------------------------|--------------|
| 60/M           | PCNL             | Nephrolithiasis                  | Dropping hematocrit for four days | First angiogram did not show any bleeders. Second angiogram showed a pseudoaneurysm and an AVF from an interlobar artery | Coils | Embolised on second angiography | Stabilised | Stable on follow up |
| 31/M           | PCNL             | Nephrolithiasis                  | Hematuria for sixteen days | First angiogram showed a pseudoaneurysm from an interlobar branch | Gelfoam and coils | Did not stabilise. Second angiogram showed bleeding from another branch. Embolised with coils | Stabilised | Stable on follow up |
| 38/M           | PCNL             | Nephrolithiasis                  | Hematuria for a month | Pseudoaneurysm from a lower pole branch | Coils | Embolised | Stabilised | Stable on follow up |
| 62/M           | PCNL             | Nephrolithiasis                  | Hematuria for eleven days | Pseudoaneurysm from an interpole branch | Coils | Embolised | Stabilised | Stable on follow up |
| 26/M           | PCNL             | Nephrolithiasis                  | Bleeding for three days | Pseudoaneurysm from an interpole branch | Coils | Embolised | Stabilised | Stable on follow up |
| 21/M           | PCNL             | Nephrolithiasis                  | Dropping hematocrit for two days | AVF from the T12 intercostal artery | Gelfoam and coils | Embolised | Stabilised | Stable on follow up |
| 39/F           | PCNL             | Nephrolithiasis                  | Bleeding from nephrostomy tube for a day | Pseudoaneurysm from a lower pole branch | Coils | Embolised | Stabilised | Stable on follow up |
| 48/M           | PCNL             | Nephrolithiasis                  | Bleeding from nephrostomy tube for two days | Pseudoaneurysm from a lower pole branch | Gelfoam and coils | Embolised | Stabilised | Stable on follow up |
| 40/M           | PCNL             | Nephrolithiasis                  | Hematuria for seven days | Pseudoaneurysm from a lower pole branch | Gelfoam and coils | Embolised | Stabilised | Stable on follow up |
| 17/M           | PCNL             | Nephrolithiasis                  | Bleeding for six days | Pseudoaneurysm from an interpole branch | Gelfoam and coils | Stabilised | Stabilised | Stable on follow up |
| 36/M           | PCNL             | Nephrolithiasis                  | Bleeding for a day | Extravasation seen from a lower pole branch | Coils and glue | Embolised | Stabilised | Stable on follow up |
| 28/M           | PCNL             | Nephrolithiasis                  | Bleeding | Pseudoaneurysm and AVF seen in a lower segmental branch | Coils | Spasm and thrombosis of the subsegmental artery | Stabilised | Stable on follow up |
| 47/M           | PCNL             | Nephrolithiasis                  | Bleeding for ten days | Pseudoaneurysm and AVF seen in a lower segmental branch | Coils | Embolised | Stabilised | Stable on follow up |
| 61/M           | PCNL             | Nephrolithiasis                  | Bleeding for twenty days | Pseudoaneurysm and AVF seen in a lower segmental branch | Coils | Embolised | Stabilised | Stable on follow up |
| 40/M           | PCNL             | Nephrolithiasis                  | Bleeding with drop in hematocrit for three days | Pseudoaneurysm seen in first angiogram | Embolised with PVA and coils | Second angiography showed an adjacent pseudoaneurysm and AVF. Embolised with Histoacryl glue | Stabilised after second embolisation | Stable on follow up |
| 58/M           | PCNL             | Nephrolithiasis                  | Bleeding for twenty four days | Extravasation from a lower pole segmental branch | PVA and coils | Embolised | Stabilised | Stable on follow up |
| 16/M           | PCNL             | Nephrolithiasis                  | Bleeding with drop in hematocrit for one day | Pseudoaneurysm seen from a lower pole branch | Glue | Embolised | Stabilised | Stable on follow up |

Contd...
| Patient details | Iatrogenic injury | Underlying disease/coagulopathy | Clinical presentation | Angiography findings | Embolisation material | Results | Further course in hospital | Final outcome |
|-----------------|------------------|----------------------------------|-----------------------|----------------------|----------------------|---------|--------------------------|--------------|
| 51/F            | PCNL             | Nephrolithiasis                  | Bleeding with drop in hematocrit for one day | No bleeders seen | None | No embolisation done | Stabilised | Stable on follow up |
| 52/F            | PCNL             | Nephrolithiasis                  | Bleeding with drop in hematocrit for one day | Extravasation from a lower pole branch. Multiple punctate bleeders over the whole kidney | PVA | Embolisation of all the branches of the renal artery | Died |
| 70/M            | PCNL             | Nephrolithiasis                  | Bleeding with drop in hematocrit for seven days | Three pseudoaneurysms seen from a lower pole branch | PVA and coils | Embolised | Stabilised | Stable on follow up |
| 45/M            | PCNL             | Nephrolithiasis                  | Bleeding with drop in hematocrit on the same day | No bleeders seen | None | No embolisation done | Stabilised | Stable on follow up |
| 55/M            | PCNL             | Grade 2 to 3 renal parenchymal changes | Bleeding for eleven days | Pseudoaneurysm and active bleed from a lower pole branch | PVA particles and coils | Embolised | Stabilised | Stable on follow up |
| 56/F            | PCNL             | Diabetic nephropathy with a staghorn calculus | Bleeding with drop in hematocrit for nine days | Two pseudoaneurysms in two lower pole branches | Coils | Embolised | Stabilised | Stable on follow up |
| 24/M            | PCNL             | Hemophilia                        | Bleeding with drop in hematocrit for one day | Pseudoaneurysm | Histoacryl glue | Embolised with 25% glue | Stabilised | Stable on follow up |
| 46/M            | PCNL             | Large staghorn calculus           | Bleeding with drop in hematocrit on the same day | No bleeders seen | None | No embolisation done | Stabilised | Stable on follow up |
| 46/F            | PCNL             | Nephrolithiasis                  | Bleeding with drop in hematocrit for one day | No bleeders seen | None | No embolisation done | Stabilised | Stable on follow up |
| 51/M            | PCNL             | Nephrolithiasis                  | Bleeding with drop in hematocrit for 64 days | No bleeders seen | None | No embolisation done | Stabilised | Stable on follow up |
| 56/M            | PCNL             | Partial staghorn calculus         | Bleeding with drop in hematocrit for 19 days | One pseudoaneurysm from a lower pole branch | Coils | Embolised | Stabilised | Stable on follow up |
| 35/M            | PCNL             | Hemophilia B with bilateral nephrolithiasis and renal failure | Bleeding with drop in hematocrit for 8 days | CO2 angiography. Pseudoaneurysms in both kidneys | Embolised both pseudoaneurysms using gelfoam and coils in two sessions. | Third angiography did not show any bleeder. Single sided nephrectomy done | Stabilised after nephrectomy | Stable on follow up |
| 33/M            | PCNL             | Nephrolithiasis                  | Bleeding for five days | Pseudoaneurysm | Coils | Embolised | Stabilised | Stable on follow up |
| 40/M            | PCNL             | Nephrolithiasis                  | Bleeding for two days | Pseudoaneurysm and extravasation from a subsegmental artery | PVA and coils | Embolised | Stabilised | Stable on follow up |
| 38/M            | PCNL             | Nephrolithiasis                  | Bleeding and dropping hematocrit for ten days | Pseudoaneurysm from an intersegmental branch | Gelfoam and 20% Histoacryl glue | Embolised | Stabilised | Stable on follow up |
| 26/M            | PCNL             | Nephrolithiasis                  | Dropping hematocrit over two days | No bleeders seen | None | No embolisation done | Stabilised | Stable on follow up |
| 32/M            | PCNL             | Nephrolithiasis                  | Dropping hematocrit over two days | Pseudoaneurysm and arteriovenous fistula seen from a lower pole branch | Branch developed spasm and thrombosed | No embolisation done | Stabilised | Stable on follow up |

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most common embolization material used in this study were embolization coils. Occasionally, polyvinyl alcohol particles were used as an adjuvant embolic material to reduce the flow. Histoacryl glue was used in a few cases where an arteriovenous fistula was seen. Other studies have used the same approach to manage renal hemorrhage. Some describe satisfactory results with only Histoacryl glue or polyvinyl alcohol particles. We have used only the transarterial approach for embolization in this group of patients. Other approaches that have been described are percutaneous ultrasound-guided embolization of a pseudoaneurysm with gelfoam or embolization coils.

It was found in this study that up to 20% of the initial angiograms did not show a bleed. This is lower compared to 30% as reported by another study.

Figure 2(A-C): (A) Flowchart showing the number of patients, procedures performed, and the outcomes in the first (A), second (B) and third angiography sessions (C)

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| **Patient details** | Iatrogenic injury | Underlying disease/ coagulopathy | Clinical presentation | Angiography findings | Embolisation material | Results | Further course in hospital | Final outcome |
|-------------------|------------------|----------------------------------|----------------------|---------------------|----------------------|---------|-----------------------------|---------------|
| 57/M              | PCNL             | Nephrolithiasis                  | Bleeding for two days | Pseudoaneurysm and arteriovenous fistula from a lower pole branch | Coils | Embolised | Stabilised | Stable on follow up |
| 42/F              | PCNL             | Nephrolithiasis                  | Bleeding for two days | No bleeders seen | None | No embolisation done | Stabilised | Stable on follow up |
| 25/M              | Partial nephrectomy | Renal cyst with enhancing solid components | Bleeding and dropping hematocrit for eight days | No bleeders seen | None | No embolisation done | Stabilised | Stable on follow up |
| 0.7/M             | Surgical biopsy  | Nephroblastoma                   | Bleeding and dropping hematocrit for one day | No bleeders seen. Only enhancing tumour | PVA particles and glue | Embolised the artery supplying the tumour | Stabilised | Stable on follow up |

DIC: Disseminated intravascular coagulation, PVA: Polyvinyl alcohol, AVF: Arteriovenous fistula, PCNL: Percutaneous nephrolithotomy, M: Male, F: Female
could be negative immediately following an acute bleed. An angiogram could be falsely negative due to the tamponading effect of the hematoma or due to hypotension or transient spasm. Removal of the drainage tube in some cases could remove the tamponade and identify a bleed, thus helping to plan definitive treatment. An arteriovenous fistula may sometimes not be visualized if there is a blood clot obstructing the calyx. The source of bleed may sometimes not be identified even on repeated angiograms in a gradually worsening patient and a CT scan could be helpful in this situation. Selective empirical embolization can be helpful in an indeterminate bleed if the site of the renal injury is known, as in iatrogenic renal bleeds. In many situations, even when the bleed was not identified, the patient’s condition resolved without further treatment, suggesting a process of spontaneous hemostasis. It is thus

Figure 3(A-E): (A) Aortogram shows a pseudoaneurysm (arrow) in the lower pole of the left kidney (B) This was confirmed by a selective angiogram of the left renal artery (C) The lower segmental artery was superselectively cannulated with a microcatheter (D) Two 0.018” embolization coils were deployed (E) Post-embolisation embolization angiogram shows complete occlusion of the branch

Figure 4(A-C): (A) Selective angiogram of the left renal artery shows a pseudoaneurysm (arrow) in the lower pole region. The large area seen as a filling defect is the surrounding hematoma (B) Superselective cannulation of this vessel and embolization with Histoacryl glue (C) Post-embolization angiogram shows occlusion of the vessel with no opacification of the pseudoaneurysm

Figure 5(A-C): (A) Selective angiogram of the left renal artery shows an arteriovenous fistula in the lower pole region with a prominent draining vein (arrow) (B) Superselective cannulation of the arterial branch which developed spasm and thrombosis (C) Angiogram shows spontaneous resolution of the arteriovenous fistula with no opacification of the draining vein

Figure 6(A-C): (A) Left renal angiogram shows a pseudoaneurysm (arrow), but the arterial branch from which this arises is unclear (B) An oblique projection of the angiogram shows the pseudoaneurysm to be arising from a specific interpolar branch (C) Embolization coils deployed within this branch to occlude it
important to evaluate and correct for any underlying coagulopathy. Two patients in this study were detected to have hemophilia. Recanalization of a bleeding vessel could be a cause for non-resolution that can persist even after embolization with coils or polyvinyl alcohol particles.

If the angiogram shows multiple punctate bleeding vessels [Figure 7] suggestive of an enlarging subcapsular hematoma,[27] a life-saving nephrectomy should be considered if the patient continues to be hemodynamically unstable. Preoperative embolization of the renal artery with Histoacryl glue may be helpful in an unstable patient while arrangements are being made for a nephrectomy. In the present study, all three patients who underwent nephrectomy were hemodynamically stable for more than a month. Only one patient died after a month in the intensive care unit due to complications related to seizures, aspiration pneumonia, and sepsis. Spasm and thrombosis of the bleeding branch vessel was inadvertently caused in three patients during superselective cannulation that resolved spontaneously [Figure 5]. This is a phenomenon that has also been described in the splanchnic territory.[28]

No major complications have been described in the literature. Minor complications include non-target glue embolization, coil migration, and renal artery occlusion.[26] Renal artery dissection is a previously described complication which resolves spontaneously.[10,29] Ureteric obstruction due to a migrated coil has also been described.[30] Non-target embolization can lead to post-embolization syndrome, hypertension,[21] and functional impairment of the kidney. None of the patients in this study developed post-embolization syndrome. The two minor complications which had occurred in this study, segmental artery dissection and coil migration [Figure 8], had both resolved spontaneously.

Conclusion

Angiography and selective embolization is safe and effective in iatrogenic renal vascular injuries. A second or a third angiogram is beneficial to detect an unidentified or recurrent bleed.

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Conflicts of interest

There are no conflicts of interest.

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