Transarterial Embolisation for Major Iatrogenic Renal Vascular Injuries: Retrospective Study

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ABSTRACT
Objective: To evaluate the efficacy of renal angiography and transarterial embolisation in the management of major iatrogenic renal vascular injuries.

Patients and Methods: Records of 9 patients with major renal vascular complications (pseudoaneurysm or arteriovenous fistula) after percutaneous renal procedures were reviewed. They were investigated with digital subtraction angiography followed by transarterial embolisation using various embolic agents. Indications for embolisation were gross or persistent haematuria that resulted in unstable haemodynamic status or that required blood transfusion. Postembolisation angiography was performed for all patients.

Results: All the pseudoaneurysms and arteriovenous fistulas were successfully embolised in 1 session without any procedure-related complications. In all patients, clinical symptoms disappeared and haemodynamic status returned to normal after embolisation.

Conclusion: Transarterial embolisation is an effective and safe technique in the management of major iatrogenic renal vascular injuries, and should be the first treatment option in acute clinical situations. In most cases, technical success can be achieved with minimal renal parenchymal tissue loss.

Key Words: Aneurysm, false; Angiography, digital subtraction; Arteriovenous fistula; Embolization, therapeutic; Renal artery/injuries

INTRODUCTION
Major iatrogenic vascular injuries occur relatively uncommonly after percutaneous renal procedures, but if they do occur, they can lead to dramatic clinical symptoms. The incidence of these injuries has increased owing to the large number of percutaneous renal biopsies (PBs), percutaneous nephrostomies (PNs), and percutaneous nephrolithotomies (PNLs) that are being performed. Injury to the intrarenal artery may result in the formation of a pseudoaneurysm or an arteriovenous fistula (AVF). Although most of these lesions heal spontaneously, some result in life-threatening haematuria or in the deterioration of renal function, which requires immediate treatment. Selective endovascular transarterial embolisation is currently regarded as the most appropriate technique in the management of these types of pseudoaneurysm and AVF.

In this article, we report our experience of using transarterial embolisation for the treatment of major iatrogenic renal vascular injuries following percutaneous renal procedures.

PATIENTS AND METHODS
A retrospective study of major vascular complications resulting from percutaneous renal procedures (PB, PN, and PNL) during a 7.5-year period from January 1996 to June 2003 was performed. Nine patients who had gross or persistent haematuria that was associated with unstable haemodynamic status and which required blood transfusion were recruited into the study. The angiographic findings, results of embolisation, and clinical outcome of these patients were analysed.

Patients were investigated with digital subtraction angiography (DSA) followed by therapeutic transarterial embolisation in the same session. Diagnostic
renal angiography was performed using a 4- to 5-French angiographic catheter (Optitorque angiographic catheters; Terumo Corporation, Tokyo, Japan) via the right femoral artery. Initial assessments of the entire renal vascular anatomy, the location of lesions, and the number of feeding vessels were made. Selective intrarenal arteriography was then performed to evaluate the pseudoaneurysm and AVF for subsequent embolisation. Superselective catheterisation using a 3-F coaxial microcatheter system (SP Catheter Hydrophilic Coated Microcatheter; Terumo Corporation) was performed in some cases to achieve distal embolisation. All the pseudoaneurysms and AVFs were successfully embolised with the use of absorbable gelatin sponge, steel coils, or polyvinyl alcohol (PVA) particles. The selection of embolic agent was determined by the site and size of the lesion. The catheter was withdrawn to the main renal artery before postembolisation angiography to evaluate the occlusion of the lesion and to assess the perfusion defect, thereby assessing the amount of parenchymal tissue loss.

RESULTS

A total of 2059 patients underwent radiological renal interventions (1233 PBs, 683 PNs, 143 PNLs) during the study period. Of these patients, 9 — 4 women and 5 men with a mean age of 52 years (range, 30-84 years) — developed serious renal vascular complications that required angiographic evaluation and transarterial embolisation. After these procedures, 9 pseudoaneurysms and 1 AVF were detected (3 after PB, 1 after PN, 5 after PNL) All 9 patients were symptomatic and had gross or persistent haematuria (Tables 1 and 2). The incidence of major renal vascular complications in our series was 0.4% (9/2059).

Diagnostic renal angiography using DSA was performed to accurately detect and locate the lesions. In 1 post-PNL case, the initial angiogram did not reveal any intrarenal abnormality despite continuous bleeding from the nephrostomy tube (Figure 1a). After the tamponade nephrostomy catheter was deflated, the repeat angiogram revealed a left lower pole interlobar pseudoaneurysm (Figure 1b), which was successfully and promptly embolised with absorbable gelatin sponge (Gelfoam, Spongostan Standard; Johnson & Johnson, Gargrave, United Kingdom) and coils (Cook Incorporated, Bloomington, IN, United States) [Figures 1c and 1d].

In our series, 5 patients underwent embolisation with coils of a size ranging from 2 to 8 mm in diameter (Figure 2). No proximal migration of the coil was detected in any of the cases. One patient underwent embolisation with PVA particles (Contour embolization particles; Boston Scientific, Cork, Ireland) of 350 to 500 µm in diameter. The remaining 3 patients required a combination of PVA, absorbable gelatin sponge, and coils (Table 3). A 3-F coaxial microcatheter system was required for 2 of the 9 patients to achieve distal embolisation.

Postembolisation angiograms were obtained in all cases and showed complete occlusion of the lesions with minimal renal parenchymal tissue loss. Haemostasis was achieved and no patients required further endovascular or surgical intervention. Clinically, the patients’ symptoms disappeared and their renal function returned to normal within 1 to 2 days. Furthermore, there were no complications associated with the diagnostic or interventional radiological procedures. Eight of the 9 patients

<table>
<thead>
<tr>
<th>Patient No.</th>
<th>Sex/Age (y)</th>
<th>Renal procedure</th>
<th>Symptoms</th>
<th>Lesions</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>F /74</td>
<td>PN</td>
<td>Gross haematuria</td>
<td>Pseudoaneurysm</td>
</tr>
<tr>
<td>2</td>
<td>M /42</td>
<td>PN</td>
<td>Gross haematuria</td>
<td>Pseudoaneurysm</td>
</tr>
<tr>
<td>3</td>
<td>M /48</td>
<td>PNL</td>
<td>Gross haematuria</td>
<td>Pseudoaneurysm</td>
</tr>
<tr>
<td>4</td>
<td>F /37</td>
<td>Biopsy</td>
<td>Gross haematuria</td>
<td>Pseudoaneurysm</td>
</tr>
<tr>
<td>5</td>
<td>M /30</td>
<td>PNL</td>
<td>Gross haematuria</td>
<td>Pseudoaneurysm</td>
</tr>
<tr>
<td>6</td>
<td>M /84</td>
<td>PNL</td>
<td>Gross haematuria</td>
<td>Pseudoaneurysm</td>
</tr>
<tr>
<td>7</td>
<td>F /45</td>
<td>Biopsy</td>
<td>Gross haematuria</td>
<td>Pseudoaneurysm</td>
</tr>
<tr>
<td>8</td>
<td>M /39</td>
<td>PNL</td>
<td>Gross haematuria</td>
<td>Pseudoaneurysm</td>
</tr>
<tr>
<td>9</td>
<td>F /71</td>
<td>Biopsy</td>
<td>Gross haematuria</td>
<td>Pseudoaneurysm, arteriovenous fistula</td>
</tr>
</tbody>
</table>

Abbreviations: PN = percutaneous nephrostomy; PNL = percutaneous nephrolithotomy.
were discharged from the hospital after successful transarterial embolisation. The remaining patient died 1 week after embolisation owing to an underlying malignant disease.

DISCUSSION
Renovascular injury (pseudoaneurysm and AVF) is a well-recognised complication after percutaneous renal procedures. It occurs relatively uncommonly, but with the increasing number of percutaneous renal procedures being performed, its incidence is increasing. The most common iatrogenic cause is percutaneous renal biopsy. Other causes include percutaneous nephrostomy, nephrolithotomy, and blunt and penetration abdominal trauma. Treatment is generally conservative, and the majority (>80%) of lesions resolve spontaneously within 1 to 18 months. However, some lesions persist and can present with symptomatic haematuria.
uncontrollable hypertension, renal failure, high-output cardiac failure, retroperitoneal haematoma, and local and peripheral thromboembolism.\textsuperscript{3,6}

Iatrogenic renal vascular injury that results in massive haemorrhage requiring transfusion or intervention is rare; it is reported to occur in only 1% to 6% of patients.\textsuperscript{5} In our series, the incidence of such life-threatening vascular complications was 0.4% (9/2059). Our lower complication rate could be because of the fewer number of needle passes and the use of smaller needles with a cutting edge. Other known risk factors include nephrosclerotic kidneys, underlying infection, and haemostatic factors.\textsuperscript{4}

Pseudoaneurysm and AVF are the most common vascular complications. They arise because a lacerated intrarenal artery results in a high-pressure leak. Rupture of the high-pressure system into a vein or renal collecting system results in gross haematuria.\textsuperscript{8} Patients with persistent or recurrent haematuria 5 to 7 days after the primary renal procedure should be investigated.

### Table 3. Types of treatment used and treatment outcome.

<table>
<thead>
<tr>
<th>Patient No.</th>
<th>Lesion</th>
<th>Location</th>
<th>Catheter</th>
<th>Embolic agent</th>
<th>Outcome</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Pseudoaneurysm</td>
<td>Left upper pole interlobar artery</td>
<td>5-F C1</td>
<td>PVA (355-500 µm)</td>
<td>Total occlusion</td>
</tr>
<tr>
<td>2</td>
<td>Pseudoaneurysm</td>
<td>Left lower pole interlobar artery</td>
<td>5-F aortic flush Coils (2 mm/2 cm x1, 2 mm/3 cm x1)</td>
<td>Total occlusion</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Pseudoaneurysm</td>
<td>Right upper pole arcuate artery</td>
<td>4-F S1</td>
<td>Coils (2 mm/2 cm x1)</td>
<td>Total occlusion</td>
</tr>
<tr>
<td>4</td>
<td>Pseudoaneurysm</td>
<td>Left lower pole interlobar artery</td>
<td>5-F S2</td>
<td>Coils (2 mm/2 cm x1)</td>
<td>Total occlusion</td>
</tr>
<tr>
<td>5</td>
<td>Pseudoaneurysm</td>
<td>Left lower pole interlobar artery</td>
<td>5-F C1</td>
<td>PVA (355-500 µm), coils (2 mm/2 cm x1)</td>
<td>Total occlusion</td>
</tr>
<tr>
<td>6</td>
<td>Pseudoaneurysm</td>
<td>Right lower pole interlobar artery</td>
<td>5-F S1</td>
<td>Gelfoam, coils (8 mm/2 cm x1, 6 mm/2 cm x2, 3 mm/2 cm x2, 4 mm/2 cm x2)</td>
<td>Total occlusion</td>
</tr>
<tr>
<td>7</td>
<td>Pseudoaneurysm</td>
<td>Left middle pole interlobar artery</td>
<td>4-F S2</td>
<td>Coils (2 mm/2 cm x2)</td>
<td>Total occlusion</td>
</tr>
<tr>
<td>8</td>
<td>Pseudoaneurysm</td>
<td>Left lower pole interlobar artery</td>
<td>4-F S2</td>
<td>Coils (4 mm/2 cm x2, 3 mm/2 cm x2)</td>
<td>Total occlusion</td>
</tr>
<tr>
<td>9</td>
<td>Pseudoaneurysm, arteriovenous fistula</td>
<td>Left lower pole interlobar artery</td>
<td>5-F aortic flush 5-F S2</td>
<td>Gelfoam, coils (5 mm/5 cm x3)</td>
<td>Total occlusion</td>
</tr>
</tbody>
</table>

Abbreviations: C1 = Cobra 1; S1 = Sidewinder 1; S2 = Sidewinder 2; SP = SP microcatheter; PVA = polyvinyl alcohol.
with an angiogram.\textsuperscript{10} This waiting period of 5 days for haemodynamically stable patients allows a high proportion of such lesions to heal spontaneously.\textsuperscript{11}

Renal DSA remains the preferred method and reference technique for the diagnosis of pseudoaneurysm and AVF.\textsuperscript{12} It provides invaluable information regarding the site, size, and number of the feeding and draining vessels. It can also provide important information regarding the contralateral kidney if nephrectomy becomes necessary. Other imaging modalities that are known to accurately evaluate these lesions include colour Doppler sonography, computed tomography angiography and magnetic resonance angiography.\textsuperscript{2} Owing to its superior 3-dimensional capability, magnetic resonance angiography is helpful in evaluating the anatomical relationships of these lesions. In our study, all patients underwent DSA, 4 underwent ultrasonography, and none underwent computed tomography angiography, or magnetic resonance angiography. In our institution, DSA was the preferred modality because it provided a ‘1-stop’ service for the patient if embolisation was required.

Common embolic agents include Gelfoam, steel coils, liquid embolic agents, and particulate materials. The choice of material depends on the site, size, and accessibility of the branch that feeds the pseudoaneurysms and AVFs. Embolic agents can also be used in combination to control the bleeding, and each agent has its own advantages and disadvantages.

Gelfoam and coils are generally regarded as the preferred embolic agent in the majority of reported series.\textsuperscript{4} Gelfoam undergoes resorption within a couple of weeks, but usually occludes the lesion long enough for the reparative process to take place. However, the occlusion of large vessels may be difficult to achieve by Gelfoam alone. In our series, 2 patients required Gelfoam and coils for complete embolisation. One of the major problems associated with the use of Gelfoam is reflux of the agent into normal arteries towards the end of embolisation.\textsuperscript{4} With careful techniques and use of an occlusion balloon, this risk can be reduced considerably. Other techniques, such as the use of a coaxial microcatheter to achieve distal catheterisation, also helps reduce the volume of infarcted renal tissue.

Steel coils are generally reserved for large vessel injuries or if Gelfoam embolisation fails.\textsuperscript{4} Particulate material is used to occlude small feeding branches in pseudoaneurysms and is not recommended in well-formed fistulas.\textsuperscript{4} In our series, 1 pseudoaneurysm was occluded with PVA alone because this agent provided a fast and permanent occlusion of the vessel. The rest of the lesions were occluded with a combination of coils, Gelfoam, and PVA owing to the location of the lesion and the large size of the feeding vessel. No major differences in clinical outcome were noted between the different embolic agents. Minimal perfusion defect, reflecting parenchymal tissue loss, was observed in all cases in postembolisation angiograms.

Other treatment options available included partial nephrectomy, total nephrectomy, or arterial ligation, all of which would have resulted in gross renal parenchymal tissue loss.\textsuperscript{5,6} Compared with surgical treatment, selective transarterial embolisation is far less invasive, has a high success rate, results in minimal renal parenchymal tissue loss, and can be repeated if necessary.\textsuperscript{4} Hence, surgery should be reserved as a last choice in cases in which bleeding does not cease with endovascular treatment.

**CONCLUSION**

Renal angiography, combined with selective transarterial embolisation in the same session, is currently considered as the most appropriate technique in the management of severe renal vascular injuries after percutaneous renal procedures.\textsuperscript{5,3} The success rate in experienced hands can be up to 100%.\textsuperscript{2} The aim is to occlude the pseudoaneurysm and the feeding arteries, with minimal parenchymal tissue loss.

The 9 patients in our study underwent diagnostic angiography followed by transarterial embolisation using various emboli agents, all with successful technical and clinical outcomes. No procedure-related complication was encountered. Minimal renal parenchymal tissue loss was observed. We conclude that the technique of renal angiography and selective transarterial embolisation is a safe and effective method in the management of major iatrogenic renal vascular injuries in centres where expertise in endovascular procedure is available.

**REFERENCES**


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