J HK Coll Radiol. 2008;11:103-107

ORIGINAL ARTICLE

CME

Endovascular Management of Iatrogenic Renal Vascular Injuries Complicating Percutaneous Nephrolithotripsy: Role of Renal Angiography and Superselective Coil Embolisation

TJ Tan, HS Teh, U Pua, SH Ho

Department of Diagnostic Radiology, Changi General Hospital, Singapore

ABSTRACT

Objective: *To describe the use of renal angiography in the detection of renal vascular injuries following percutaneous nephrolithotripsy and to assess the efficacy of endovascular management of these complications.*

Methods: *This was a retrospective review of 131 consecutive patients who underwent percutaneous nephrolithotripsy for renal calculi from January 2001 to July 2005. All patients who presented with significant postoperative haemorrhage were evaluated by renal angiography as a first-line diagnostic study, followed by superselective coil embolisation of identified renal vascular injuries at the same session. The mean follow-up period was 5.8 months (range, 1 to 17 months). The parameters assessed for each patient included preoperative investigation findings, surgical technique, clinical presentation following surgery, type of renal vascular injury identified, embolisation technique, and therapeutic outcome.*

Results: *Five arterial lesions were diagnosed in 4 patients (3 men and 1 woman) with a mean age of 51.5 years (range, 45 to 62 years). Three pseudoaneurysms and 2 arteriovenous fistulas were identified. All patients were treated with superselective coil embolisation, with complete resolution of haemorrhage, no further clinical deterioration, and preservation of renal function.*

Conclusions: *Renal vascular injury is a rare complication of percutaneous nephrolithotripsy. Early renal angiography and superselective coil embolisation can play an integral diagnostic and therapeutic role.*

Key Words: *Angiography; Embolization, therapeutic; Lithotripsy; Nephrostomy, percutaneous*

INTRODUCTION

Percutaneous nephrolithotripsy (PCNL) is a safe and effective treatment modality for the management of renal calculi. This technique is associated with high success rates, decreased morbidity, and few complications. The incidence of postoperative haemorrhage complicating PCNL ranges from 0.8% to 7.0%.[1-8]

PCNL has largely replaced open surgery for patients of all ages and for nearly all types of renal stones. The reported incidence of vascular injury and haemorrhage is lower for PCNL than for open surgery for renal stones.[4] This study aimed to describe the use of renal angiography in the detection of renal vascular injuries following PCNL, and to assess the efficacy of endovascular management of these complications.

Correspondence: *Dr TJ Tan, Department of Diagnostic Radiology, Singapore General Hospital, Outram Road, Singapore 169608.*
Tel: (65) 9746 5867; Fax: (65) 6326 5242;
E-mail: ahjin107@hotmail.com

Submitted: 28 April 2008; Accepted: 14 July 2008.

METHODS

Patients

This study was a retrospective review of 131 consecutive patients who underwent PCNL for renal calculi at Changi General Hospital, Singapore, from January 2001 to July 2005. The parameters assessed for each patient included preoperative investigation findings, surgical technique used, clinical presentation following surgery, type of renal vascular injury identified, embolisation technique, and therapeutic outcome, including the overall effect on haemoglobin and serum creatinine levels. Institutional review board approval was waived for this retrospective study.

Design

All patients who presented with significant postoperative haemorrhage were evaluated by renal angiography

as a first-line imaging study. Those patients who had vascular complications identified by renal angiography were subsequently treated with superselective coil embolisation in the same session.

Common femoral artery access was followed by an abdominal aortogram to demonstrate the vascular anatomy, determine the presence of accessory renal arteries, and exclude iatrogenic injury to extra-renal vessels. Selective renal arteriogram on the affected side was then performed following assessment of the anatomical configuration of the ipsilateral renal artery. After the site and type of vascular injury was identified by the renal arteriogram (Figure 1a), superselective catheterisation of the supplying vessel was then performed using microcatheters. In all affected patients, coils were successfully deployed using this technique to exclude the lesion from the renal circulation without compromising the vascular supply to the rest of the kidney (Figure 1b). A completion angiogram was performed 3 to 5 minutes after the procedure to document vascular stasis.

The mean follow-up period was 5.8 months (range, 1 to 17 months). Subjective and objective criteria were used for the assessment of therapeutic outcome. Subjective assessment of a successful outcome was based on symptom resolution, while measurements of haemoglobin and serum creatinine levels were used for objective assessment.

RESULTS

Four of 131 consecutive patients (3%) who underwent PCNL from January 2001 to July 2005 presented with significant postoperative haemorrhage, for which renal angiography was used to identify iatrogenic renal vascular injury. There were 3 men and 1 woman, with a mean age of 51.5 years (range, 45 to 62 years). All 4 patients were initially diagnosed with renal calculi measuring ≥2.5 cm in widest diameter by intravenous urogram (Table 1). The transparenchymal posterolateral approach was used during nephrostomy for all 4 patients. Three patients received a lower pole puncture, while an upper pole puncture was used to gain access to the renal calculi in the remaining patient. The NephroMax™ balloon (Boston Scientific, Natick, USA) was used for dilatation of the nephrostomy tract and the Swiss LithoClast® (EMS-Boston Scientific Corp, Natick, USA) was used for pneumatic and ultrasonic lithotripsy of renal calculi in all 4 patients (Table 1). The mean operative time was 102.5 minutes (range, 80 to 115 minutes).

Three patients presented with new-onset postoperative gross haematuria, one of whom complained of additional ipsilateral loin pain. The remaining patient presented with haemorrhage from the nephrostomy site (Table 2). The mean time to presentation was 6.2 days (range, 4 to 13 days) following PCNL. Renal angiograms were performed as first-line imaging studies for all 4 patients within 4 days of symptom presentation. Five arterial

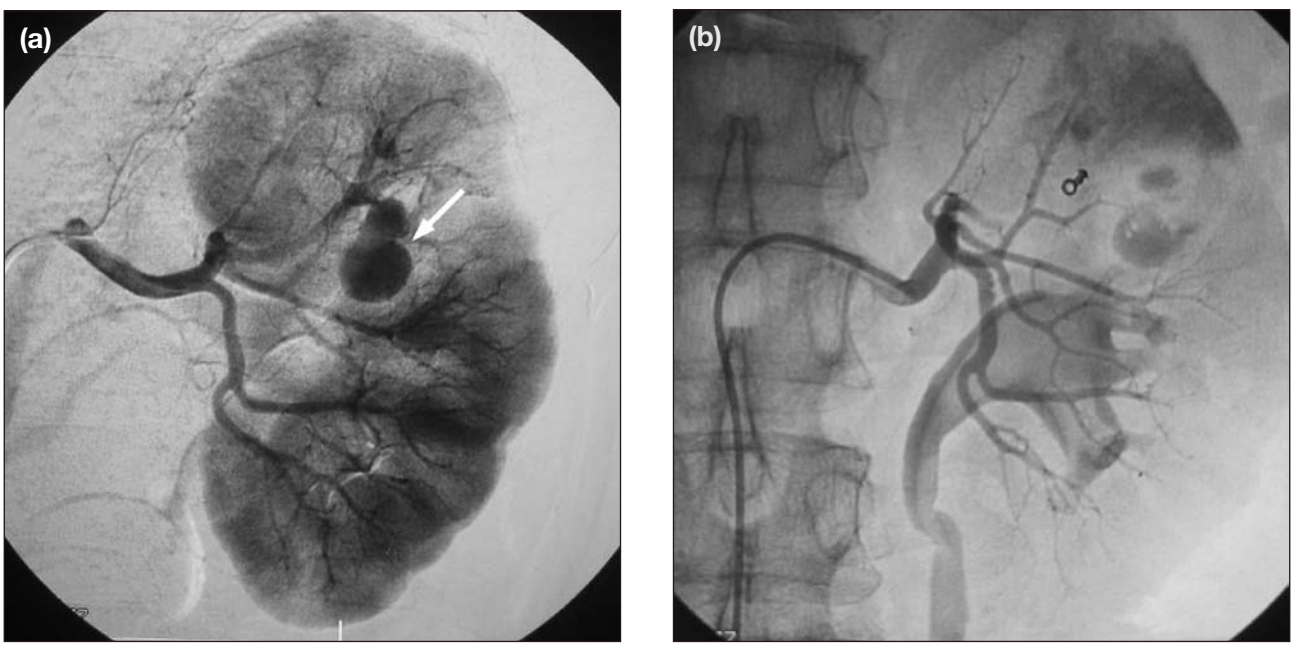

Figure 1. Selective left renal angiogram showing (a) a pseudoaneurysm (arrow) supplied by an upper pole posterior segmental branch of the left renal artery; and (b) post-coil embolisation showing successful occlusion of the supplying vessel and non-filling of the pseudoaneurysm.

Table 1. Preoperative findings and surgical technique used for patients with iatrogenic renal vascular injuries following percutaneous nephrolithotripsy.

Patient number	Position of renal calculus	Size of calculus (cm)	Site of nephrostomy	Number of punctures	Method of nephrostomy tract dilatation	Method of lithotripsy
1	Left upper calyx	2.5 x 2.0	Upper pole	1	NephroMax	Swiss LithoClast
2	Left renal pelvis	2.5 x 2.2	Lower pole	1	NephroMax	Swiss LithoClast
3	Right staghorn	3.0 x 1.0	Lower pole	1	NephroMax	Swiss LithoClast
4	Right lower calyx	2.5 x 2.5	Lower pole	1	NephroMax	Swiss LithoClast

Table 2. Angiography findings and endovascular treatment in patients with iatrogenic renal vascular injuries following percutaneous nephrolithotripsy.

Patient number	Clinical presentation	Vascular lesion	Artery involved	Embolisation agent	Outcome
1	Bleeding from nephrostomy site	Pseudoaneurysm	Left upper pole segmental artery	Coils	Successful
2	Gross haematuria	Arteriovenous fistula	Left lower pole segmental artery	Coils	Successful
3	Gross haematuria and right loin pain	Pseudoaneurysm	Right lower pole segmental artery	Coils	Successful
4	Gross haematuria	Arteriovenous fistula and pseudoaneurysm	Right lower pole segmental artery	Coils	Successful

Table 3. Haemoglobin levels before surgery, prior to embolisation, and after embolisation.

Patient number	Haemoglobin levels (g/L)			Blood transfusion
	Before surgery	Prior to embolisation	After embolisation	
1	132	107	89	1 day after embolisation
2	158	94	86	Nil
3	132	99	90	1 day prior to embolisation
4	149	147	132	Nil

Table 4. Serum creatinine levels before surgery, prior to embolisation, and after embolisation.

Patient number	Serum creatinine levels (μmol/L)		
	Before surgery	Prior to embolisation	After embolisation
1	42	59	77
2	88	94	105
3	69	81	92
4	90	115	116

lesions were diagnosed among the 4 patients. Three pseudoaneurysms and 2 arteriovenous fistulas were identified (Table 2).

All 4 patients were treated with superselective coil embolisation, with completion renal angiograms demonstrating exclusion of the vascular lesions from the rest of the renal vascular supply and vascular stasis. Resolution of haemorrhage occurred within 1 to 3 days for all 4 patients. One patient had recurrence of gross haematuria 12 days after PCNL despite successful superselective coil embolisation of an arteriovenous fistula. Repeat renal angiogram showed a pseudoaneurysm distinct from the previous arteriovenous fistula and subsequent superselective coil embolisation was successfully used to achieve symptom resolution with no further recurrence. No procedure-related complications such as non-target embolisation, renal infarct, or groin haematomas were encountered.

At the time of presentation of significant haemorrhage, all 4 patients had elevation of serum creatinine levels and reduction of haemoglobin levels from their pre-PCNL baseline values. Postembolisation, none of the patients required blood transfusion after the first day (Table 3) and no further deterioration of renal function was seen in the immediate postembolisation period (Table 4). Clinically, complete cessation of gross haematuria and flank pain was achieved for all 4 patients within 1 to 3 days. All 4 patients had an uneventful recovery. None of the patients had recurrence of symptoms during the subsequent clinical follow-up.

DISCUSSION

PCNL is the treatment of choice for most large renal calculi. Although the technique is safe and effective, complications of significant postoperative haemorrhage have been reported.[1-4] Bleeding may also be encountered during puncture and track dilatation, but this often responds to the tamponade effect provided by placement of the nephrostomy tube.[8]

Nephrostomy-related vascular injuries are believed to be the result of trauma to either the anterior or posterior segmental arteries, rather than the smaller peripheral interlobular arteries, which are surrounded by dense parenchyma and therefore easier to tamponade with the nephrostomy tube.[8] This is reflected in the patients in this study, for whom all the lesions arose from the segmental arteries. A transparenchymal posterolateral puncture directed towards the fornix or infundibulum of a middle or lower pole calyx is theoretically the safest approach because the puncture is most likely to pass through the area of Brodel's avascular line (the least vascular portion of the kidney).[7,9] However, despite using a transparenchymal posterolateral approach, 4 patients had renal vascular injuries in this study.

A relationship between multiple-access approaches in PCNL and postoperative vascular complications has previously been suggested.[6,9] However, this was not the case in this study, as each of the 4 patients who had significant post-PCNL haemorrhage had only 1 nephrostomy tract. Srivastava et al reported that a mean stone size of ≥2.97 cm significantly predicted for the occurrence of vascular complications following PCNL.[5] In comparison, the mean stone size in this study was 2.6 cm. El-Nahas et al concluded that significant risk factors for severe post-PCNL bleeding included an upper calyceal puncture, a solitary kidney, and a staghorn stone.[6] In contrast, 3 of the 4 patients with significant post-PCNL haemorrhage in this study had lower pole punctures, while the remaining patient had an upper pole puncture (Table 1). In addition, only 1 patient had a staghorn calculus (Table 1), and none of the patients had a solitary kidney. Possible reasons for the apparent disparity between this study and those in the literature include differences in surgical technique and patient selection, although a larger study cohort is necessary for a more accurate assessment of the predictive factors for significant post-PCNL haemorrhage.

The incidence of 3% for serious iatrogenic post-PCNL vascular injury in this study is similar to that reported in other studies of 0.8% to 7.0%.[1-8] All 4 patients presented within 2 weeks of PCNL, a time interval comparable with that of previous studies.[5,7,8] Only 1 patient experienced a recurrence of significant gross haematuria (after the first embolisation) on the 12th postoperative day, and was treated successfully with repeat embolisation. The second lesion was not identified during the first angiogram and this reflects the usefulness of a repeat angiogram in the detection and treatment of occult lesions on recurrence of symptoms.

Endovascular techniques are increasingly used to accurately diagnose and effectively treat vascular complications arising from percutaneous renal surgery,[7,8,10,11] renal biopsies,[7,12] and trauma,[13,14] as well as rare congenital renal arteriovenous fistulas.[15,16] The choice of embolic material depends on the site and accessibility of the vessel feeding the pseudoaneurysm or arteriovenous fistula.[7] Phadke et al have recommended using steel coils after gelfoam pledgets for medium-sized feeding vessels.[7] Steel coils without prior gelfoam pledgets were used successfully for similar medium-sized segmental arteries in all 4 patients with post-PCNL haemorrhage in this study. By occluding the pressure head to the vascular lesion, coil embolisation of the offending vessel works similarly to surgical ligation, but without the risk of further renal parenchymal injury. The minimally invasive nature and the rapid cessation of haemorrhage, together with minimal loss of renal function, makes superselective coil embolisation a valuable tool.

There are several limitations to this study. The rarity of significant post-PCNL haemorrhage enabled only a retrospective study to be performed for this small group of patients. Furthermore, all 4 patients who had superselective coil embolisation were only followed up clinically. It is uncertain whether their serum creatinine and haemoglobin levels returned to baseline levels. The authors recognise that renal ultrasonography and computed tomography scans of the kidneys are potentially valuable non-invasive imaging modalities that can also be used to objectively assess the therapeutic outcome of embolisation for serious iatrogenic post-PCNL vascular injuries.

Renal angiography and embolisation play an important role in the early diagnosis and treatment of significant post-PCNL haemorrhage and should be considered as a first-line management tool.

REFERENCES

1. Skolarikos A, Alivizatos G. Percutaneous nephrolithotomy and its legacy. Eur Urol. 2005;47:22-8.
2. Kim SC, Kuo RL, Lingeman JE. Percutaneous nephrolithotomy: an update. Curr Opin Urol. 2003;13:235-41.
3. Wong MY. An update on percutaneous nephrolithotomy in the management of urinary calculi. Curr Opin Urol. 2001;11:367-72.
4. Al-Kohlany KM, Shokeir AA, Mosbah A, et al. Treatment of complete staghorn stones: a prospective randomized comparison of open surgery versus percutaneous nephrolithotomy. J Urol. 2005;173:469-73.
5. Srivastava A, Singh KJ, Suri A, et al. Vascular complications after percutaneous nephrolithotomy: are there any predictive factors? Urology. 2005;66:38-40.
6. El-Nahas A, Shokeir A, El-Assmy A, et al. Post-percutaneous

nephrolithotomy extensive haemorrhage: a study of risk factors. J Urol. 2007;177:576-9.
7. Phadke RV, Sawlani V, Rastogi H, et al. Iatrogenic renal vascular injuries and their radiological management. Clin Radiol. 1997;52:119-23.
8. Kessaris DN, Bellmann GC, Pardalidis NP, Smith AG. Management of haemorrhage after percutaneous renal surgery. J Urol. 1995;153:604-8.
9. Netto NR Jr, Ikonomidis J, Ikari O, Claro JA. Comparative study of percutaneous access for staghorn calculi. Urology. 2005;65: 659-63.
10. Takebayashi S, Hosaka M, Kubota Y, et al. Transarterial embolization and ablation of renal arteriovenous malformations: efficacy and damages in 30 patients with long-term follow-up. J Urol. 1998; 159:696-701.
11. Martin X, Murat FJ, Feitosa LC, et al. Severe bleeding after nephrolithotomy; results of therapeutic embolization. Eur Urol. 2000;37:136-9.
12. Bilge I, Rozanes I, Acunas B, et al. Endovascular treatment of arteriovenous fistulas complicating percutaneous renal biopsy in 3 paediatric cases. Nephrol Dial Transplant. 1999;14:2726-30.
13. Hans PD, Hasjorg D, Jurgen T. Blunt renal trauma: minimally invasive management with microcatheter embolization — experience in nine patients. Radiology. 2002;223:723-30.
14. David AB, Zsolt TS, Norman EM. Embolization of an acute renal arteriovenous fistula following a stab wound: case report and review of literature. Am Surg. 2005;71:62-5.
15. Lupattelli T, Garaci FG, Manenti G, Belli AM, Simonetti G. Giant high-flow renal arteriovenous fistula treated by percutaneous embolization. Urology. 2003;61:837.
16. Christophe S, Alain R, Francois B. Idiopathic renal arteriovenous fistula: treatment with embolization. Ann Vasc Surg. 1998;12:75-7.