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Transarterial Embolization of Renal Vascular Lesions after Percutaneous Nephrolithotomy

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Abstract

Introduction: Percutaneous nephrolithotomy (PCNL) is a safe and effective procedure in the surgical management of renal stone disease. Hematuria is one of the most common complications following PCNL. In most cases, the bleeding is self-limited and do not require surgical intervention. Renal arteriography with selective angiographic embolization is required in patients with massive hemorrhage or continuous hematuria. Our aim was to evaluate the effectiveness of percutaneous transarterial embolization for the treatment of renal pseudoaneurysms following post-PCNL bleeding.

Materials and Methods: A total of 852 patients who underwent PCNL for renal calculus, between March 2014 and October 2017 and included 12 patients who had undergone renal embolization due to significant post-PCNL renal artery bleeding. The site, number, and type of bleeding lesions, and the result of the embolization procedure were recorded. We report on the incidence, treatment, radiological and clinical results of these serious vascular injuries at our institution.

Results: Our study has included a large group of patients, the 100% angiographic success rate confirming that percutaneous transcatheter embolization is a valuable treatment for most renal vascular injuries. Renal angiography revealed pseudoaneurysm in 10 patients, arteriovenous fistula in 1, and arterial laceration in 1 patients. Significant risk factors on univariate analysis for severe hematuria requiring superselective angiography were multiple/staghorn calculi, upper calix puncture, and history of pyelonephritis. The severity of the hematuria after PCNL is influenced by many factors, including mean stone size and mean operative time, and is correlated with duration of hospitalization and mean hemoglobin drop.

Conclusions: Percutaneous transarterial embolization of the injured vessel is an effective,f minimally invasive and relatively easy procedure in experienced centers, with a high rate of success and immediate benefits, thus saving the patient from the morbidity that result from severe renal bleeding.

Key words: Angioembolization, Post-PCNL bleeding, Renal pseudoaneurysms

INTRODUCTION

Percutaneous nephrolithotomy (PCNL) is a safe and effective Minimally invasive procedure for the renal stone disease.[1-3] Nevertheless, surgeons have to face specific complications during and after the procedure, hemorrhage being one of the most common, with a reported incidence that varies between 0.8% and 7.6%.[4-7] Usually, renal injuries are self-limited and conservative measures are adequate to control bleeding in most of the cases.[8] Renal arteriography with selective or over selective angiographic embolization is needed in patients with massive hemorrhage or continuous hematuria,[9] while nephrectomy is reserved only for the cases in which the minimally invasive endovascular treatment fails.[10] The purpose of this study is to review the severe hemorrhagic complications that are associated with PCNL and to prove the efficacy of endoluminal management in taking control of them. We report on the incidence, treatment, radiological and clinical results of these serious vascular injuries at our institution.

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MATERIALS AND METHODS

The data from all 852 patients undergoing PCNL for removal of renal calculi between March 2014 and October

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2017 were retrospectively reviewed. A number of 102 hemorrhagic complications were observed, but only 12 patients (1.4%) had significant bleeding that required angiography and embolization for bleeding control. Hemogram, coagulation profile, serum electrolytes, glucose, serum creatinine levels, urinalysis and urine culture, liver function tests, ultrasonography, and computed tomography (CT) were performed before the patients underwent PCNL. Our operative technique involved percutaneous puncture under multidirectional C-arm fluoroscopic guidance, dilation of the nephrostomy track up to 30F, and use of an Amplatz sheet. Smaller stones were removed with the help of forceps, larger ones being crushed with pneumatic lithotripsy before extraction. For all patients, we have used "tubeless" PCNL, in which the nephrostomy tube was replaced with internal drainage provided by a double - J stent or a ureteral catheter. After informed consent was obtained and digital subtraction angiography confirmed the diagnosis of pseudoaneurysm (PA) or arteriovenous fistula (AVF), percutaneous embolization was performed by our interventional radiologist. For the DSA procedure, the left brachial[3] or right main femoral artery[9] was punctured under local anesthesia using Seldinger technique and a 6F vascular sheath was inserted as an introducer. Over a 0.035-inch diameter guidewire, an abdominal aortography was obtained with a 5F Cobra catheter (Cordis, Johnson and Johnson, Miami, USA) by injecting a 8–10 ml contrast media, which shows the main or accessory renal arteries on either side. Thereafter, a selective renal DSA was performed by advancing the catheter into the injured branch of the renal artery feeding the lesion. Rapid filming sequences and careful examination of all phases of the arteriogram are necessary to assess the site and feeding pedicle, flow pattern, and venous drainage of the vascular lesion. In 8 cases in which the lesion was at or near a segmental branch, we used a 4F catheter for selective catheterization and embolization; while in the remaining 8 patients the location of the injury at a subsegmental branch necessitated the use of a superselective microcatheter (Progreat, Terumo). The catheters were inserted as near as possible to the lesion, and the embolizing agent inserted. Pushable fibered coils (VortX, Boston Scientific), 3–5 mm diameter, were deployed for superselective vascular occlusion (10 patients), the number and size of them being adapted to the lesion size. Microparticles (MCP) (Embozene, CeloNova Biosciences), 1100–1300 mi, or Amplatzer vascular plugs (AVP II, AGA Medical) were applied in 2 patients in whom the lesion could not be superselective catheterized. A combination of coils and MCP was necessary in 4 patients. The procedure was completed when total occlusion of the lesion and cessation of the hemorrhage on the control angiogram was seen. After institutional review board approval, we extracted from the patient medical charts and examined in relation to bleeding the following variables: Patient characteristics, renal function prior and after embolization, hemoglobin concentration and requirement of blood transfusion, timing of embolization, intraoperative variables, interventional radiology procedure details, and outcomes. Data were analyzed using MedCalc for Windows, version 11.6.1.0, MedCalc Software, Mariakerke, Belgium. Quantitative variables were provided as mean ± standard deviation and compared by independent samples t-test, $P < 0.05$ being considered statistically significant.

RESULTS

Of the 852 PCNL procedures, 10 patients (1.25%), 7 males and 3 females, aged 28–69 years (mean, 52.8), required superselective renal angiography due to severe/persistent hematuria from the right (6 cases) or left kidney (4 cases). As the first imaging modality, DSA was used in 6 patients, while remaining 6 patients underwent USG/CT (PLAIN) renal CT angiogram. Indications for renal DSA were severe hematuria with hemodynamic instability associated with important decrease of the hemoglobin and hematocrit values during the first 24 h after surgery (3 patients); frank renal hemorrhage necessitating blood transfusion in the early post-operative period, 2–14 days after PCNL (8 patients); and sudden hemorrhage more than 14 days postoperatively (4 patients). The severity of the hematuria after PCNL is influenced by many factors, including mean stone size and mean operative time, and is correlated with duration of hospitalization and mean hemoglobin drop. All patients had a normal coagulation profile before surgery. Patients' blood loss, need for transfusion and number of units transfused according to the moment of the post-PCNL bleeding debut. Hematuria in the early post-operative period required a mean of 2.88 ± 1.49 U of blood transfused in addition to replacement of the intraoperative blood loss. The mean interval between the debut of hematuria and embolization was 5.33 ± 0.47 h for patients with severe hematuria during the first 24 h after surgery, 156.72 ± 41.76 h for gross renal hemorrhage in the early post-operative period, and 15.6 ± 1.69 h for those with tardive post-PCNL bleeding. Significant risk factors on univariate analysis for severe hematuria requiring superselective angiography were multiple/staghorn calculi, upper calix puncture, and history of pyelonephritis[Table 1]. After successful embolization no patient required transfusion, and no further deterioration of renal function was observed. Renal angiography revealed PA [Figure 1] in 10 patients, AVF in 1, and arterial laceration in 1 patients. In one patient, we observed the presence of 2 PA, filled from different subsegmental arteries that were successively catheterized and occluded with coils [Figure 2]. Bleeding was controlled with superselective

Table 1: Risk Factors for Hematuria Requires Angiography

Chacracters	Mild to moderate hematuria	Hematuria requires angiography	P value
Upper calyceal puncture	35	4	0.032
Multiple tracts	30	5	0.021
Renal failure	25	6	0.020
UTI	89	8	0.011

Figure 1: Digital signature algorithm - pseudoaneurysm of the left kidney

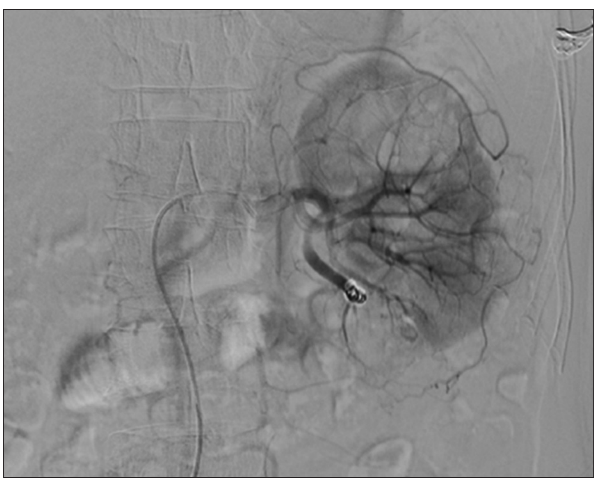

Figure 2: Post coiling - complete resolution of pseudoaneurysm

embolization in 10 patients (95.45%). Gross hematuria persisted 24 h after the procedure in one case, which was being successfully managed with repeated embolization. The early post-embolization course was smooth in 11 patients with cessation of hematuria within 24 h, only one patient presenting persistent moderate hematuria for a period of 2.25 ± 1.08 days, that resolved spontaneously, the most likely cause being lysis of the collecting system clot related to the pre-embolization bleeding rather than ongoing hemorrhage. Hemoglobin, hematocrit, blood urea nitrogen, serum creatinine values, and glomerular filtration rate were measured and recorded for every patient, and median values were reported preoperatively, at diagnosis of the vascular lesion, after embolization and at follow-up. Post-embolization syndrome (hyperpyrexia, nausea, vomiting, and pain) did not develop in any patient, although in the literature pyrexia and pain have been reported at a rate of 9% and 5%, respectively. Renal ultrasonography detected perinephric hematomas in 3 patients, all of them being successfully managed with conservative therapy. Renal biochemistry and ultrasonography were performed at 3 months for all 12 patients with successful embolization. There were no procedure-related complications during follow-up period or worsening of previously controlled hypertension, all patients presenting normal renal vascularity, with no increase in serum creatinine levels.

DISCUSSION

As the kidney is an extremely vascular organ, blood loss is a normal feature of PCNL, necessitating transfusion in 3–23% of cases.[6,7,11] Excessive bleeding usually arises from injury of the segmental arteries, which are surrounded by dense parenchyma and, thus, easier to tampon with the nephrostomy sheath or tube.[12] The bleeding may occur during renal puncture, Amplatz tract dilatation, manipulation of the nephroscope, or in the post-operative period.[13] The arterial system is an increased pressure one, which means that the risk of an AVF (blood passage from the high pressure of the injured artery to the injured adjacent vein) or a PA (blood passage to the parenchyma) is high.[13] Venous bleeding can usually be managed conservatively with tamponade nephrostomy tubes, whereas severe arterial bleeding requires selective angiographic embolization (range 0.3–1.4%).[14-18] The transfusion and embolization rates in our series were comparable to these ranges (15.5% and 1.05%, respectively). US, multidetector spiral CT and magnetic resonance angiography (MRA) may detect vascular renal lesions and offers information about lesion site, type, and flow pattern,[9] while angiography remains the gold standard procedure, capable to provide endovascular treatment during the same imaging session.[19] Duplex ultrasound may be used initially to detect clinically suspected PA, the images showing sonolucent lesions with turbulent flow. Ultrasound with color Doppler assessment could suggest AVF in the presence of a focal flurry of disorganized color beyond the vessel lumen thought to be due to vibration of the tissue surrounding the fistula. The feeding artery will demonstrate a high-velocity, low-resistance waveform and the draining vein may show pulsatile, arterialized flow. In this study, DSA was performed as first imaging method in 6 patients with ongoing hematuria, who required transfer to the angiography unit as soon as possible. However, in 6 patients with irregular or intermittent bleeding, US and CT exam provided important clues for the diagnosis and influenced interventional treatment decisions. In patients with decreased renal function, we have avoided CT exam due to the risk of contrast-induced nephropathy.[20] We have also excluded the possibility of performing a MRA exam since it can be associated with the risk of developing cutaneous changes of nephrogenic systemic fibrosis after exposure to gadolinium-containing contrast.[21] Our study has included a large group of patients, the 95.45% angiographic success rate confirming that percutaneous transcatheter embolization is a valuable treatment for most renal vascular injuries.[22] The majority number, 72.72% (8/12), of massive bleeding episodes occurred in the early post-operative period (2–14 days after PCNL). The decision to transfer the patient to an interventional radiology department is delayed in most of the cases by the intermittent character of the bleedings. Optimal monitoring of hemoglobin and hematocrit values, together with quantity of transfused units evaluation, represent an indicator of the moment when selective angiography should be used.[24] A particular situation is represented by the cases with severe bleeding, hemodynamic instability, and a significant decrease of hemoglobin value in the 1st h after the surgery (an average of 4.33 g/dL), that require immediate investigation and treatment (5.33 $\pm$ 0.47 h). We have registered 1 AVF forming as a late complication, confirming the results of Gavant *et al*. that have reported bleeding as late as 13 weeks after PCNL.[23] We performed a comparison between patients with mild, moderate and severe post-PCNL hematuria and found statistically significant differences in terms of number of blood unit transfused (P 0.0001), mean hemoglobin drop (P 0.0001), and duration of hospitalization (P 0.0001). The patients with severe post-PCNL hematuria had a statistically significant difference in stone size ($P = 0.018$) and mean operative time ($P = 0.0023$) when compared with mild hematuria patients, but no difference was observed with regard to moderate hematuria ones. This phenomenon implies that excessive manipulation of the rigid nephroscope to access stones in different calices should be avoided, especially in the group with massive bleeding and increased intraoperative blood transfusion. Our results and those of Srivastava *et al*.[6] stated that stone size significantly predicted severe vascular lesions after PCNL, while Lam *et al*. reported that we can decrease the transfusion rate with the use of a flexible nephroscope and by improving the operator skills.[25] The incidence of chronic renal failure between the three groups was similar. The number of renal punctures was not correlated with the degree of hematuria, contradicting the assumption that minimizing the number of needle punctures is a key factor in preventing excessive blood loss[7,26] and sustaining the results of Kessaris *et al*.[12] Multiple/staghorn stones, upper calix puncture, and history of pyelonephritis, significantly predicted severe vascular lesions after PCNL. However, in this study, the data were collected retrospectively and, therefore, the influence of some factors could not be tested or are subject to bias. Ideally, a multicenter, randomized, prospective study comparing post-PCNL renal hemorrhage treated with embolization, surgery or conservative management would define the most effective treatment modality. The choice of the embolization material is important to achieve good results and depends on the accessibility, size and the flow pattern of the vessels to be occluded. Platinum microcoils are the most commonly used embolic agents because of their accuracy and radiopacity, designed to provide complete vascular occlusion. The main disadvantage was represented by the use of more than one coil in 5 patients for adequate occlusion, which increased the cost and time of the procedure. The microspheres are designed to regain their original shape and volume after passage through the catheter, and represent a versatile embolic platform with superior biocompatibility and structural integrity that provides a tightly calibrated sizing system designed for targeted embolization. The Amplatzer Vascular plug II's unique design significantly reduces the time to occlusion for transcatheter embolization procedures and can be used to occlude larger vessels that would previously have required numerous coils for occlusion.

CONCLUSION

PCNL is currently the procedure of choice for removal of large renal calculi. Percutaneous transarterial embolization of the injured vessel is an effective, minimally invasive and relatively easy procedure in experienced centers, with high rate of success and immediate benefits, thus saving the patient from the morbidity that result from severe renal bleeding. The variations of hemoglobin, together with the quantity of transfused units represent the indicator and decide the moment when selective angiography should be used. By shortening the period between the complication diagnostic and the endovascular treatment the number of hospitalization days could be reduced.

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