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Transarterial Embolization of Renal Vascular Lesions after Percutaneous Nephrolithotomy

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Rezumat

Embolizarea transarterială a leziunilor vasculare renale apărute după nefrolitotomie percutanată

Introducere: Nefrolitotomia percutanată (PCNL) reprezintă o procedură sigură și eficienta de tratament chirurgical al litiazei renale. Cu toate acestea, urologii trebuie să facă față unor complicații specifice în timpul și după intervenția chirurgicală, hemoragia fiind una dintre cele mai frecvent întâlnite. În majoritatea cazurilor tratamentul este conservator, arteriografia renală cu embolizare angiografică selectivă fiind necesară doar la pacienții cu hemoragie masivă sau persistentă. Obiectivul nostru a fost de evaluare a eficienței embolizării percutanate transarteriale în cazul sângerărilor apărute după nefrolitotomia percutanată.
Material și metodă: Acest studiu retrospectiv a fost efectuat între Martie 2007 și Octombrie 2012 și a inclus 22 pacienți la care s-a efectuat embolizare selectivă sau superselectivă datorită sângerărilor semnificative apărute în timpul sau după PCNL. Au fost înregistrate locul, numărul, tipul leziunilor arteriale apărute și rezultatul procedurii de embolizare. Am raportat incidența, modalitatea de tratament, rezultatele radiologice și clinice în cazul acestor serioase leziuni vasculare din instituția noastră.
Rezultate: Studiu nostru a inclus un număr mare de pacienți, rata de succes angiografic de 95.45% confirmând ca embolizarea percutanată transarteriala este tratamentul de elecție pentru majoritatea leziunilor vasculare renale. Angiografia renală a evidențiat pseudoanevrism la 15 pacienți, fistula arteriovenoasă la 5 pacienți și leziune arterială la 2 pacienți. Factorii de risc semnificativ pentru hematuria severă ce necesită angiografie superselectivă în analiza univariată au fost reprezentați de: calculi multiplii/coraliformi, puncția calicelui superior și istoric de pielonefrită. Severitatea hematuriei post PCNL este influențată de factori multiplii, incluzând dimensiunea medie a calculului și timpul operator mediu și este corelată cu durata spitalizării și scăderea medie a hemoglobinei.
Concluzii: Embolizarea transarterială percutanată a vaselor lezate reprezintă o procedură minim invazivă, relativ simplă dacă este efectuată în centre cu experientă, cu rată crescută de succes și beneficii imediate, prin aceasta salvând pacientul de la complicațiile rezultate din sângerarea renală importantă.

Cuvinte cheie: litiază renală, nefrolitotomie percutanată hematurie, embolizare

Abstract

Introduction: Percutaneous nephrolithotomy (PCNL) represents a safe and efficient procedure in the surgical management of renal lithiasis. Nevertheless, surgeons have to face specific complications during and after the procedure, hemorrhage being one of the most common. In most cases the injuries are self-limited and do not need a surgical intervention. Renal arteriography with selective angiographic embolization is needed in patients with massive hemorrhage or continuous hematuria. Our objective was to evaluate the effectiveness of percutaneous transarterial embolization for the treatment of

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renal arterial post-PCNL bleeding.
Material and method: This retrospective study was performed between March 2007 and October 2012 and included 22 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 95.45% angiographic success rate confirming that percutaneous transcatheter embolization is a valuable treatment for most renal vascular injuries. Renal angiography revealed pseudoaneurysm in 15 patients, arteriovenous fistula in 5 and arterial laceration in 2 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, 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 results from severe renal bleeding.

Key words: kidney calculi, percutaneous nephrolithotomy, hemorrhage, therapeutic embolization

Introduction

Percutaneous nephrolithotomy (PCNL) is a safe and efficient procedure in the surgical treatment of renal lithiasis (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). Fortunately, the 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.

Material and Methods

The data from all 2095 patients undergoing PCNL for removal of renal calculi between March 2007 and October 2012 were retrospectively reviewed. A number of 226 hemorrhagic complications were observed, but only 22 patients (1.05%) 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 intravenous urography 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 or baskets, larger ones being crushed with ultrasonic or pneumatic lithotripsy before extraction. The nephrostomy tube was retained only in cases with a stone burden ≥3 cm, multiple access tract, significant residual stones, perforation, bleeding, and requirement for a secondary percutaneous procedure. In the rest of the 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 (sixteen cases) or right main femoral artery (six cases) was punctured under local anesthesia using Seldinger technique and a 6 F vascular sheath was inserted as an introducer (Cordis, Johnson&Johnson, Miami, USA). Over a 0.035-inch diameter guidewire (Terumo, Osaka, Japan), an abdominal aortography was obtained with a 5F Cobra catheter (Cordis, Johnson&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 14 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 (Embozene, CeloNova Biosciences), 1100 –1300 mì, or Amplatzer vascular plugs (AVP II, AGA Medical) were applied in 8 patients in whom the lesion could not be superselectively catheterized. A combination of coils and microparticles (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 analysed using MedCalc for Windows, version 11.6.1.0, MedCalc Software, Mariakerke, Belgium. Quantitative variables were provided as mean ± standard deviation (SD) and compared by Independent Samples t test, *P* values less than .05 being considered statistically significant.

Results

Of the 2095 PCNL procedures, 22 patients (1.05%), 15 males and 7 females, aged 28-69 years (mean, 52.8), required superselective renal angiography due to severe/persistent hematuria from the right (13 cases) or left kidney (9 cases). The diagnosis present at admission was of unilateral renal lithiasis in 16 patients (72.72%) and bilateral in 6 patients (27.27%). *Table 1* lists patients' demographic profile and surgical procedure characteristics in cases requiring angiographic imaging.

As the first imaging modality, DSA was used in six patients, while sixteen patients underwent ultrasound (US) (14 cases) and/or computed tomography (CT) (4 cases). The indications for renal DSA were: severe hematuria with hemodynamic instability associated with important decrease of the hemoglobin and hematocit values during the first 24 hours after surgery (3 patients); frank renal hemorrhage necessitating blood transfusion in the early postoperative period, 2 to 14 days after PCNL (16 patients); and sudden hemorrhage more than 14 days postoperatively (3 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 (*Table 2*).

All patients had a normal coagulation profile before surgery. *Table 3* lists patients' blood loss, need for transfusion and number of units transfused according to the moment of post-PCNL bleeding debut. Hematuria in the early postoperative 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 hours for patients with severe hematuria during the first 24 hours after surgery, 156.72 ± 41.76 hours for gross renal hemorrhage in the early postoperative period, and 15.6 ± 1.69 hours for those with tardive post PCNL bleeding. Significant risk factors on univariate

Table 1. *Patient and surgical procedure characteristics of 22 cases requiring angiography*

Character			Number	Percentage
Median Age ± SD	48.6 ± 17.02	MALE	15	68.18%
	53.4 ± 11.85	FEMALE	7	31.81%
Side		Right	13	59.09%
		Left	9	40.90%
Stone burden		Single	5	22.72%
		Multiple	12	54.54%
		Staghorn	5	22.72%
Number of tracts		Single	16	72.72%
		Multiple	6	27.27%
History of urinary tract infection		None	14	63.63%
		Uncomplicated	5	22.72%
		Pyelonephritis	3	13.63%
Renal morphology		No abnormalities	13	59.09%
		Hydronephrosis	6	27.27%
		Pieloureteral duplication	1	4.54%
		Pieloureteral junction syndrome	2	9.09%
Renal unit		Not solitary	21	95.45%
		Solitary	1	4.54%
History of previous renal surgery	Extracorporeal shock			
		wave lithotripsy	5	22.72%
		Previous PCNL	3	13.63%
		Open nephrolithotomy	1	4.54%
Concurrent medical illnesses		Hypertension	9	40.90%
		Diabetes mellitus	4	18.18%
		Ischemic heart disease	7	31.80%
Timing of massive bleeding		Within 24 h after PCNL	3	13.6%
		Within 2 to 14 days after PCNL	16	72.72%
		More than 14 days after PCNL	3	13.6%

Table 2. *Various parameters of patients with post-PCNL bleeding*

Parameter	Mild hematuria N = 1869 patients	Severe hematuria N = 22 patients requiring angiography	*p*-value *mild versus* severe hematuria (significant if <0.05)	Moderate hematuria N = 204 patients requiring conservative measures	*p*-value *moderate versus* severe hematuria (significant if <0.05)
Mean stone size (cm)	2.98 ± 1.35	3.66 ± 0.78	P = 0.018	3.42 ± 1.28	P = 0.390
Renal puncture sites (n)	1.23 ± 0.51	1.34 ± 0.57	P = 0.315	1.28 ± 0.53	P = 0.185
Chronic renal failure (n)	261	4	P = 0.599	18	P = 0.181
Intra and postoperative blood transfusion (U)	0.51 ± 0.54	3.87 ±1.21	P<0.0001	2.25 ± 0.86	P<0.0001
The mean operative time (minute)	52.4 ± 20.6	65.9 ± 22.6	P = 0.0023	60.3 ± 21.3	P = 0.245
Mean hemoglobin drop (g/dL)	1.53 ± 0.97	4.90 ± 1.34	P<0.0001	3.15 ± 1.20	P<0.0001
Duration of hospitalization (days)	2.62 ± 0.86	7.65 ± 2.88	P<0.0001	4.12 ± 0.78	P<0.0001

Table 3. *Blood loss, need for transfusion, number of units transfused according with the moment of post-PCNL hematuria debut*

Parameter	Hematuria during the first 24 hours after surgery	Hematuria in the early postoperative period (2 to 14 days after surgery)	Sudden hemorrhage more than 14 days postoperatively
Number of patients	3	16	3
Interval between the debut of hematuria and embolization (hours)	5.33 ± 0.47	156.72 ± 41.76	15.6 ± 1.69
Mean blood units transfused during postoperative period (U)	2.33 ± 0.57	2.88 ± 1.49	2.66 ± 1.15
Mean blood units transfused intraoperatively (U)	1.33 ± 0.57	1.13 ± 0.83	0.66 ± 0.57
Mean hemoglobin drop (g/dL)	4.33 ± 0.57	5.05 ± 1.47	4.66 ± 0.57

analysis for severe hematuria requiring superselective angiography were multiple/staghorn calculi, upper calix puncture and history of pyelonephritis (*Table 4*). After successful embolization no patient required transfusion and no further deterioration of renal function was observed.

Renal angiography revealed PA in 15 patients, AVF in 5 and arterial laceration in 2 patients. In one patient we observed the presence of 2 PA, filled from different

Table 4. *Univariate analysis of risk factors for severe hematuria requiring angiography*

Character		Mild and moderate hematuria patients	Severe hematuria patients requiring superselective angiography	p-value
Sex	Male	1215	15	
	Female	858	7	0.3632
Side	Right	1123	13	0.6422
	Left	950	9	
Punctured calix	Lower	1493	13	
	Middle	484	6	0.4716
	Upper	96	3	0.0431
Tracts	Single	1741	16	
	Multiple	332	6	0.154
Chronic renal failure	Yes	279	4	
	No	1794	18	0.509
Solitary Kidney	Not Solitary	2024	21	
	Solitary	49	1	0.504
History of urinary tract infection	None	1739	14	
	Uncomplicated	245	5	0.071
	Pyelonephritis	89	3	0.022
Stone burden	Single	1242	5	
	Multiple	746	12	0.009
	Staghorn	85	5	<0.001
Skin puncture	Subcostal	1638	16	
	Supracostal	435	6	0.468

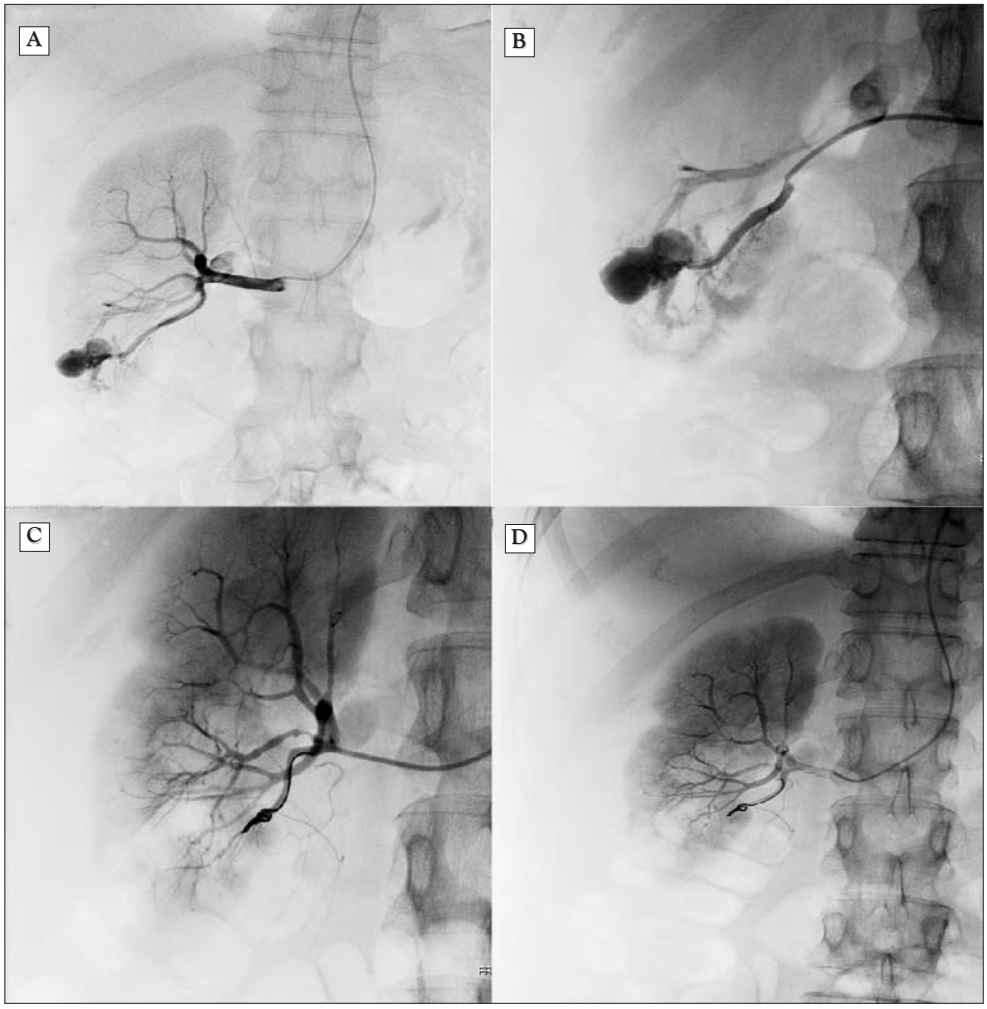

Figure 1. *(**A-D**) Right superselective renal angiography of a 48-year-old woman who presented with bleeding after PCNL. DSA showed a pseudoaneurysm (arrow) arising from a peripheral branch of the lower segmental artery (**A, B**). After the lesion was superselectively catheterized, a coil was inserted, and on post-embolization DSA, no filling of the lesion is seen (**C, D**)*

subsegmental arteries that were successively catheterized and occluded with coils. Vascular injuries disclosed by angiography were related to the upper, middle, and lower polar segmental renal vessels in 3, 6, 13 patients, respectively. Bleeding was controlled with superselective embolization in 21 patients (95.45%). Gross hematuria persisted 24 hours after the procedure in two cases, the first one being successfully managed with repeated embolization. An emergency nephrectomy was required for the second patient, due to a rapid deterioration of his haemodynamic status, which did not allow for the transfer to another embolization session. The early post-embolization course was smooth in 16 patients with cessation of hematuria within 24 hours, only four patients 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 (BUN), serum creatinine values and glomerular filtration rate (eGFRs) 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 (*Table 5*).

Post-embolization syndrome (hyperpyrexia, nausea, vomiting, pain) did not develop in any patient, although in

Table 5. *Variance of biochemical parameters in patients with post-PCNL severe bleeding*

Parameter	Preoperative	Pre-embolization	24 hours Post-embolization	3 months Follow-up
Hemoglobin (mg/dL)	13.43 ± 2.56	8.53 ± 2.24	8.69 ± 2.58	13.21 ± 2.25
Hematocrit (%)	42.97 ± 3.56	26.81 ± 3.41	28.04 ± 3.67	41.62 ± 3.47
Creatinine (mg/dL)	1.06 ± 0.55	1.35 ± 0.62	1.23 ± 0.57	1.15 ± 0.46
Blood urea nitrogen (mg/dL)	18.54 ± 3.87	20.68 ± 4.90	19.27 ± 5.13	18.81 ± 4.91
Glomerular Filtration Rate (ml/min/1.73 m2)	98.77 ± 37.91	91.81 ± 36.83	93.27 ± 36.08	97.36 ± 35.65

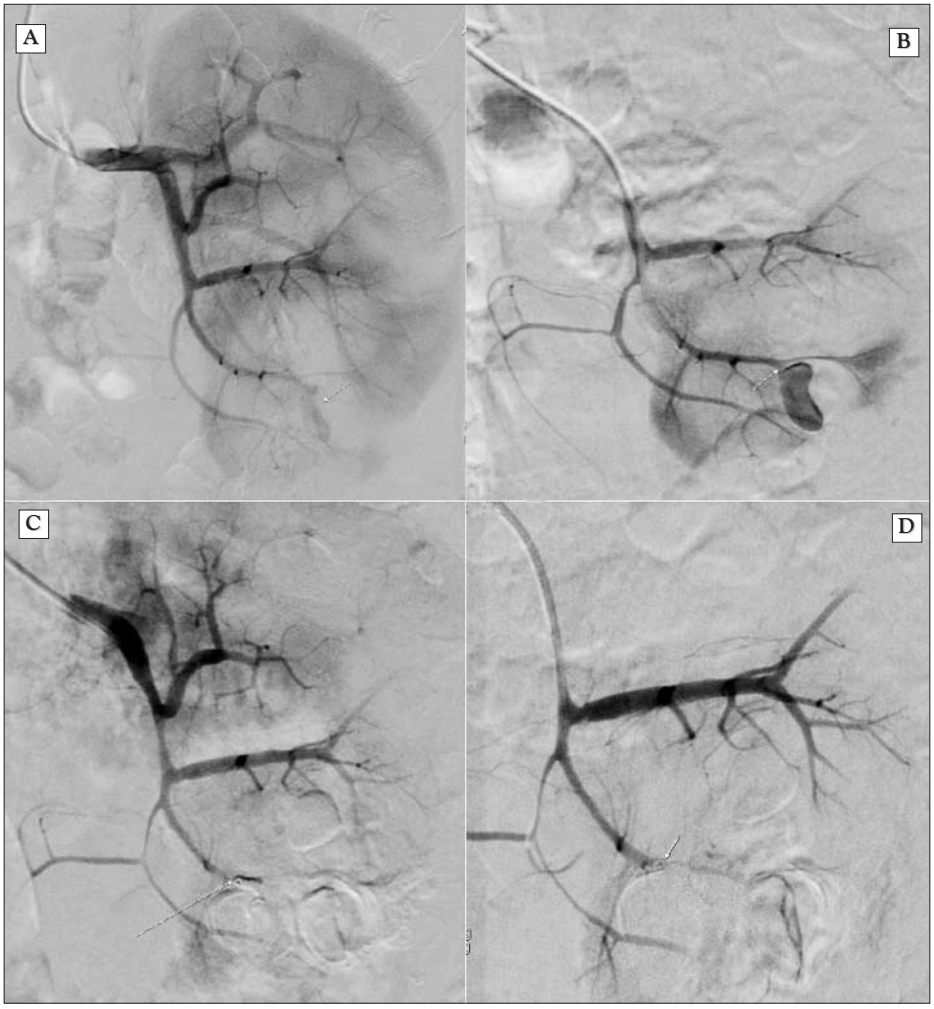

Figure 2. *(**A-D**) Left renal arteriography shows lower pole arteriovenous fistula. Embolization using pushable fibered coils (**A, B**). After the lesion was superselectively catheterized, a coil was inserted, and on post-embolization DSA, no filling of the lesion is seen (**C, D**).*

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 21 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 percutaneous nephrolithotomy, necessitating transfusion in 3% to 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 dilation, manipulation of the nephroscope, or in the postoperative period (13). The arterial system is an increased pressure one, which means that the risk of an arteriovenous fistula (blood passage from the high pressure of the injured artery to the injured adjacent vein) or a pseudoaneurysm (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% to 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

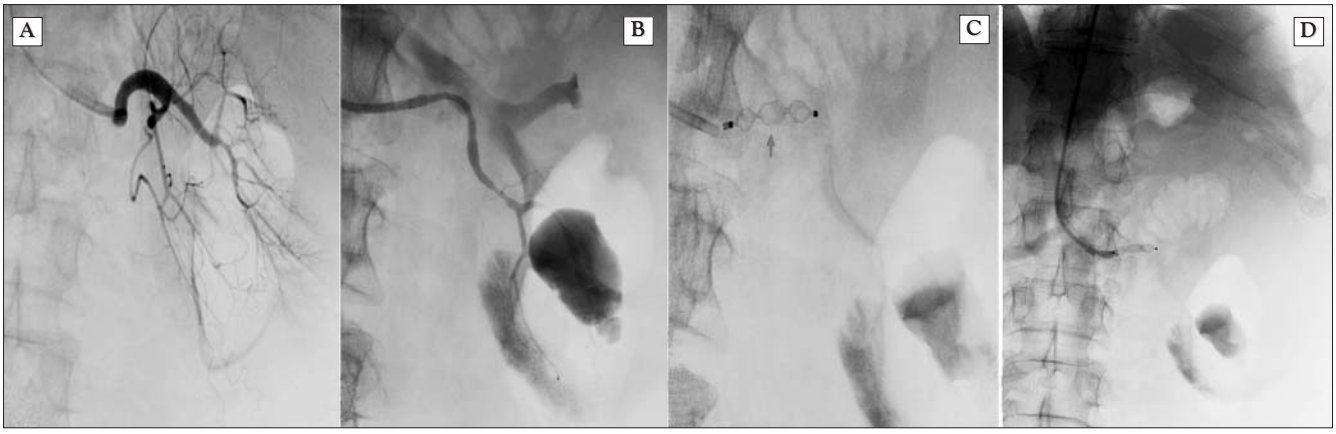

Figure 3. (A-D) *Left lower pole PA. Embolization using Amplatzer Vascular Plug II, placed in distal aspect of feeding artery and composed of three lobes that are designed to better conform to vessel landing zones. A single device can be used to occlude larger vessels that would often require many coils, which makes it an efficient and cost-effective alternative*

angiography unit as soon as possible. However, in 16 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% (16/22), of massive bleeding episodes occurred in the early postoperative period (2 to 14 days after PCNL). The

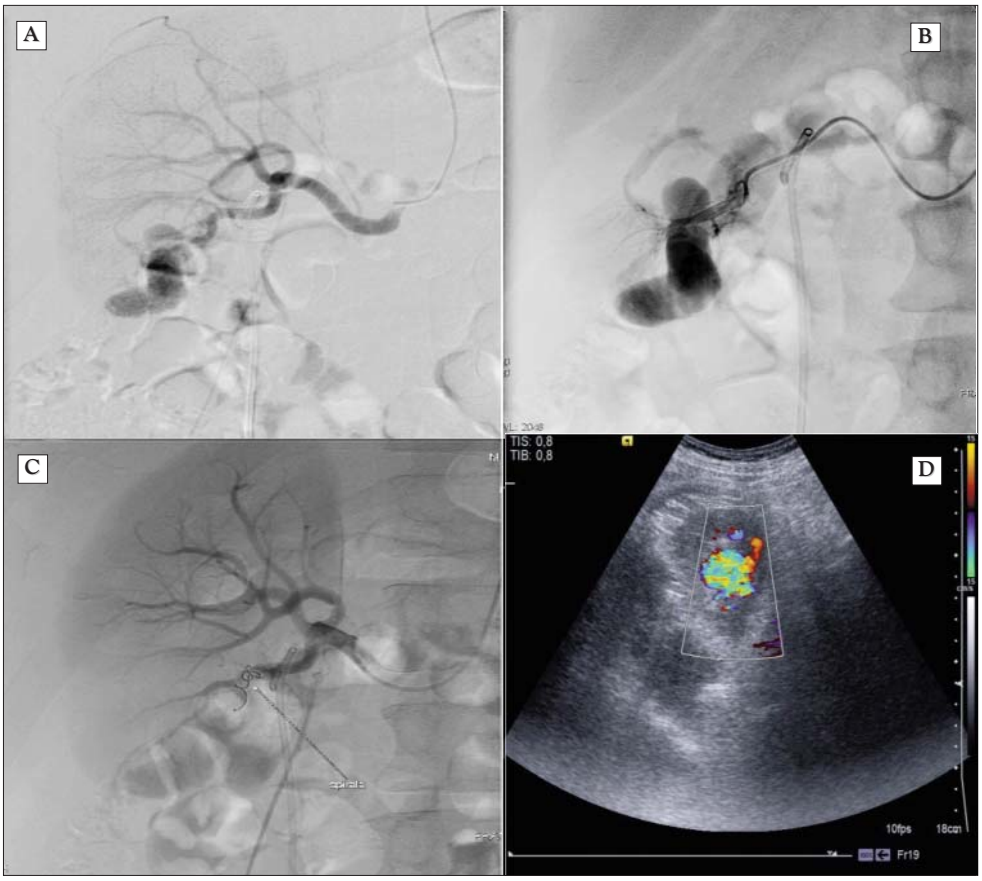

Figure 4. (A-D) *54-year-old man with severe hematuria from right lower pole AVF.* ***(A)*** *right renal arteriography shows arteriovenous fistula.* ***(B)*** *selective catheterization of lower polar artery determines type of vascular lesion feed by small artery (arrow).* ***(C)*** *AVF and small artery are embolized with micro-coil. Distal normal arteries supplied by the same polar artery are permeable with no cortical defect in the late phase of control angiogram.* ***(D)*** *Ultra-sound with color Doppler - focal flurry of disorganized color beyond the vessel lumen thought to be due to vibration of the tissue surrounding the fistula*

decision to transfer the patient to an interventional radiology department is delayed (156.72 ± 41.76 hours) 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. A particular situation is represented by the cases with severe bleeding, hemodynamic instability, and significant decrease of hemoglobin value in the first hours after the surgery (an average of 4.33 g/dL), that require immediate investigation and treatment (5.33 ± 0.47 hours). We have registered 3 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). A decrease in glomerular filtration rate combined with an increase in creatinine and BUN levels was observed pre-embolization (See *Table 5*) and could be explained by the obstructive effects of blood clots in the collecting system, hypovolemia, hypotension or acute kidney injury related to the hemorrhage (24).

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 ($P<0.0001$) (See *Table 2*). 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 3 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 (*Table 4*). 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.

Conclusions

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 results 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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