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ORIGINAL ARTICLE

Transarterial embolization for delayed bleeding after percutaneous nephrolithotomy

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ABSTRACT

Objectives: The study aimed to evaluate the effectiveness and reliability of transarterial embolization (TAE) in managing delayed bleeding after percutaneous nephrolithotomy (PNL).

Materials and Methods: Patients presenting to our hospital's emergency department with hematuria following PNL and treated with TAE were included in the retrospective analysis. Demographic, clinical, and radiological data were collected. Technical and clinical success rates of TAE were calculated. The impact of the embolization procedure on kidney function was determined using angiographic images, and pre- and post-procedure serum creatinine levels.

Results: A total of 13 patients included in the study presented with intermittent visible hematuria. The average interval between hematuria onset and PNL was 11.92±7.27 days. No hemodynamic instability was observed in any patient. CT angiography identified vascular pathology in 11 patients (84.6%), who subsequently underwent renal angiography for TAE without conservative treatment. Pseudoaneurysms were found in 7 patients (63.6%), and both pseudoaneurysms and arteriovenous fistulae in 4 patients (36.4%). Technical success was achieved in all embolization procedures. Hematuria resolved in all patients during follow up with a clinical success rate of 100%. Renal parenchymal loss after embolization was <%10 in 8 patients (72.7%), %11-24 in 2 patients (18.2%), and %25-50 in 1 patient (7.7%). There was no significant difference in serum creatinine levels before (mean 1.09±0.53 mg/dl) and after (mean 1.06±0.71 mg/dl) TAE (p=0.5). No major procedure related complications were observed.

Conclusions: TAE is an effective and safe method for the treatment of delayed bleeding following PNL. CT angiography facilitates diagnosis and treatment planning for patients with hematuria after discharge. Early TAE for patients with identified vascular pathology can increase technical and clinical success rates.

Keywords: Percutaneous nephrolithotomy, delayed bleeding, hematuria, transarterial embolization, superselective embolization.

INTRODUCTION

Percutaneous nephrolithotomy (PNL) is an effective and safe method that has replaced open surgical techniques, especially in the treatment of large kidney stones. PNL is considered the standard treatment for the management of staghorn/ large kidney stones, upper pole stones resistant to other treatments, difficult-to-reach lower pole stones, cystine stones, and stones in kidneys with abnormal anatomy [1]. Although PNL has improved significantly over the years, serious complications such as bleeding can still occur [2]. While a certain amount of bleeding related to manipulations within the pelvicalyceal system is usually self-limiting, major bleeding requiring transfusion after PNL has been reported with an incidence ranging from 2% to 23% [3]. Bleeding can occur in the early postoperative period or as "delayed bleeding" days or weeks later. The most common presentation is the onset of active, macroscopic, and intermittent delayed hematuria after discharge, leading to emergency department visits [3]. Pseudoaneurysms (PAs) are the most common cause of delayed bleeding, followed by arteriovenous fistulas (AVFs) and mixed lesions. Pseudoaneurysms are most commonly observed in interlobar and arcuate arteries, followed by posterior segmental arteries [4, 5].

The treatment approach for delayed bleeding after PNL varies depending on the patient's clinical condition. Initially, conservative treatments such as hydration, hemostatic medications, and blood transfusion are used. Angiographic embolization is reserved for patients with ongoing bleeding despite conservative treatment or those who are hemodynamically unstable [6]. Transarterial embolization (TAE) has been shown to be effective and safe in the management of renal bleedings [7]. Technological advancements in interventional radiology have allowed for superselective arterial embolization (SAE), which preserves most of the renal parenchyma by using smaller microcatheters and embolic agents.

There are no definitive guidelines regarding the duration of conservative treatment and the timing of angiography. Transarterial embolization (TAE) is typically indicated in patients with ongoing bleeding, a drop in hemoglobin level >3 g/dL, and hemodynamic instability [6]. However, in the current practice, patients presenting with delayed bleeding most commonly seek emergency department care, and routine computed tomography (CT) scans are performed, which can demonstrate the presence of active bleeding, PA, or AVF. The primary aim of this study is to evaluate the effectiveness of same-day SAE in treating patients with delayed bleeding after PNL and to assess the reliability of renal function in these patients.

MATERIALS AND METHODS

After approval from our Institutional Ethics Committee (2020/20-81), the study was conducted retrospectively. The study included adult patients (>18 years) who presented to our hospital's emergency department between December 2014 and December 2020 with complaints of hematuria following PNL and were subsequently treated with transcatheter arterial embolization (TAE). Patients with other etiologies of renal bleeding (renal biopsy, trauma, partial nephrectomy etc.) were excluded from the study. Patient characteristics were obtained from the hospital's electronic medical records. Demographic data, known systemic diseases, anticoagulant/antiplatelet medication use, duration between PNL and symptom onset, as well as pre- and post-procedure creatinine values were analyzed. Pre-procedural CT images and angiographic images related to the TAE procedure were evaluated using the hospital's Picture Archiving and Communication System (PACS). Types of kidney injuries related to PNL (side, presence of PA, AVF, active bleeding), number of renal arteries, localization of bleeding, number and level of injured renal artery branches, were evaluated separately using both CT scans and angiographic images and correlated with each other. However, the final decision was based on angiographic images. Additionally, the type of embolic agent used, number and level of embolized branches, and the percentage of renal parenchymal loss after TAE were evaluated based on angiographic images.

Transarterial Embolization

All procedures were performed by experienced interventional radiologists in our hospital's interventional radiology unit, after obtaining informed consent from the patients. After ensuring standard sterile conditions, access was obtained through the right or left common femoral artery using an 18 G needle under ultrasound guidance, followed by placement of a 4F short vascular sheath (Terumo, Tokyo, Japan). Subsequently, selective access was achieved with a 4F diagnostic catheter (Cobra, Sim1, Shepherd) based on the exit angle of the renal artery of the affected kidney, and selective renal arteriography images were obtained. Following the identification of the vascular injury (contrast extravasation/ active bleeding, presence of PA or AVF), microcatheters (2.0-2.4F) were advanced coaxially to the most distal accessible segment. Detachable coils (Concerto coil, Medtronic, USA) were used for embolization based on the diameter of the responsible vessel. Post-embolization, a control renal arteriography was performed to confirm complete occlusion of the target vessel and absence of any other pathology, and the extent of renal parenchymal loss was evaluated. Hemostasis at the access site was achieved by manual compression, and patients were closely monitored with vital signs in strict bed rest. Following the procedure, patients were discharged based on daily monitoring of hemoglobin levels, presence of hematuria, as well as serum creatinine values.

Definitions and Data Analysis

Technical success was defined as the complete occlusion of the vascular lesion (active bleeding/ PA/AVF) on post embolization angiography. Clinical success was defined as resolution of hematuria, normalization of clinical and laboratory values, and no occurrence of new bleeding requiring repeat TAE or surgical intervention within 4 weeks. Complications were graded according to the classification system by the Society of Interventional Radiology based on clinical outcomes [8]. Major complications included post-procedural death, permanent damage/disability requiring increased level of care, displacement of embolization coils causing hospitalization or prolonging the hospital stay, renal function loss, renal artery dissection, and other events. All other complications were considered minor.

The percentage of renal parenchymal loss after embolization was evaluated based on angiographic images, comparing the maximum extent of parenchymal staining before (pre-TAE) and after (post-TAE) embolization. The maximum length of post-TAE parenchymal defect was divided by the maximum length of pre-TAE parenchymal staining and multiplied by 100. Patients were classified into three groups based on the percentage of renal parenchymal loss: <%10, %11-24, and %25-50. Additionally, the impact of SAE on renal function was assessed by comparing the serum creatinine values at the time of admission and post-procedure.

RESULTS

Patients

A total of 13 patients (9 males, 4 females) with a mean age of 44.08±20.18 were included in the study (Table 1). All patients presented to the emergency department with hematuria complaints following delayed bleeding after discharge from PNL. Only 4 patients underwent PNL at our institution, while the rest were performed at external centers. The mean serum creatinine level at the time of admission was 1.09±0.53 mg/dl. The time interval between the onset of hematuria and PNL was determined to be a mean of 11.92±7.27 days (ranging from 3 to 30 days). None of the patients showed hemodynamic instability. Among the obtained CT scans, the affected side of the kidney was determined to be the right in 9 patients (69.2%) and the left in 4 patients (30.8%). Among them, lesion localization was observed in the middle and lower poles in 3 patients (23.1%) and 10 patients (76.9%), respectively. In two patients, typical pseudoaneurysm or arteriovenous fistula was not observed on CT scans, but on venous phase images there were focal areas of contrast suspicious of leakage into the collecting system.

Angiography and Embolization

A total of 13 patients underwent renal angiography. Among the study population, vascular pathology was detected in 11 (84.6%) patients during angiography. Active contrast extravasation was observed in only one patient. The most common angiographic findings were pseudoaneurysm (PA) in 7 (63.6%) patients and both PA and arteriovenous fistula (AVF) in 4 (36.4%) patients. The type and localization of angiographically detected vascular pathologies were correlated with the patients' CT images. Two patients with significant hematoma in

Table 1. Demographic and clinical characteristics of patients

Gender n (%)	
Female	4 (30.8%)
Male	9 (69.2%)
Age	
Mean± SD	44.08±20.18
Range	16-83
Hypertension	
Yes	4 (30.8%)
No	9 (69.2%)
Diabetes	
Yes	2 (15.4%)
No	11 (84.6%)
Anti-coagulation therapy	
Yes	2 (15.4%)
No	11 (84.6%)
Side	
Right	9 (69.2%)
Left	4 (30.8%)
Presence of staghorn stone	
Yes	7 (53.8%)
No	6 (46.2%)
Lesion localization	
Middle pole	3 (23.1%)
Lower pole	10 (76.9%)
Clinical Characteristics	
Hematuria	13 (100%)
Hypovolemic shock	0 (0%)
Interval between onset and PNL (days)	
Mean ± SD	11.92±7.27
Range	3-30

the collecting system, despite the absence of typical vascular lesions (contrast extravasation/PA/AVF) on CT imaging, did not show any focal bleeding on angiography. All patients with identified vascular pathology were treated with selective arterial embolization. All bleeding foci originated from renal arteries. Detachable coils were used as embolic agents in all patients.

Technical success rate was 100% as complete occlusion of the target vessel was achieved in all 11 patients who underwent embolization. In all patients, the presenting complaint of hematuria resolved, and clinical and laboratory values returned to normal, eliminating the need for repeat SAE or surgical intervention, resulting in a clinical success rate of 100%. In the two patients without detectable vascular foci on angiography no embolization was performed and conservative treatment led to resolution of symptoms.

Renal Function and Complications

The rates of renal parenchymal loss on post-embolization control angiography images were observed as follows: <%10 in 8 (72.7%) patients, %11-24 in 2 (18.2%) patients, and %25-50 in 1 (7.7%) patient. The mean serum creatinine levels after SAE were 1.06±0.71 mg/dl. The decrease between these values was calculated as 0.03±0.27, and no statistically significant difference was found ($p=0.50$). No major complications were observed in any of the patients after the procedure. Minor complications associated with post-embolization syndrome, such as fever or flank pain, were not observed in any of the patients.

DISCUSSION

The efficacy and safety of SAE in the management of severe and persistent post-PNL bleeding has been demonstrated in several studies [9]. The literature reports technical and clinical success rates ranging from 87% to 100% and 57% to 100%, respectively, and our study's 100% technical and clinical success rates fall within these defined ranges [10-12].

Delayed post-PCNL bleeding is relatively rare and is typically defined as bleeding occurring more than 24 hours after the procedure, with varying degrees of severity [6]. The most common presentation is intermittent gross hematuria. In our study population, the mean time from PNL to presentation was 11 days, and all patients presented to the emergency department with intermittent gross hematuria. According to some studies, most cases of post-PNL bleeding in stable patients can be managed conservatively, while 4-5% may require embolization. Transarterial embolization (TAE) is typically indicated in cases of persistent bleeding, hemoglobin drop >3 g/dL, and hemodynamically unstable patients [6]. However, these indications are independent of the vascular lesions detectable by CT angiography and are based on clinical criteria. Delayed, sudden, intermittent hematuria is characteristic of PAs and AVFs. The sensitivity of CT angiography in detecting these lesions ranges from 86% to 100% [12-13].

For patients suspected of renal bleeding, the required CT protocol is defined as non-contrast, arterial phase, and venous phase, known as triphasic CT angiography (CTA). Non-contrast images can differentiate high-attenuation structures, such as hematomas or residual stones, and residual contrast material from previously administered contrast material. Arterial originated bleedings are visualized as focal areas of high-density (>90 HU) attenuation in arterial phase images, while in the venous phase, these areas increase in both size and attenuation. Pseudoaneurysms on the other hand, remain the same size in the venous phase but show decreased attenuation. Arteriovenous fistulas are visualized as early contrast material filling into the renal vein in arterial phase images [14]. Additionally, CT images provide additional advantages such as providing information about the entry tract of the PNL procedures, identifying the patient's renal artery anatomy, and determining the level of vascular injury (segmental artery, interlobar artery, arcuate artery, etc.). These factors can be advantageous for the operator performing TAE during the procedure [15]. In our study, 69% of the patients (9/13) underwent PNL procedures at external centers, and therefore, detailed information about their surgical procedures was lacking. However, in all patients, the PNL tract was visualized using CT, indicating the entry point in the kidney. Furthermore, there was a 100% correlation between CTA and angiography in determining the type and localization of vascular lesions in our study population. The specificity of CTA has been reported as 83-100% in the literature, which is consistent with our findings [16,17]. The findings obtained from cross-sectional imaging guide the interventional operator, reducing procedure time, the amount of contrast material used during the procedure, and allowing the selection of embolization agents based on the identified lesion [15].

In our study, TAE was performed in 11 patients based on the presence of lesions identified on CT angiography, while in 2 patients, typical lesions were not detected on CT. However, CT revealed the presence of hematomas in the collecting system and suspicious focal areas of attenuation increase within the collecting system in delayed-phase images in these patients. However, renal angiography did not reveal any vascular pathology such as active bleeding, PA, or AVF in these patients. Previous studies have shown that conventional angiography can demonstrate the presence of lesions even in cases where negative findings are observed on cross-sectional imaging, and angiography is still considered the gold standard method [12]. Therefore, although our study showed a correlation between the negative predictive value of CT and angiography, the number of patients in the study is not sufficient to support this finding. In their study, Yang et al. stated that the presence of hydronephrosis and hematomas in the collecting system increases intrarenal pressure, leading to reduced contrast perfusion. They further explained that in their own study, when no findings were detected on CT in patients with negative findings, the presence of lesions on angiography could be attributed to the injection of contrast into intraarterial segmental branches, which can demonstrate pathology independent of intrarenal pressure [17].

In our study group, the clinical success rate was 100%, and none of the patients required a second TAE session or surgical exploration. However, the literature reports cases of clinical failure after the first TAE, and several factors have been identified as risk factors, including multiple PNL access points, the use of large tracts during PNL, multiple bleeding foci, and the use of gelatin sponge as an embolization agent [2,18]. None of the patients in our study had multiple foci. For patients with multiple arterial foci, the main reason for failure is the inability to visualize the lesions angiographically due to arterial vasospasm caused by bleeding [19]. In our study, all patients were hemodynamically stable and underwent TAE directly when the lesion was detected on cross-sectional imaging, which contributed to their appropriate management. Furthermore, gelatin sponge was not used as an embolization agent in any of the patients in our study [19]. Patients with negative angiographic findings also had venous-originated bleeding and self-limited conditions managed conservatively.

Some studies in the literature argue that renal angiography should be the first diagnostic procedure in the presence of delayed bleeding. These studies suggest that in the majority of delayed bleeding cases, traumatic vascular injuries such as pseudoaneurysms and AVFs are the underlying cause. Performing early TAE without compromising the patient's hemodynamics has been shown to reduce hospital stay and the need for blood transfusion [3]. Additionally, these studies recommend direct TAE instead of performing contrast-enhanced cross-sectional imaging in cases of massive bleeding and renal dysfunction, as it allows both diagnosis and treatment [12]. The main reason for cross-sectional imaging being performed in our study was the fact that most patients had undergone PNL at external centers. Furthermore, in our study, no renal function impairment was observed after CT angiography and subsequent TAE. The preservation of renal function after TAE for renal bleeding has been demonstrated in our study and other studies in the literature [9, 10, 20, 21].

Renal artery dissection and coil migration, which are complications associated with renal embolization, were not observed in our study group. Post-embolization syndrome was also not observed, which can be attributed to the fact that 90.2% of our patients (10/11) had a renal parenchymal loss of less than 25%.

Our study is subject to several limitations that should be acknowledged. Firstly, its retrospective nature introduces inherent biases and limits the ability to establish causality. Secondly, the relatively small sample size might restrict the generalizability of our findings. Furthermore, the acute nature of the clinical presentation poses challenges in conducting a prospective randomized study, as immediate intervention is often necessary. It is also important to note that our assessment of renal function relied solely on creatinine levels, without incorporating more comprehensive methods such as nuclear imaging, which could provide a more accurate evaluation of renal compensatory function. These limitations should be taken into consideration when interpreting the results of our study.

In conclusion, TAE is an effective and safe method for the treatment of delayed hemorrhage following PNL. Particularly in patients presenting to the emergency department with intermittent macroscopic hematuria in the late post-PNL period, CT angiography provides valuable information for both the diagnosis of vascular lesions and treatment planning. Prompt TAE in patients with identified lesions on cross-sectional imaging improves technical and clinical success rates.

Author contribution

Study conception and design: FGE, FÇ, AG, and BP; data collection: FÇ and FGE; analysis and interpretation of results: FGE, FÇ, AG and BP; draft manuscript preparation: FGE, FÇ and BP. All authors reviewed the results and approved the final version of the manuscript.

Ethical approval

The study was approved by Institutional Ethics Committee of Hacettepe University (Protocol no. GO 2020/20-81).

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Conflict of interest

The authors declare that there is no conflict of interest.

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