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Renal Artery Embolization for Post-Traumatic Hematuria: A Nephron-Sparing Strategy

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Abstract

Objectives: Illustrate the role of embolization as a therapeutic alternative to surgery for renal bleeding.

Clarify the benefits of embolization in preserving renal function.

Materials and methods: Retrospective study including observations of 22 patients with hematuria secondary to renal trauma. The cases collected in our study were diagnosed by abdominal angiography and then underwent renal arterial embolization over a period of 4 years from January 2020 to December 2024.

Results: Our series was characterized by a predominance of males with a sex ratio of 1.2 and an average age of 35 years. All patients presented with uncontrolled gross hematuria and 41% of cases had hemorrhagic shock. The etiologies were: blunt abdominal renal trauma 36% (n=8), open trauma 32% (n=7), iatrogenic trauma post renal biopsy 22% (n=5), and iatrogenic hematuria after percutaneous lithotomy 10% (n=2). The embolization agents used were: coils 64% (n=14), biological glue 27% (n=6), and a combination of coils and biological glue in 9% (n=2).

Our results were satisfactory with immediate cessation of hematuria in all cases, stabilization of hemoglobin, preservation of pre-existing renal function, and near-total preservation of renal parenchyma on imaging control.

Conclusion: Embolization of post-traumatic renal hematuria is an effective alternative to surgery, avoiding partial or sometimes total nephrectomy and deterioration of renal function.

Keywords: Renal trauma; Transcatheter arterial embolization; Hematuria; Interventional radiology; Nephron-sparing; Pseudoaneurysm.

1. Introduction

Renal traumas are rare and account for 1 to 5% of abdominal traumas with a predominance of closed traumas. The latter are 9 times more frequent than open traumas [1]. A severe arterial-origin renal bleeding can compromise the patient's prognosis and requires immediate diagnosis and treatment. Conservative treatment is often ineffective and predisposes to the risk of hemorrhagic recurrence. The management of renal traumas has evolved towards endovascular treatment, increasingly avoiding surgery, thanks to the evolution of embolization techniques [2]. Partial or total nephrectomy is difficult to perform in emergency conditions, can be mutilating, and often compromises renal function. Angio-CT is the key examination for detecting vascular abnormalities such as pseudo-aneurysm, contrast medium extravasation, and arteriovenous fistulae [3]. The discovery of these lesions on the CT scan is another argument

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for an interventional approach alongside hemorrhagic shock and a significant drop in hemoglobin. In this study, the clinical and etiological data of patients with severe renal bleeding were retrospectively studied to evaluate the effectiveness of embolization in stopping bleeding and particularly in preserving nephron capital.

2. Materials and methods

Our retrospective study covers 4 years from January 2020 to December 2024. We collected data from 22 patients who presented with severe renal bleeding secondary to iatrogenic or non-iatrogenic renal trauma and who underwent emergency renal embolization at the central Radiology department of CHU Hassan II in Fez. Severe renal bleeding was defined as abundant hematuria, associated or not with a significant drop in hemoglobin to less than 1 g/dL, with a renal or retroperitoneal hematoma on CT scan. All our patients underwent abdominal angio-CT at admission, the results of which allowed the indication for embolization to be determined. It consisted of a multiphase examination with 4 acquisitions: without contrast, arterial phase, venous phase, and late phase. The amount injected using an automatic injector was an average of 120 cc of contrast medium concentrated at 300 mg/ml of iodine, with a flow rate of 3.5 cc/second.

3. Results

Males were predominant (sex ratio: 1.2) with a mean age of 35 years. 32% (n=07 cases) of the cases were chronic kidney disease patients. All patients presented post-traumatic renal-origin hematuria, of which 41% (n=9 cases) were complicated by hemorrhagic shock. The mean hemoglobin level was 8.6 g/dL, with levels below 8 g/dL in 45% (n=10 cases). The mean creatinine level was 30 mg/L. The injury mechanisms were diverse in our series, with a predominance of closed traumas in 36% (n=08 cases), followed by open traumas caused by a knife strike in 32% (n=07 cases). Iatrogenic traumas represented one-third of the patients, mainly represented by renal biopsies in 22% (n=05 cases) and post-surgical or percutaneous lithotomy traumas in 10% (n=05 cases). The American classification of renal traumas defines 5 grades, allowing the severity and indications of surgical treatment to be defined. In our series, we found that grade IV was predominant, representing 36% (n=08 cases), and grades V and III representing 27% (6 cases). Vascular anomalies were detected by imaging in 45% (10 cases) of the cases, including pseudo-aneurysms (figures 01-03) in 45%, PDC extravasations (figures 04) in 32% (n=07 cases), arteriovenous fistulas in 18% (n=04 cases), and arteriocaliceal fistulas in 5% (n=01 case) (figures 05).

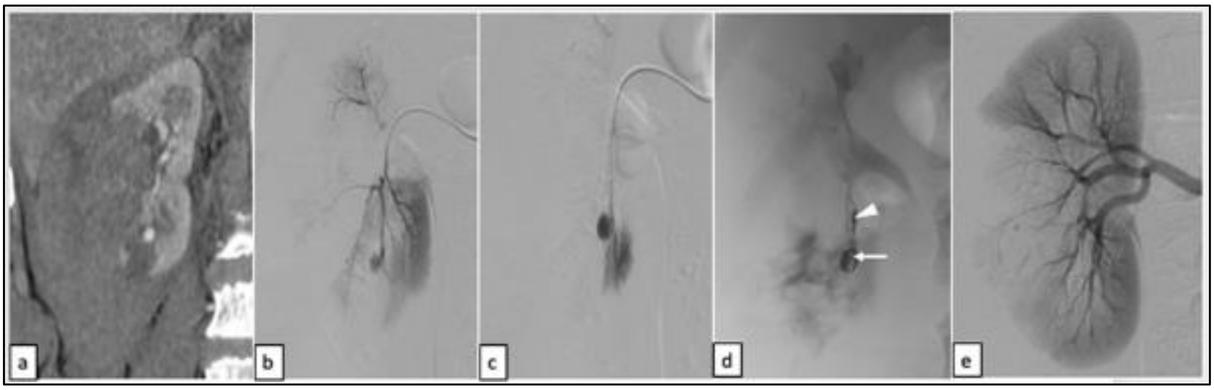

Figure 1 Renal artery pseudoaneurysm in an 18-year-old male with lumbar trauma and hemorrhagic shock (Hb: 9 g/dL)

- **Coronal arterial-phase CTA** showing a pseudoaneurysm arising from the right inferior polar artery.
- **Selective digital subtraction angiography (DSA)** confirming the pseudoaneurysm's supply from a lower-pole branch.
- **Super-selective microcatheterization** of the feeding vessel.
- **(d-e) Embolization and final control:** Targeted coiling of the pseudoaneurysm (arrow) and its feeding branch (arrowhead), achieving complete exclusion with full preservation of the surrounding renal parenchyma.

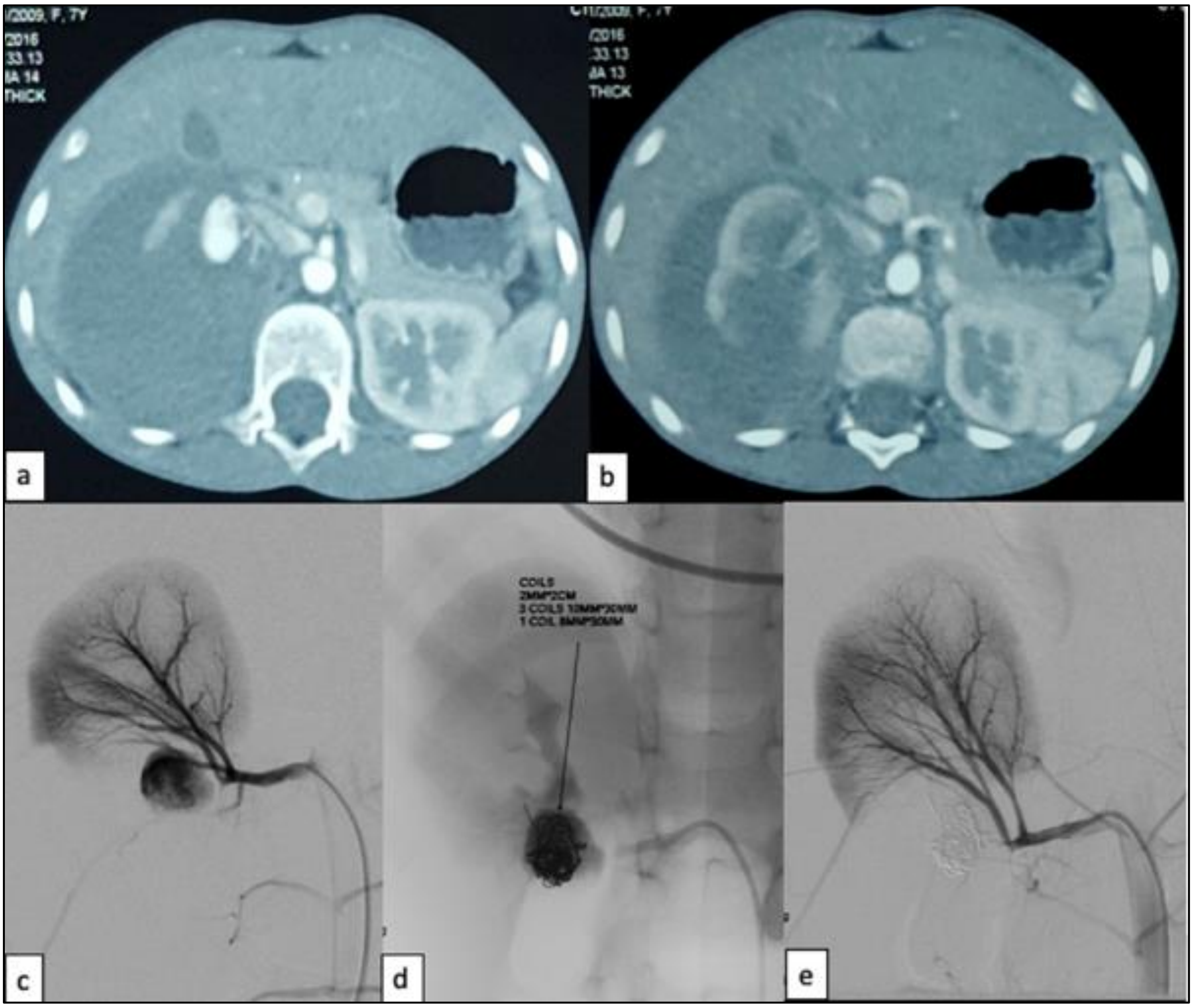

Figure 2 Grade IV renal trauma in an 8-year-old child following a road traffic accident with right lumbar impact (Admission Hb: 9 g/dL)

- **(a, b) Axial arterial-phase CT angiography:** Right mid-renal pseudoaneurysm associated with a renal fracture, parenchymal contusion, and a perirenal hematoma.
- **(c) Digital subtraction angiography (DSA):** Large pseudoaneurysm arising from the right middle interlobar artery.
- **(d-e) Embolization and follow-up:** Selective coil embolization achieving complete exclusion of the pseudoaneurysm on the final control.

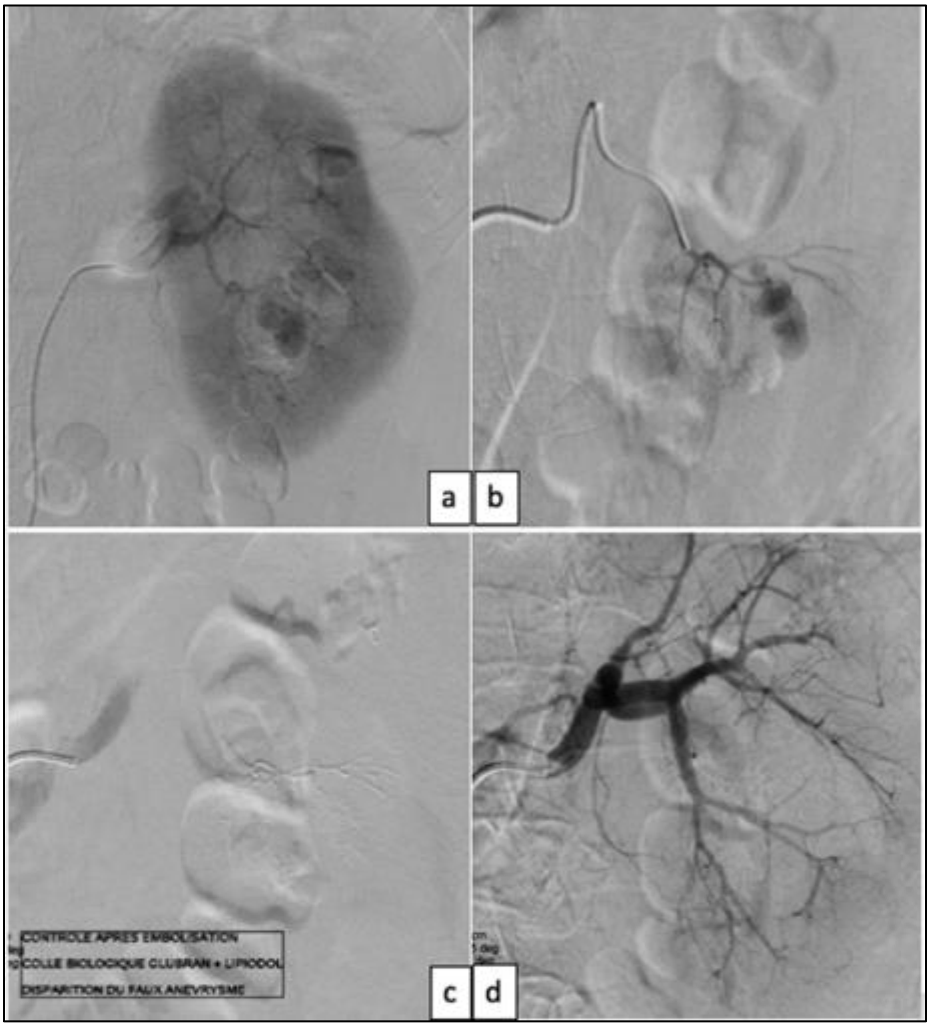

Figure 3 Iatrogenic injury in a 70-year-old patient with a solitary left kidney, following a left-sided lithotomy

- Presentation: Postoperative course complicated by massive hematuria and a significant hemoglobin drop. CT angiography revealed a pseudoaneurysm of the left inferior polar artery.
- **Selective DSA:** Opacification of the left renal artery confirming a pseudoaneurysm arising from the inferior polar branch.
- **Super-selective microcatheterization:** Targeted approach of the inferior polar artery branch supplying the lesion.
- **(c, d) Final angiographic control:** Complete exclusion of the pseudoaneurysm following embolization with a mixture of N-butyl cyanoacrylate (NBCA) glue and Lipiodol, with maximum preservation of the functional solitary kidney.

Figure 4 Grade IV penetrating renal trauma (stab wound) in a 39-year-old patient presenting with hemorrhagic shock

- **(a, b, c) multi-phase abdominal CT angiography:** Left mid-renal fracture with a large perirenal hematoma. Note the presence of air bubbles along the stab wound tract. Active contrast extravasation is visible during the arterial phase (a, b), significantly increasing during the delayed phase (c), confirming active bleeding.
- **(d, e) Digital subtraction angiography (DSA):** Selective left renal arteriography revealing a pseudoaneurysm arising from the middle lobar artery.
- **(f-i) Embolization and follow-up:** Hemostasis achieved using N-butyl cyanoacrylate (NBCA) glue. The final angiographic control confirms the complete occlusion of the pseudoaneurysm. A focal perfusion defect is noted in the left upper pole, corresponding to the embolized territory.

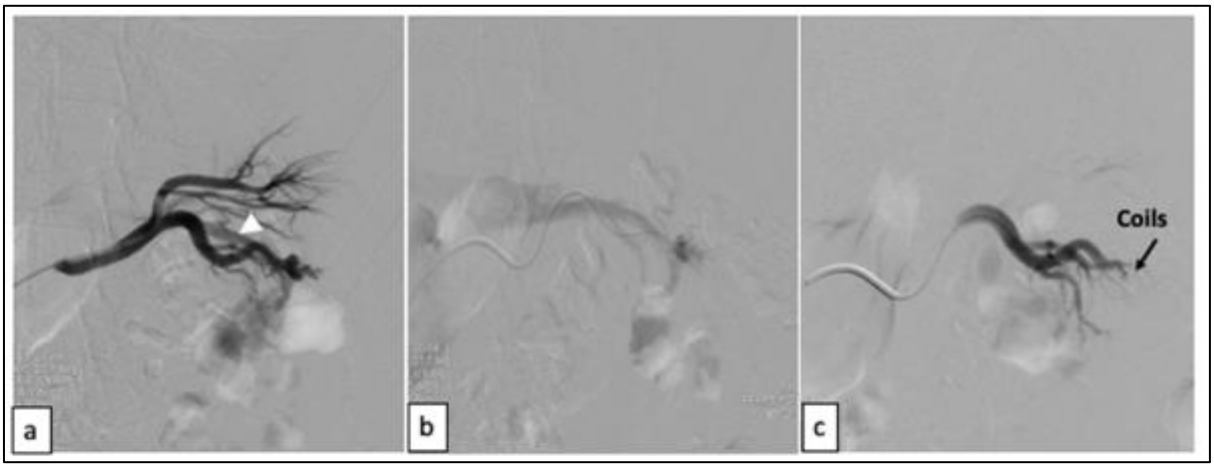

Figure 5 Iatrogenic arteriovenous fistula (AVF) in a 41-year-old patient with chronic kidney disease

- Clinical Presentation: Following a percutaneous renal biopsy, the patient developed massive hematuria with a severe hemoglobin drop (9 g/dL to 6 g/dL). CT angiography confirmed a left inferior polar AVF and a retroperitoneal hematoma.
- **Initial DSA:** Selective opacification reveals a high-flow shunt between the inferior polar artery and the renal vein, evidenced by early venous filling (arrow).
- **Procedure:** Super-selective microcatheterization allowed for precise access to the fistulous communication.

- **Final Control:** Post-coil embolization imaging demonstrates complete resolution of the shunt with the disappearance of the early venous return.

Associated traumatic injuries were rare in our study, with hepatic trauma in 2 cases, two cases of splenic rupture, two cases of thoracic trauma, and one case of severe head trauma. All our patients were admitted to the angiography room after stabilization of their hemodynamic states. Local anesthesia and puncture of the right femoral artery using Sedlinger catheterization with a 5 French caliber Desilet were performed, and renal artery catheterization was performed using a diagnostic Cobra catheter with a 4 French caliber to locate the vascular leak and plan for embolization. Selective microcatheterization of the vessel carrying the vascular lesion was then performed using a 2.4 French caliber microcatheter and a 0.016-inch caliber microguide. Two embolization products were used: coils in 14 cases, accounting for 64% of the cases, followed by a mixture of biological glue (N-butyl 2-cyanoacrylate + metacrylosulpholane) and lipiodol in a proportion of 1/4 in 06 cases, accounting for 27%, and an association between biological glue and coils was used in 02 cases (9%). The final angiography control showed the cessation of the contrast leak in all patients, with a renal parenchymal loss of less than 30% in all patients. Post-procedure follow-up was marked by the total cessation of hematuria within 48 hours following embolization, which was sometimes necessary for the dissolution of bladder clots, and the stabilization of the hemodynamic state in all cases. There were no reports of pain, post-embolization syndrome, or infectious syndrome. Patients with open renal trauma were placed on prophylactic antibiotic therapy systematically.

A short- and medium-term biological follow-up was provided for all patients with hemoglobin and creatinine measurements on the second day and second week after embolization. Comparison of hemoglobin levels before and after embolization showed stabilization or even improvement of hemoglobin levels. The latter case is explained by the use of transfusion for severe anemia in some patients (Figure 6). Creatinine levels before embolization, 24 hours after the procedure, and 2 weeks post-procedure were compared, leading to the distinction of two patient groups. The first group consists of healthy patients who underwent renal trauma and whose creatinine values did not change after embolization, while the second group includes patients with underlying chronic nephropathy who underwent renal biopsy for etiological purposes and whose creatinine values were altered after embolization but returned to their usual values two weeks later (Figure 7). Finally, embolization avoided surgery in all cases and hospitalization did not exceed 15 days.

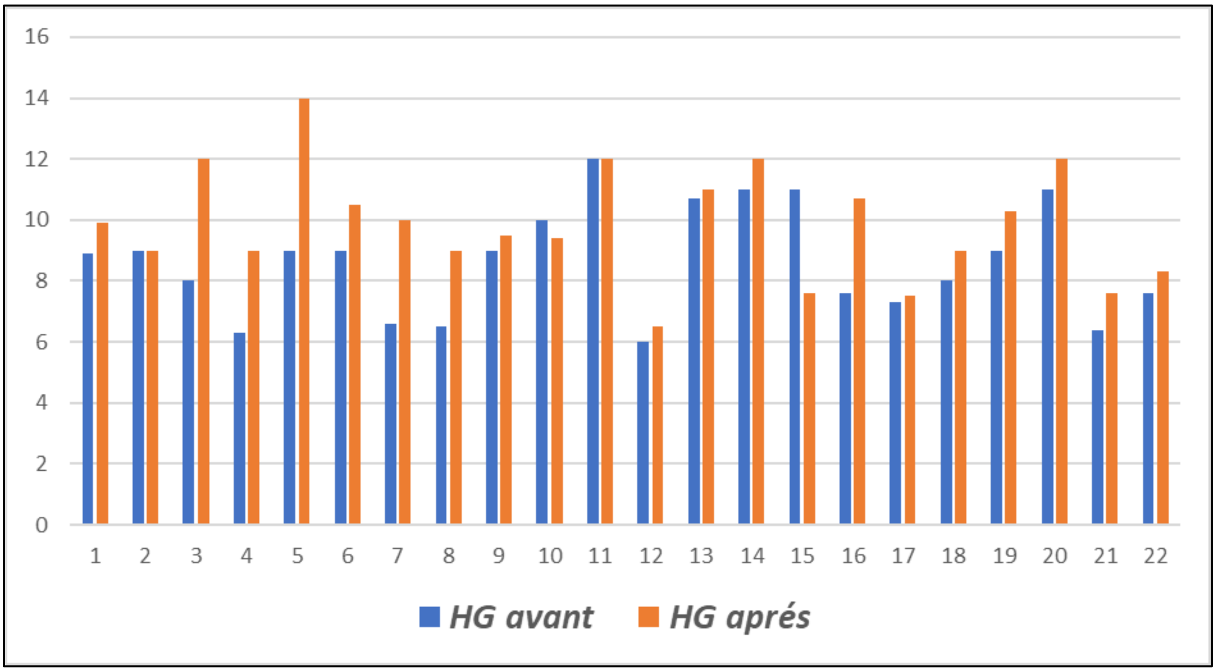

Figure 6 Comparative hemoglobin values before and after arterial embolization

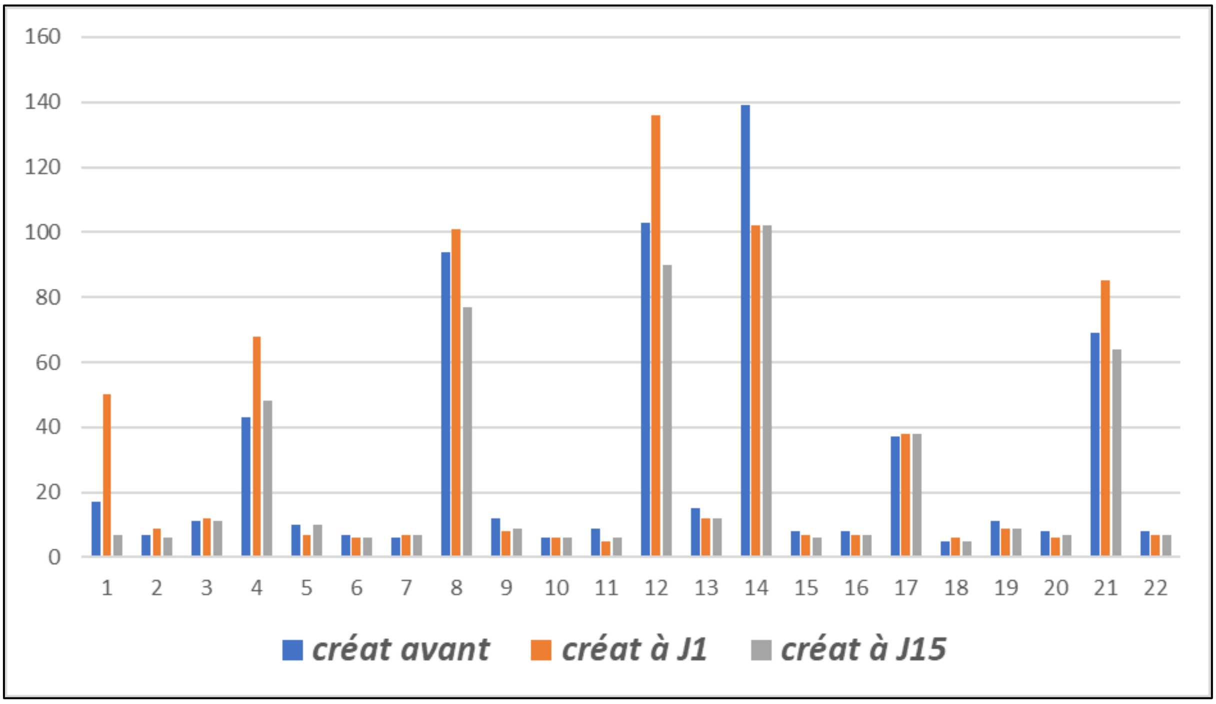

Figure 7 Longitudinal evaluation of serum creatinine levels: pre-embolization vs. short-term follow-up (Day 1 and Day15)

4. Discussion

Trauma to the entire urogenital system represents 1% to 5% of all traumas and 10% to 30% of abdominal traumas. Closed traumas predominate in the literature, accounting for 80% to 90% of cases, while open traumas account for 10% to 20% of renal traumas [4]. Men are more frequently affected than women. Renal trauma can occur at any age, with a predominance in young adults, especially between 20 and 40 years old. The clinical manifestation is macroscopic hematuria, which is often present, associated or not with signs of shock that are present in 30.7% of cases [5].

Abdomino-pelvic ultrasound is the first examination to be performed in the event of suspected renal trauma. It allows for morphological and dynamic study, as well as detection of perirenal or pararenal hematoma, hemoperitoneum, or sometimes lacerations and fractures. Ultrasound remains a good method for analyzing the morphology of the traumatized kidney, and coupling it with color Doppler allows for evaluation of renal flow. Despite these advantages, it remains less sensitive than angiographic CT scan for lesion assessment [6].

Angiographic CT scan is the gold standard and is indicated in cases of macroscopic hematuria, hemorrhagic shock, or polytrauma. The angiographic CT scan should be performed in four acquisitions: without contrast, arterial phase, venous phase, and delayed phase. The amount injected using an automatic injector is on average 120 cc of a contrast agent concentrated at 300 mg/ml of iodine, with a flow rate of 3.5 cc/second. Important parameters to specify on an abdominal angiographic CT scan are vascular anomalies, hematoma volume, and location. Studies have shown that a hematoma limited by Gerota's fascia can compress active bleeding and can therefore be managed conservatively. On the other hand, a hematoma in the retroperitoneal space, known to be capacitive, cannot spontaneously stop bleeding, hence the indication for emergency embolization [3].

Vascular anomalies include pseudo-aneurysms, contrast extravasation, arteriovenous fistulas, and arterio-caliceal fistulas. Pseudo-aneurysms are defined as a rupture of arterial wall continuity creating a circulatory pouch contained by adjacent tissues, which is well defined in imaging and different from contrast extravasation, which is poorly defined and may increase during the venous phase. They may appear at a delayed time after trauma. Arteriovenous fistula is a shunt between an artery and a vein that often accompanies a pseudo-aneurysm. In imaging, early opacification of the vein in the arterial phase is noted.

The vascular anomalies described in the literature are mainly pseudo-aneurysms, followed by contrast extravasation, and then arteriovenous and arterio-caliceal fistulas. Our results are consistent with those in the literature [2].

Angioscanning also plays an important role in pre-embolization vascular assessment. Anatomical variations in renal vascularization can limit technical success, and bleeding from an accessory artery may occur and pose a challenge in interventional imaging. This situation represents a major technical difficulty, highlighting the importance of detecting anatomical variations to avoid unnecessary intervention. Anatomical variations of the renal arteries are among the most common abdominal vascular anatomical variations, found in about 30% of the population and in nearly 28% of cases. These variations are present in both kidneys. The radiologist must mention them during pre-embolization vascular mapping. Multiple arteries are usually observed bilaterally in about 10% of patients, with two arteries in 25% of cases, three in 4%, and four or more in nearly 1% of patients. The presence of polar accessory arteries, which are usually smaller than the main artery, can also be observed. In 10-12% of cases, an early division of the renal artery into segmental branches is observed, defined as a division located less than 1.5 cm after the ostium of the renal artery.

Indications for renal embolization are severe renal trauma of grade II to V according to the AAST classification with uncontrolled massive hematuria or hemorrhagic shock [1]. The embolization technique is performed in two steps: the first is a diagnostic angiography followed by a therapeutic second step. Embolization should be as selective as possible to preserve maximum parenchyma. The renal parenchyma is better preserved when using hyper-selective microcatheterization and with the development of the coaxial system [7,8]. Embolization can be performed using different embolic agents: microcoils, particles, N-butyl-2-cyanoacrylate, and microparticles. The choice of embolic agent is important for the success of the procedure. Coils are the most commonly used agents and are metal spirals used as endovascular occlusion material. It is the most usable agent in renal embolization, particularly for pseudoaneurysms, because it allows for precise delivery with a low risk of infarction related to the preservation of distal microvessels. However, it requires hyper-selective micro-catheterization. Biological glue has marked hemostatic and adhesive properties. It polymerizes quickly when its particles come into contact with blood or biological fluids, solidifying independently of the patient's coagulation parameters. It is the second agent of choice in renal embolization, but its use is difficult with a potential risk of off-target embolization due to reflux. Its main indication is in case of difficulty with hyper-selective micro-catheterization. Microparticles are agents that allow for rapid occlusion of the diseased artery, but their manipulation is difficult with a risk of off-target embolization [9,10,11]. They are increasingly less used in the hemostasis of post-traumatic lesions. In our series, coils are the most commonly used agents.

The major concern in the management of renal trauma is the preservation of nephron capital, which is why surgical treatment is no longer the first-line therapy and embolization is most indicated. Several studies have shown that embolization allows for preservation of nephrons with a loss of less than 30% of nephron capital; this is explained by the development of hyper-selective micro-catheterization and the fact that embolization only affects the area affected by the trauma, unlike total nephrectomy, which involves the entire kidney [1].

Patient follow-up did not show any alteration in creatinine levels after embolization, and hemoglobin levels even increased after embolization. Complications of renal embolization are rare and are classified into two types. Early complications include post-embolization syndrome, fever with early-onset intense pain, renal function impairment, hypertension, and recurrence of heavy bleeding. Late complications include renal function impairment, hypertension, and renal abscess.

Renal embolization has several advantages, the main one being the preservation of renal parenchyma. The current issue is the indication in grade V trauma, as several studies recommend renal surgery for the severity of its post-traumatic lesions.

5. Conclusion

Post-traumatic renal embolization is a minimally invasive treatment indicated for any renal trauma with abundant bleeding and signs of active bleeding on angioscan. It allows for control of renal hemorrhage with success rates approaching 100%. The most considerable loss of renal tissue is usually inherent and limited to the initial trauma itself.

Compliance with ethical standards

Disclosure of conflict of interest

No conflict of interest to be disclosed.

Statement of ethical approval

This retrospective study was approved by the Institutional Review Board of our University Hospital.

Statement of informed consent

Informed consent was obtained from all individual participants included in the study.

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