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Arterial Embolization: A Superior Treatment for Massive Urinary Tract Bleeding in Emergency Care

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Abstract: *Objective:* To analyze the effect of arterial embolism (AE) in patients with massive urinary system bleeding (MBUS). *Methods:* From September 2018 to September 2023, 175 cases of MBUS patients in the emergency department of the hospital were randomly selected and divided into groups according to the length of stay. Among them, 85 cases (September 2018 – September 2020) underwent bladder irrigation treatment with aluminum potassium sulfate solution through a catheter (Group A), and 90 cases (October 2020 – September 2023) underwent AE treatment (Group B). The treatment effects of the two groups were compared. *Results:* The treatment effectiveness of Group B is higher than that of Group A ($P < 0.05$). The urinary hemoglobin level of Group B is lower than that of Group A at 1, 6, 12, and 24 hours after treatment ($P < 0.05$). Among the 90 cases treated with AE, 7 cases had a fever, with body temperatures ranging from 37.3°C to 38.9°C, with a mean temperature of 38.2 ± 0.3°C. Four cases experienced local pain, nausea, and vomiting, while two cases of intra-iliac AE showed transient buttock pain. These patients with adverse reactions were treated symptomatically for 7 days. All patients recovered after treatment. Intravenous urography of 87 patients in June showed that the renal pelvis and calyces were in good condition, the renal function returned to normal, and the blood urea nitrogen and blood creatinine test results were within the normal range. After 1 year of follow-up, no hypertension occurred. *Conclusion:* AE treats MBUS patients in the emergency department with remarkable efficacy. It has the advantages of less damage to the body, rapid hemostasis, high safety, and maximum preservation of organ function.

Keywords: Emergency; Arterial embolism; Urinary tract bleeding

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1. Introduction

Massive bleeding of the urinary system (MBUS) encompasses various bleeding sites, including the kidneys, ureters, bladder, and urethra, among others, and constitutes a significant portion of clinical emergency cases. Additionally, MBUS can arise from systemic diseases or conditions affecting adjacent organs [1]. The predominant symptom in most MBUS cases is hematuria, though some patients may primarily present with pelvic and abdominal bleeding without evident hematuria. Without prompt and effective intervention, MBUS patients are at risk of succumbing to hemorrhagic shock. Therefore, a pressing challenge for urology departments is expedited hemostasis in MBUS patients.

Historically, clinical management of MBUS has relied on systemic hemostatic agents, continuous bladder irrigation, and similar approaches. While these methods can mitigate bleeding to a certain extent, patients with substantial hemorrhage often necessitate surgical intervention or ligation of major blood vessels to achieve hemostasis. However, swiftly identifying the bleeding source poses challenges and may result in increased bodily harm. Advancements in digital subtraction angiography (DSA) technology have facilitated the widespread adoption of arterial embolism (AE) in clinical practice for MBUS patients, offering simplicity of procedure, high efficacy, and safety [2,3]. This study aims to analyze the efficacy of AE in treating MBUS patients.

2. Materials and methods

2.1. General information

MBUS patients from the emergency department of the hospital between September 2018 and September 2023 were randomly selected and categorized based on their duration of stay. Among them, Group A comprised 85 cases (September 2018 – September 2020), while Group B included 90 cases (October 2020 – September 2023). In Group A, the age range is between 20 and 65 years, with a mean age of 43.68 ± 4.52 years, and their weight ranging from 45.62 to 87.95 kg, with a mean weight of 63.17 ± 6.59 kg. The predominant bleeding types were pelvic fracture combined with massive urethral bleeding (27 cases), bleeding after percutaneous nephrolithotomy (43 cases), and traumatic closed renal contusion and laceration bleeding (15 cases). The male/female ratio was 41/44. In Group B, the age range is between 21 and 63 years, with a mean age of 43.15 ± 4.49 years, and their weight ranging from 45.56 to 87.82 kg, with a mean weight of 63.69 ± 6.63 kg. The predominant bleeding types were pelvic fracture combined with urethral bleeding (28 cases), bleeding after percutaneous nephrolithotomy (45 cases), and traumatic closed renal contusion and laceration bleeding (17 cases). The male/female ratio was 43/47. General data comparison showed no significant difference ($P > 0.05$).

Inclusion criteria: (1) Patients diagnosed with MBUS; (2) Patients providing voluntary participation with complete medical history; (3) Patients providing informed consent for study participation and signing relevant documentation.

Exclusion criteria: (1) Individuals with mental illness; (2) Patients diagnosed with malignant tumors; (3) Individuals with severe disorders of major organs such as liver and kidney; (4) Patients with incomplete medical history data; (5) Individuals who dropped out midway.

2.2. Methods

Group A: Treatment involved bladder irrigation with aluminum potassium sulfate solution via a urinary catheter. Preparation of potassium aluminum sulfate solution: The Pharmacy Department's preparation room utilized 0.9% sodium chloride injection to prepare potassium aluminum sulfate into a 1.0% aluminum solution, autoclaved for sterility. For patients with cystostomy tubes, continuous irrigation was administered using an irrigation device at a rate of 50 mL/min. Retention flushing involved connecting a three-lumen balloon catheter to the bladder flushing device, followed by injecting 150–250 mL of aluminum solution into the bladder, retaining for 10 minutes, and subsequently flushing. The irrigation volume ranged from 2,000–3,000 mL, administered once daily, ceasing when urine clarity was achieved.

Group B: AE involved local anesthesia using the Seldinger technique, with femoral artery puncture and cannulation. DSA guided the identification of damaged and bleeding vessels. For example, patients with pelvic fractures and urethral rupture underwent bilateral internal iliac artery angiography, while those with kidney damage underwent bilateral renal artery angiography. Following ultra-smooth loach guidewire insertion, a

4–5F Cobra catheter was advanced to the bleeding artery branch, and embolization materials were selected based on arterial injury severity. Successful embolization was confirmed via DSA examination, indicating interrupted bleeding, absent blood flow, intact contrast agent containment, and stable vital signs postoperatively. Compression and bandaging were applied to the puncture site, with a prescribed 24-hour limb immobilization period and 7-day bed rest with close monitoring of urine and vital signs.

2.3. Observation indicators

(1) Treatment effectiveness: Calculated as the sum of the markedly effective rate and the effective rate, with markedly effective indicating clear urine, urinary Hb < 0.1 g/L, and 24-hour urinary blood loss < 2 mL; effective indicating slightly mixed urine, urinary Hb 0.1–1 g/L, 24-hour urinary blood loss 2–20 mL; ineffective indicating no change in fluid color, urine Hb > 1 g/L, and 24-hour urinary blood loss > 20 mL.

(2) Urinary hemoglobin (Hb) level: Urine occult blood test assessed urinary Hb levels before treatment, and at 1 h, 6 h, 12 h, and 24 h post-treatment.

(3) Analysis of patient response after AE.

2.4. Statistical analysis

SPSS 25.0 was used for data analysis. Measurement data were expressed as mean ± standard deviation (SD) and processed with the *t*-test. Count data were presented as *n* (%) and processed with the χ^2 test. A *P*-value of less than 0.05 is considered as statistically significant.

3. Results

3.1. Treatment effectiveness

Table 1 shows that the treatment effectiveness of Group B was significantly higher than Group A ($P < 0.05$).

Table 1. Comparison of treatment effectiveness [*n* (%)]

Group	*n*	Markedly effective	Effective	Ineffective	Total effective rate
Group B	90	54 (60.00)	34 (37.78)	2 (2.22)	88 (97.78)
Group A	85	33 (38.82)	41 (48.24)	11 (12.94)	74 (87.06)
χ^2	-	-	-	-	7.303
P	-	-	-	-	0.006

3.2. Urine hemoglobin levels

As seen in **Table 2**, there were no significant differences in the urinary Hb levels between the two groups before treatment ($P > 0.05$). However, Group B showed significantly lower urinary Hb levels than Group A at 1, 6, 12, and 24 hours after treatment ($P < 0.05$).

Table 2. Comparison of urine hemoglobin levels (mean ± SD, g/L)

Group	*n*	Before treatment	1 hour after treatment	6 hours after treatment	12 hours after treatment	24 hours after treatment
Group B	90	15.38 ± 5.64	0.52 ± 0.14	0.38 ± 0.12	0.19 ± 0.10	0.11 ± 0.06
Group A	85	15.67 ± 5.58	3.76 ± 0.25	1.64 ± 0.23	0.68 ± 0.37	0.53 ± 0.15
t	-	0.341	106.537	45.794	12.106	24.566
P	-	0.733	0.000	0.000	0.000	0.000

3.3. Patient response after AE

Out of the 90 cases treated with AE, 7 experienced post-operative fever, with body temperatures ranging from 37.3°C to 38.9°C, with a mean temperature of 38.2 ± 0.3°C. Additionally, 4 cases reported local pain, nausea, and vomiting, while 2 cases showed transient buttock pain following internal iliac AE. All patients with adverse reactions recovered after receiving 7 days of symptomatic treatment. Intravenous urography conducted on 87 patients in June revealed favorable conditions of the renal pelvis and calyces, with normalized renal function and blood urea nitrogen and blood creatinine levels within the normal range. No instances of hypertension were observed during the 1-year follow-up period.

4. Discussion

In cases of MBUS where bleeding is not excessive, conservative treatment can suffice for achieving hemostasis. However, if bleeding is rapid or extensive, and hemodynamics become unstable, surgical intervention becomes necessary to halt the bleeding. Yet, surgical procedures entail greater bodily damage and risk factors for patients. Complicated bleeding scenarios post-surgery may impede quick identification of damaged blood vessels and prompt cessation of bleeding, potentially leading to organ dysfunction. With ongoing advancements in interventional radiology, DSA-guided AE emerges as a simple, highly effective, and safe approach for treating various major hemorrhages [4,5]. Urology has increasingly adopted AE to treat MBUS patients, achieving notable efficacy and safety through clinical practice. In this study, AE treatment in 90 MBUS patients resulted in rapid hemostasis and significant hemostatic effects.

Successful AE treatment for MBUS hinges on swiftly and accurately locating the damaged blood vessels for intubation [6]. This study utilizes DSA to pinpoint damaged blood vessels, providing precise anatomical understanding and bleeding extent assessment, thereby ensuring patients do not miss optimal treatment opportunities: (1) where MBUS patients show no significant improvement after 6 hours of conservative treatment; (2) in cases of substantial bleeding and persistent blood pressure instability post-conservative treatment; and (3) instances where patients experience bleeding recurrence post-effective conservative treatment, prompting AE combined with stabilizing vital signs and anti-shock measures. In this study, 7 patients with unstable blood pressure and heart rhythm underwent AE following DSA examination, leading to stabilized vital signs and urine color improvement [7]. Additionally, four patients developed MBUS post-percutaneous nephrolithotomy, stabilized after active symptomatic treatment. Subsequent DSA examination located bleeding vessels, facilitating successful AE completion.

During AE treatment, after successful intubation, appropriate embolization materials selection based on damaged blood vessel conditions (diameter, blood flow, etc.) is crucial [8]. For MBUS patients with larger blood vessel branch damage, especially arteriovenous fistulas or pseudoaneurysms, non-transparent X-ray coils are preferred for easier monitoring during the operation. This allows for quick collateral circulation reconstruction post-AE, preventing organ necrosis in most patients. Gelatin sponge, as an AE material, is cost-effective, readily available, and effectively stops bleeding, with most patients absorbing it within about 3 weeks post-AE. Beyond this period, inflammatory packaging of damaged tissues and organs begins, aiding in tissue repair and minimizing further bleeding risk, particularly beneficial for organ function recovery [9]. In this study, 13 patients with thin blood vessels and bleeding were treated with Gelfoam sponge strips or gelatin sponge particles, achieving prompt bleeding cessation and ideal hemostatic effects with no recurrence observed post-AE. Furthermore, five patients with thick blood vessels and extensive bleeding were treated with spring steel coils in AE. As a result, 3 patients with severe closed renal contusion and laceration had a large degree of vascular damage. To address damaged capillaries, a small amount of gelatin sponge particles was used in conjunction with spring steel coils, and no further bleeding or ectopic embolism was observed post-AE.

Complications post-AE treatment included fever in 7 patients, with temperatures ranging from 37.3°C to 38.9°C, averaging 38.2 ± 0.3°C, and local pain, nausea, and vomiting in 4 cases. Following symptomatic treatment within 7 days, complication symptoms resolved. Common complications after AE include bleeding recurrence, embolism syndrome, and ectopic embolism. Nausea, vomiting, fever, and low back pain are key manifestations of embolism syndrome, potentially resulting from local tissue edema and necrosis due to ischemia and hypoxia post-AE. Ensuring the catheter enters the bleeding vessel during intubation and placing the catheter tip as close to the bleeding site as possible helps reduce the risk of embolization of other arterial branches, particularly in embolizing renal-damaged blood vessels. Bleeding recurrence, mainly due to thrombus absorption and emboli shedding, necessitates a second AE or conversion to open surgery. Using metal springs to embolize damaged, thick blood vessels effectively reduces the bleeding recurrence rate [10].

In conclusion, AE proves highly effective in the emergency treatment of MBUS patients, offering the advantages of minimally bodily harm, rapid hemostasis, high safety, and optimal organ function preservation.

Disclosure statement

The authors declare no conflict of interest.

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