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Original Research Article

EFFICACY AND CLINICAL OUTCOMES OF ENDOVASCULAR INTERVENTIONS IN THE MANAGEMENT OF HEMATURIA: A PROSPECTIVE OBSERVATIONAL STUDY

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ABSTRACT

Background: Hematuria is a common urological emergency arising from a wide spectrum of benign and malignant disorders involving the kidneys, ureters, urinary bladder, and prostate. Although conservative measures and surgical interventions remain conventional treatment options, transcatheter arterial embolization (TAE) has emerged as an effective minimally invasive alternative for controlling severe or persistent bleeding while preserving organ function. However, data regarding its efficacy and safety from Indian tertiary care centers remain limited. The aim is to evaluate the efficacy and safety of vascular interventional embolization techniques in the management of hematuria using clinical outcomes, laboratory parameters, and procedural characteristics. **Materials and Methods:** This prospective observational study included 31 consecutive patients presenting with significant hematuria requiring endovascular intervention. Patients with contrast allergy, renal insufficiency, coagulopathy, or pregnancy were excluded. Digital subtraction angiography (DSA) was performed to identify the bleeding source, followed by selective or super-selective embolization using coils, polyvinyl alcohol (PVA) particles, gelfoam, or glue according to lesion characteristics. Clinical success was assessed by cessation of hematuria without further intervention, while technical success was defined as complete angiographic occlusion of the bleeding vessel. Hemoglobin values before and after embolization were compared using paired t-test. **Result:** The majority of patients were between 41 and 70 years of age (74.1%), with males accounting for 77.4% of the study population. Renal tumors constituted the most frequent etiology (32.3%), followed by carcinoma of the bladder (25.8%) and carcinoma of the prostate (25.8%). Renal arterial branches were embolized in 44.8% of procedures. Coil with gelfoam was the most commonly employed embolic combination (35.2%). Technical success was achieved in 96.7% of patients, while significant clinical improvement was observed with a mean hemoglobin increase from 7.0 ± 1.8 g/dL to 11.4 ± 1.2 g/dL ($p < 0.001$). Procedure-related complications were infrequent, with post-embolization syndrome occurring in only 10% of patients. **Conclusion:** Transcatheter arterial embolization is a safe, effective, and minimally invasive therapeutic modality for managing severe hematuria of diverse etiologies. The procedure demonstrates high technical and clinical success with low complication rates, making it an excellent alternative to emergency surgery in appropriately selected patients.

INTRODUCTION

Hematuria, defined as the presence of blood in urine, is among the most frequent manifestations of urinary tract pathology encountered in urological practice. It may present either as microscopic hematuria detected during laboratory evaluation or as gross hematuria, which frequently requires emergency assessment because of significant blood loss and urinary obstruction. The prevalence of microscopic hematuria in adults ranges from 2% to over 30%, depending on the study population and

diagnostic criteria, while gross hematuria is more commonly associated with clinically significant pathology requiring prompt evaluation.[1,2]

The etiology of hematuria is diverse and includes malignant neoplasms, trauma, vascular abnormalities, urinary tract infections, inflammatory disorders, congenital anomalies, and iatrogenic injuries. In elderly patients, urological malignancies such as renal cell carcinoma, bladder carcinoma, and prostate carcinoma account for a substantial proportion of severe bleeding episodes. Conversely, younger individuals more commonly present with traumatic vascular injuries, renal artery aneurysms, arteriovenous fistulas, or benign renal lesions such as angiomyolipoma.[3,4]

Conventional management of hematuria initially involves conservative measures including bladder irrigation, blood transfusion, correction of coagulation abnormalities, antimicrobial therapy when indicated, and endoscopic interventions. Although these approaches successfully control bleeding in many patients, persistent or recurrent hematuria often necessitates more invasive treatment. Surgical procedures such as nephrectomy, partial nephrectomy, internal iliac artery ligation, urinary diversion, or cystectomy are associated with considerable perioperative morbidity, prolonged hospitalization, and loss of organ function, particularly in elderly patients and those with advanced malignancy.[5,6]

Advances in interventional radiology have revolutionized the management of vascular causes of hematuria. Digital subtraction angiography (DSA) enables precise localization of bleeding vessels and facilitates selective or super-selective catheterization, allowing targeted embolization while preserving uninvolved renal or pelvic parenchyma. Modern embolic materials—including detachable coils, polyvinyl alcohol particles, gelfoam, N-butyl cyanoacrylate glue, and vascular plugs—provide rapid hemostasis with excellent technical success and minimal complications.[7]

Renal arterial embolization has become an established treatment for renal trauma, pseudoaneurysms, arteriovenous fistulas, angiomyolipomas, and renal cell carcinoma. Likewise, vesical and prostatic artery embolization are increasingly utilized for intractable hematuria associated with bladder carcinoma, radiation cystitis, prostate cancer, and benign prostatic hyperplasia. Several systematic reviews have demonstrated technical success rates exceeding 90%, with clinical success ranging from 80% to 100%, highlighting the effectiveness of embolization in avoiding emergency surgery.[8,9]

The success of embolization depends upon meticulous angiographic evaluation, identification of all bleeding vessels, and appropriate selection of embolic agents according to vascular anatomy and lesion characteristics. Super-selective embolization minimizes ischemic complications by preserving normal tissue perfusion while effectively controlling hemorrhage. Consequently, vascular embolization has become the preferred first-line intervention for many patients with persistent hematuria who fail conservative treatment.[10]

Despite growing international evidence, published data from Indian tertiary care institutions regarding the efficacy of vascular interventional techniques for hematuria remain relatively scarce. Furthermore, limited information is available regarding the spectrum of underlying etiologies, embolic materials employed, procedural outcomes, and complications within the Indian healthcare setting. The present study was therefore undertaken to evaluate the efficacy of vascular embolization in patients presenting with hematuria at a tertiary care center by assessing technical success, clinical outcomes, hematological improvement, procedural characteristics, and complications.

MATERIALS AND METHODS

This prospective observational study was conducted in the Department of Radiodiagnosis and Interventional Radiology at a tertiary care teaching hospital in Tamilnadu over a period of two years from 2024 to 2026. A total of 31 consecutive patients presenting with clinically significant hematuria who required vascular interventional management after failure of conservative treatment were included in the study. Patients with known iodinated contrast allergy, severe renal insufficiency, uncorrectable coagulopathy, pregnancy, or incomplete clinical records were excluded. Institutional Ethics Committee approval was obtained before commencement of the study, and written informed consent was obtained from all participants.

All patients underwent a comprehensive clinical evaluation, including detailed history taking, physical examination, laboratory investigations comprising complete blood count, renal function tests, coagulation profile, and urine analysis. Imaging evaluation included ultrasonography, contrast-enhanced computed tomography (CECT), magnetic resonance imaging (MRI), or positron emission tomography-computed tomography (PET-CT), wherever clinically indicated, to identify the probable source of bleeding and guide further intervention.

Digital subtraction angiography (DSA) was performed under strict aseptic precautions using transfemoral arterial access by the Seldinger technique. Selective angiography was undertaken to identify the bleeding vessel, vascular abnormality, or tumor blush. Depending on the angiographic findings, selective or super-selective embolization was performed using appropriate embolic agents, including detachable coils, polyvinyl alcohol (PVA) particles, gelfoam, or N-butyl cyanoacrylate (glue), either alone or in combination. The choice of embolic material was based on the underlying

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pathology, vascular anatomy, and operator discretion. Completion angiography was performed in all patients to confirm successful occlusion of the target vessel and cessation of contrast extravasation or tumor blush.

The primary outcome measure was clinical success, defined as complete cessation of hematuria without the need for additional surgical or endoscopic intervention. Technical success was defined as complete angiographic occlusion of the bleeding vessel or disappearance of tumor blush immediately after embolization. Secondary outcome measures included changes in pre- and post-procedure hemoglobin levels, procedural duration, radiation exposure, embolic materials used, and procedure-related complications.

The collected data were entered into Microsoft Excel and analyzed using the Statistical Package for the Social Sciences (SPSS) version 25.0 (IBM Corp., Armonk, NY, USA). Continuous variables were expressed as mean ± standard deviation, while categorical variables were presented as frequencies and percentages. Pre- and post-procedure hemoglobin levels were compared using the paired Student's t-test. A p-value of less than 0.05 was considered statistically significant.

RESULTS

A total of 31 patients with persistent hematuria who underwent vascular interventional embolization were included in the study. The demographic profile, etiological spectrum, embolized arteries, embolic materials used, technical outcomes, hematological improvement, and procedure-related complications are presented below. Most patients were between 41 and 70 years of age (74.2%), with the highest proportion in the 51–60 years age group (29.0%), indicating that hematuria requiring embolization predominantly affected middle-aged and elderly individuals. [Table 1] Of the 31 patients, 24 (77.4%) were males and 7 (22.6%) were females, demonstrating a marked male predominance among patients undergoing vascular embolization. [Table 2]

Renal tumors (32.3%) were the most common cause of hematuria, followed by carcinoma of the bladder (25.8%) and carcinoma of the prostate (25.8%). Malignancies accounted for the majority of cases requiring embolization. [Table 3]

The main renal artery and its branches (45.2%) were the most frequently embolized vessels, followed by the vesical arteries (19.4%) and internal iliac arteries (19.4%). [Table 4]

The most commonly used embolic agent was coil with gelfoam (35.5%), followed by gelfoam with PVA particles (25.7%), reflecting appropriate embolic selection based on lesion characteristics. [Table 5] Technical success was achieved in 30 of 31 patients (96.8%), confirming the high efficacy of transcatheter arterial embolization in controlling hemorrhage. [Table 6] The mean hemoglobin increased significantly from 7.0 ± 1.8 g/dL pre-procedure to 11.4 ± 1.2 g/dL post-procedure ($p < 0.001$), indicating effective control of bleeding. [Table 7]

Most patients (87.1%) had no complications. Post-embolization syndrome (9.7%) was the most common adverse event, while groin hematoma (3.2%) occurred in one patient. No major complications were observed. [Table 8]

Table 1: Age Distribution of the Study Population (n = 31)

Age Group (Years)	Frequency (n)	Percentage (%)
<30	4	12.9
31–40	2	6.5
41–50	8	25.8
51–60	9	29.0
61–70	6	19.4
71–80	2	6.5
Total	31	100.0

Table 2: Gender Distribution of the Study Population (n = 31)

Gender	Frequency (n)	Percentage (%)
Male	24	77.4
Female	7	22.6
Total	31	100.0

Table 3: Etiology of Hematuria (n = 31)

Etiology	Frequency (n)	Percentage (%)
Renal tumor	10	32.3
Carcinoma urinary bladder	8	25.8
Carcinoma prostate	8	25.8
Renal artery aneurysm	1	3.2
Renal arteriovenous fistula	1	3.2
Renal trauma	1	3.2
Transplant renal injury	1	3.2
Renal angiomyolipoma	1	3.2
Total	31	100.0

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Table 4: Arteries Embolized During the Procedure (n = 31)

Artery Embolized	Frequency (n)	Percentage (%)
Main renal artery and branches	14	45.2
Bilateral superior and inferior vesical arteries	6	19.4
Bilateral internal iliac arteries	6	19.4
Prostatic arteries	4	12.9
Second and fourth lumbar arteries	1	3.2
Total	31	100.0

Table 5: Embolic Materials Used (n = 31)

Embolic Material	Frequency (n)	Percentage (%)
Coil	7	22.6
Coil + Gelfoam	11	35.5
Coil + PVA	3	9.7
Gelfoam + Glue	2	6.5
Gelfoam + PVA	8	25.7
Total	31	100.0

Table 6: Technical Success of Embolization (n = 31)

Technical Outcome	Frequency (n)	Percentage (%)
Successful	30	96.8
Failed	1	3.2
Total	31	100.0

Table 7: Comparison of Hemoglobin Levels Before and After Embolization

Parameter	Pre-procedure	Post-procedure	Mean Difference	t value	p value
Hemoglobin (g/dL)	7.0 ± 1.8	11.4 ± 1.2	4.4	15.84	<0.001*

Paired Student's t-test

Table 8: Procedure-Related Complications (n = 31)

Complication	Frequency (n)	Percentage (%)
Post-embolization syndrome	3	9.7
Local groin hematoma	1	3.2
Buttock/perineal pain	0	0
Bladder necrosis	0	0
Coil migration	0	0
Neurological complications	0	0
No complications	27	87.1

DISCUSSION

Transcatheter arterial embolization (TAE) has become an established minimally invasive treatment for patients with persistent or life-threatening hematuria when conservative measures fail. The present study demonstrated a high technical success rate of 96.8% with significant clinical improvement and minimal complications, confirming that vascular interventional techniques are highly effective in the management of hematuria from a variety of urological conditions.

The majority of patients in the present study were between 41 and 70 years of age (74.2%), with a marked male predominance (77.4%). These findings are consistent with previous reports, which have shown that severe hematuria is more frequently encountered among older males due to the increasing incidence of renal, bladder, and prostatic malignancies with advancing age.[11,12] Similar demographic patterns have also been reported in studies evaluating endovascular treatment of urological hemorrhage.[13]

Malignancy was the leading cause of hematuria in our series, with renal tumors accounting for 32.3% of cases, followed by carcinoma of the urinary bladder and prostate (25.8% each). These observations are in agreement with studies by Loffroy et al. and Taha et al., who reported that malignant tumors constitute the commonest indication for embolization because tumor-related neovascularization frequently results in recurrent or intractable bleeding.[14,15] In addition, vascular lesions such as renal artery aneurysm, arteriovenous fistula, and traumatic renal injuries were effectively managed by selective embolization, consistent with published evidence supporting organ-preserving endovascular therapy.[16,17]

Renal arterial embolization was the most frequently performed procedure (45.2%), reflecting the predominance of renal pathologies in the study population. Super-selective embolization enables precise occlusion of bleeding vessels while preserving functional renal parenchyma, thereby reducing the need for nephrectomy and minimizing procedure-related morbidity.[18] The combination of coils and gelfoam was the most commonly used embolic material in the present study because it provides immediate vascular occlusion together with durable hemostasis. Previous investigators have similarly emphasized that the choice of embolic agent should depend on the vascular anatomy, lesion

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characteristics, and desired permanence of vessel occlusion.[19,20]

A technical success rate of 96.8% observed in the present study is comparable with previously published success rates ranging from 90% to 100%. Taha et al. reported excellent technical and clinical outcomes following embolization for intractable bladder hemorrhage, while Loffroy et al. demonstrated high success rates for both renal and pelvic embolization procedures.[15,21] The high success rate in our study may be attributed to careful angiographic localization of the bleeding source, super-selective catheterization, and appropriate selection of embolic materials.

A significant improvement in hemoglobin levels was observed following embolization, with the mean value increasing from 7.0 ± 1.8 g/dL pre-procedure to 11.4 ± 1.2 g/dL post-procedure ($p<0.001$). This reflects effective hemorrhage control and reduced transfusion requirements following successful embolization. Similar improvements in hematological parameters have been reported in studies evaluating embolization for renal tumors, traumatic vascular injuries, and bladder hemorrhage.[22,23]

The safety profile of embolization in the present study was highly favorable. Post-embolization syndrome occurred in only 9.7% of patients, while a minor groin hematoma was observed in one patient. No major complications such as bladder necrosis, coil migration, neurological deficits, or procedure-related mortality were encountered. These findings are comparable with those reported in contemporary studies, where super-selective embolization has been associated with low complication rates due to advances in microcatheter technology and embolic materials.[24,25]

Although the present study demonstrated encouraging clinical outcomes, certain limitations should be acknowledged. The relatively small sample size and single-center design may limit the generalizability of the findings. Furthermore, long-term follow-up was not available to assess delayed recurrence or late complications. Nevertheless, the consistently high technical success, significant clinical improvement, and low complication rates observed in this study support the role of vascular interventional techniques as a safe, effective, and organ-preserving treatment option for patients with severe hematuria.

CONCLUSION

The present study demonstrates that transcatheter arterial embolization is a safe, effective, and minimally invasive treatment modality for the management of hematuria secondary to various urological and vascular conditions. Renal tumors, bladder carcinoma, and prostate carcinoma were the most common etiologies requiring intervention. The procedure achieved an excellent technical success rate of 96.8%, with significant improvement in hemoglobin levels and effective control of bleeding. The low incidence of minor complications and absence of major procedure-related adverse events further highlight the safety and reliability of vascular interventional techniques. Selective and super-selective embolization not only provides rapid hemostasis but also preserves organ function, thereby reducing the need for emergency surgical intervention. These findings support transcatheter arterial embolization as an effective first-line therapeutic option for patients with persistent or life-threatening hematuria when conservative management is unsuccessful.

Recommendations

Vascular embolization should be considered early in the management of patients with persistent or recurrent hematuria, particularly in those with renal, bladder, or prostatic malignancies and vascular lesions. Selective or super-selective embolization should be performed whenever feasible to maximize bleeding control while preserving normal organ function. A multidisciplinary approach involving urologists, interventional radiologists, and oncologists is recommended to optimize patient selection and treatment outcomes. Larger multicenter studies with longer follow-up are warranted to evaluate long-term clinical success, recurrence rates, renal functional outcomes, and the comparative effectiveness of different embolic materials and embolization techniques.

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