INTERVENTIONAL RADIOLOGY IN HEMATURIA

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Abstract: *Hematuria is a common complaint encountered in surgical practice. When severe and life threatening, it requires emergency intervention. Interventional radiology (IR) techniques, being minimally invasive, are now amongst the mainstay techniques for management of these patients. A multidisciplinary approach involving the surgeon and the interventional radiologist helps in deciding the appropriate form of therapy in a particular patient.Plain CT is the most effective modality to detect small calculi, hemorrhage and tumoral calcification. CT urography demonstrates the pelvicalyceal system and ureters. CT is useful in cases of trauma, detecting small tumors and help in staging advanced cancers. It depicts vascular abnormalities like aneurysms, arteriovenous malformation (AVM) and arteriovenous fistula (AVF). Ultrasound and Color Doppler are also useful. Embolization Procedures are useful in renal cell carcinomas, angiomyolipoma, AVM's, renal trauma, polycystic disease of kidneys, including bladder & prostate carcinoma and widespread gynecological malignancy. Embolization therapy can be performed under local anesthesia and hence patients unfit for surgery can undergo this safely. It can provide permanent relief in conditions like vascular abnormalities, trauma and benign tumors like angiomyolipoma. Embolization therapy plays an useful role in the treatment of massive hematuria in various conditions as outlined above.*

Key Words : Hematuria : Interventional Embolization therapy : Pelvic tumor, trauma and malignancy

INTRODUCTION

Presence of a cloudy or frankly bloody appearance of urine can be a source of significant concern to the patient. Reliable evidence of hematuria is obtained from microscopic examination of urinary sediment, when greater than three red blood cells are seen per high power field. Hematuria is a common complaint encountered in surgical practice. It may result from a variety of causes, ranging from strenuous exercise to extensive malignancy to trauma (Table 1). When severe and life threatening, it requires emergency intervention. Interventional radiology (IR) techniques, being minimally invasive, are now amongst the mainstay techniques for management of these patients. The advances in catheter design and introduction of new embolizing materials have contributed to this trend. In this article, we briefly review the various conditions in which IR can play a role in the management of hematuria.

TESTS FOR HEMATURIA

Tests for presence of hematuria should be performed even if the gross appearance is suggestive, as many drugs and foods can cause urine to appear various shades of orange and reddish-brown. Besides physical examination of urine, hematuria can also be detected by performing the Benzidine test on urine. A quick and simple test for detecting microscopic hematuria is the "dipstick" test for urine. However, it may be associated with a high number of false positives. Immediate microscopy following a positive dipstick test can improve diagnostic efficiency in these situations.

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Table 1. *Common causes of Hematuria*

I Nephrologic Causes
Glomerular hematuria [>80% dysmorphic erythrocytes, red blood cell (RBC) casts, proteinuria] –
- Glomerulonephritis
  Non glomerular hematuria (Circular RBC, proteinuria, no casts)
- Tubulointerstitial - Papillary necrosis, Chronic Interstitial nephritis, Irradiation nephritis, Autosomal Dominant Polycystic Kidney Disease (ADPKD)
- Renovascular - Congenital - Arteriovenous Malformation (AVM); Traumatic (including iatrogenic) - Arteriovenous fistula (AVF), pseudoaneurysms; Others -malignant hypertension, Vasculitis
- Systemic – Drugs, Bleeding disorders.

II Urological Causes (Non Glomerular – Surgical)
(Circular RBCs, No Casts, No Significant Proteinuria)
- Tumors- bladder, kidney, prostate, ureter, others (in order of frequency).
- Calculus disease
- Infection- cystitis, tuberculosis
- Benign Prostatic enlargement
- Trauma- Blunt, penetrating, Iatrogenic
- Miscellaneous – Radiation cystitis, Schistosomiasis, endometriosis

ESTABLISHING THE CAUSE AND PLANNING THE MANAGEMENT OF HEMATURIA

A careful physical examination is the first essential step in establishing the cause and extent of the disease leading to hematuria. Patient may give a history of recent procedures being performed [renal biopsy, percutaneous nephro-

lithotomy (PCNL), percutaneous nephrostomy (PCN)]. History of trauma may be present. Importantly, a multidisciplinary approach involving the surgeon and the interventional radiologist is necessary for deciding the appropriate form of therapy in a particular patient.

RADIOLOGICAL INVESTIGATIONS

CT Scan

The most helpful radiological investigation for hematuria is a CT scan of the abdomen. It is non-invasive, widely available and rapidly performed. A combination of non-contrast and contrast-enhanced CT is generally performed. Where necessary, CT urography is also done to demonstrate the pelvicalyceal system and ureters. Thus, both parenchyma and collecting system can be evaluated in a single sitting. NCCT is the most effective modality to detect small calculi, hemorrhage and tumoral calcification. In cases of trauma, CT can accurately depict visceral and bony injuries, and associated injuries to other organs of the body. CT scan is the modality of choice to detect small tumors. For advanced neoplastic lesions, CT can help to stage the disease. Vascular abnormalities like aneurysms, arteriovenous malformation (AVM) and arteriovenous fistula (AVF) can also be visualized on "multiphase" CT angiography. CT is truly a "one-stop shop" in the setting of hematuria. Multidetector row CT Scanners are even faster (and hence are useful in imaging trauma cases and other unstable patients) and reduce the dose of contrast medium required. Different phases of contrast uptake can be differentiated (arterial, cortico-medullary, nephrographic, and excretory phase). Further, the narrow collimation data sets acquired during a single breath-hold allow reconstruction of high-quality multiplanar reconstruction (MPR) and maximum intensity projection (MIP) images in virtually any plane, which add to the diagnostic information[1].

ULTRASOUND AND COLOR DOPPLER

Ultrasound (US) is a rapidly performed, easy to use and universally available modality for the imaging of the urinary tract. It is useful in evaluating solid renal masses, bladder outlet obstruction, or urethral atresia. Color Doppler US (CDUS) is a good screening modality for the depiction of various vascular abnormalities. However, it is operator dependent, time consuming, and requires patient co-operation. Thus it is not helpful in the setting of massive hematuria. In a hemodynamically stable patient however, CDUS can be useful for demonstrating lesions like AVM and AVF.

CATHETER ANGIOGRAPHY

A high quality angiogram is helpful to depict the vascular anatomy, active contrast extravasation suggesting the culprit vessel and tumor neovascularity. For visualization of fine vascular lesions free of overlap from bones or soft tissue, it is important to acquire images in the digital subtraction angiography (DSA) mode. The initial arteriographic evaluation should begin with aortography. Multiple renal arteries are common, occurring in approximately 30% of patients[2]. These may be missed if direct selective renal artery injections are performed. In trauma patients, injury to the vascular pedicle can be identified on the aortogram, and hence selective catheterization of the injured vessels can be avoided. Selective renal arteriography is performed with a preshaped catheter such as Simmons 1 or Cobra catheter. It may be necessary to obtain multiple views for accurate diagnosis, as evaluation in only the frontal plane may miss the abnormality. An ipsilateral anterior oblique projection shows the renal parenchyma to best advantage.

The major advantage of DSA is that it can be combined with catheter based interventional therapy in the same sitting. Decision to proceed with the intervention is generally based upon the lesion morphology. For example, in cases of pseudoaneurysm or AVM/AVF, particular attention should be paid to the feeding artery/arteries, site of communication/ neck, and draining veins (in cases of AVM/AVF). Delayed images may be necessary to reveal subtle extravasation. Besides serving as a roadmap, the initial angiogram is useful to choose the appropriate embolizing agent.

TECHNIQUE OF EMBOLIZATION

Informed Consent

The procedure should be explained completely to the patient and/or his relatives, outlining the associated risk of complications. Specific attention should be given to describing the risks of post-embolization syndrome and non-target embolization.

Sedation/Analgesia

It is helpful but not mandatory. If required, conscious sedation using Pethidine and Promethazine can be used.

Procedure

It is performed in the angiography suite. The images of CT scan and other radiological investigations should be available for reference. There should be clear understanding between the surgeon and interventional radiologist regarding the triage of the patient. As many of these patients have major blood loss, hemodynamic stability should be maintained using IV fluids and transfusion of blood products as required. After identifying the culprit lesion responsible for hematuria, decision regarding whether to embolize, choice of embolizing agent and the extent of embolization procedure must be made. Important factors to consider before embolizing any vessel include whether the vessel can be sacrificed and the alternative methods of treatment. The kidney is an end-artery organ with small collaterals from capsular branches. Occlusion of renal branch vessels will cause parenchymal infarction congruent to the size of the vessel. Before the advent of the newer coaxial catheters, it was often impossible to catheterize subsegmental branches, and embolization had to be performed more proximally, which resulted in considerable non-target organ damage and loss of function. Improvements in catheter technology and the availability of microcatheters now make it possible to cannulate 1- to 2- mm vessels. Use of the coaxial technique and delivery of microcoils permits precise and localized embolization of bleeding arterial branches with minimal loss

of tissue and function. This is the advantage of embolization compared to surgical procedures like partial or total nephrectomy, where a non-affected tissue or organ may get sacrificed[3]. In addition, surgical treatment is much more invasive and has the associated risks and morbidity of a major surgical procedure under general anesthesia.

Table 2: *Materials used for Transarterial embolization (*Most commonly used)*

Material	Comments
Gelfoam*	· Cheapest · Can be used as pledgets to match vessel diameter · Chances of reflux and non- target embolization · Potential for recanalization after 3-4 weeks
Poly Vinyl Alcohol particles	· Quasi-permanent agent · Enable distal embolization (useful for tumor and AVM) · Chances of reflux and non-target embolization
Coils*	· Used to block a major vessel or for vascular lesions like aneurysm and AVF · Less chance of non-target embolization
Glue	· Permanent agent · Used for vascular lesions · Expensive · Experience and careful use required
Detachable Balloons	· Permanent agent · Useful for a large aneurysm, large AVF
Alcohol	· Permanent agent · Used for embolization of tumor neovascularity · Painful · Chances of reflux are greater

The artery to be embolized is selectively cannulated and embolization is performed after placing the catheter as close as possible to the area of interest and the bleeding site/ vascular abnormality. The procedure is performed under strict fluoroscopy control to check for reflux of embolizing material.

A variety of embolization materials are available (Table 2). Their usage depends upon the type of lesion to be embolized and preference of the interventional radiologist. Recently developed devices such as interlocking detachable coils and Guglielmi detachable coils allow for controlled deployment of a coil and its easy retrieval if it is deployed in an unfavorable position. However, their usage may be limited by cost concerns[3]. While using non-detachable coils, it is important to keep retrieval devices such as snares ready in case the coils are deployed suboptimally, enter a non-culprit vessel, or pass through AVFs into the lungs. Different embolic materials can be combined or used sequentially for proximal and distal embolization. Also, while injecting glue and alcohol, use of balloon catheters to prevent reflux into systemic circulation is helpful[4, 5].

Table 3. *Conditions in which Embolization is helpful*

1. **Renal –**
   - · Tumors – Renal cell carcinoma, Angiomyolipoma
   - · Vascular lesions – pseudoaneurysm, AVM, AVF – Iatrogenic (Post PCNL, PCN or Biopsy), trauma, Congenital
   - · Blunt Trauma
   - · Autosomal Dominant Polycystic Kidney Disease (ADPKD)
2. **Pelvis –**
   - · Trauma (including surgical)
   - · Advanced malignancy – Urinary Bladder, Prostate, Gynaecological
   - · Miscellaneous – radiation cystitis, pelvic congestion disorders

INDICATIONS FOR EMBOLIZATION PROCEDURES

Various conditions in which IR is useful to control hematuria are listed in Table 3. Salient features regarding each condition are discussed below.

RENAL TUMORS

Renal Cell Carcinoma

Renal Cell Carcinoma (RCC) arises from the proximal tubular epithelium. Symptoms may occur late and as a result upto 30% of patients have distant metastases at presentation, and a further 25% have local spread. The 5-year survival rate for patients with metastases is <20%. The basis of treatment for localized disease is surgical resection, as tumors are relatively resistant to both radiotherapy and chemotherapy.

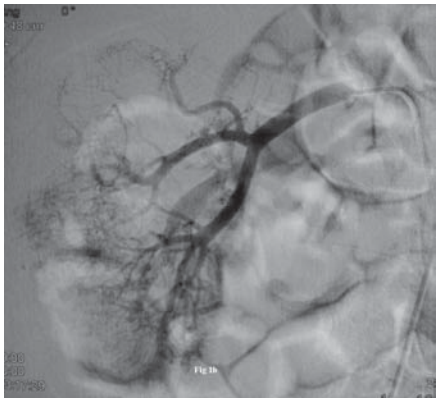
Transarterial Embolization (TAE) of renal tumors was first described in 1973 by Almgard and associates as a preoperative aid to resecting localized RCC and to palliate symptoms in metastatic disease[6]. Presently, TAE in renal tumors is mainly performed for palliation to control hematuria, relieve pain (including that arising from bony metastasis), relieve symptoms of congestive heart failure, control spontaneous perinephric and subcapsular renal hemorrhage and as a preoperative measure[7]. TAE is very useful for controlling hematuria, particularly in inoperable cases, with minimum morbidity and mortality (Fig 1). The most popular embolic agent is ethanol, although PVA particles are also used. While using ethanol, one should place an occlusion balloon in the distal renal artery beyond the adrenal and ureteral branches to avoid reflux of alcohol into the aorta[5]. Success of treatment depends on how completely the tumor and kidney are embolized. It is important that the central and more peripheral branches of the artery are occluded to achieve complete embolization. Several clinical studies have shown beneficial effects, especially in large hypervascular tumors[8], while other investigators have found no benefit[9]. A significant role of TAE in improving patient survival was also found in a large series of 474 patients comparing preoperative embolization followed by radical

nephrectomy with radical nephrectomy alone for RCC[10]. TAE for renal tumors can be associated with many complications. A post-embolization syndrome of fever, pain, nausea, ileus and leucocytosis associated with negative urine and blood cultures is well described and can be considered as part of the process of embolization. Renal failure and unintentional embolization of contralateral kidney, bowel and spine are the other common complications after TAE. Renal abscess has also been reported[11]. It is important that there be no active urinary tract infection at the time of embolization that may predispose to abscess formation or sepsis. The target kidney should also be stone-free, since stones are a nidus of infection. After embolization, intrarenal gas may be seen and may be mistaken for abscess or emphysematous pyelonephritis, especially in association with the fever, pain and leukocytosis of the post-embolization syndrome.

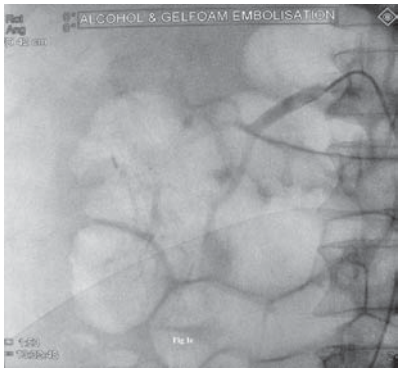
Other complications can be uremia, hyperpyrexia, right heart failure, pleural effusion, skin necrosis, coil dislocation and iliac artery thrombosis. There have been reports of aneurysmal ruptures during embolization with an occlusive balloon[12]. This was attributable to increased intravascular pressure generated by the forced injection of alcohol into a closed system or to erosion of the thin aneurysm wall by the caustic alcohol. In patients with aneurysms in their tumors, embolization should be performed cautiously, and use of fine particles, ethiodized oil, or both without a balloon catheter should be considered.

Figure 1. *59-year-old man with persistent hematuria due to an inoperable Renal Cell Carcinoma.*

A.*T2 weighted MRI image shows the heterogeneous mass in the lower pole of the right kidney. Arrow points to a signal void indicating increased tumor vascularity.*



B. *DSA of the right renal artery shows the tumor neovascularity with arteriovenous shunting indicated by early filling of right renal vein (arrow)*



C.*Palliative embolization was performed using alcohol and gelfoam particles. Post-embolization angiogram image shows complete obliteration of abnormal vascularity. There was significant reduction in hematuria for a period of 4 months following the procedure.*

ANGIOMYOLIPOMA

Renal angiomyolipoma (AML) is a benign tumour (hamartoma) of the kidney composed of mature or immature fat, thick-walled abnormal blood vessels and smooth muscle components in varying proportions. After RCC, AML is the second most common renal cause of retroperitoneal hemorrhage. Incidence of hematuria in AML has been reported to be 40%[13]. Hemorrhagic risk factors of AML are size, multifocality and vascular abnormality.

Most AML can be managed by nephron conserving approaches, including observation, angiographic embolization or partial nephrectomy [14]. For embolization, ethanol, PVA particles and gelfoam particles, with or without coils in combination have all been used. Selective TAE has been used with increasing frequency to manage symptomatic AMLs. The reasons are: tumors are benign, symptoms are usually the result of hemorrhage (including hematuria) and bleeding vessels can be selectively visualized and embolized. Post-embolization, the decrease in tumor size and volume is variable and sometimes very slow in AML. The muscular and vascular components of the tumor are the ones most significantly affected by the procedure[15]. Tumor bleeding most commonly occurs from the microaneurysms involving the tumor vessels, and embolization helps to control this bleeding. The adipose tissue is resistant to embolization because of its hypovsacularity, so the volume of adipose tissue is not highly affected after embolization[15]. On follow-up studies, enhancement or vascularity must be considered an important finding of the possibility of tumor bleeding[15]. Cystic change and liquefactive necrosis are also seen on CT. Complications after TAE for AML are similar to those seen for RCC. However, potential ischemic damage to the limbs or spinal cord due to non-target embolization is not seen in series of embolization of AML[14].

In a recent study to evaluate the long term results of TAE for AML, Kothary et al[16] found that this procedure is highly effective for sporadic AML and none of these patients had recurrence. However, as many as 42.9% (9 out of 21) patients who had AML associated with Tuberous Sclerosis (TS) had recurrence of symptoms. Hence, the authors recommended lifelong surveillance for recurrence after embolization of lesions in patients with TS [16].

RENAL VASCULAR LESIONS

While vascular lesions such as pseudoaneurysm and AVF most commonly arise due to trauma (which may be iatrogenic or inflicted), AVMs are congenital in origin. Ultrasound-guided biopsy is the most common iatrogenic cause of hematuria. Other less frequent traumatic causes of hematuria include procedures like PCNL and PCN and renal trauma. The incidence of significant post-biopsy hematuria (requiring transfusion or intervention) has reduced from 7.7% to 0.36%. Major reason for this is the reduction in biopsy needle size from 14 G to 18 G. Embolization is used to manage the infrequent cases of uncontrolled hematuria following these interventional procedures (Fig 2).

Many case series and studies have been published which document the role of embolization in uncontrolled hematuria resulting from vascular complications of renal trauma, iatrogenic or otherwise[17]. Embolization is also useful for hematuria resulting from biopsy procedures on transplanted kidneys[18].

Various embolization agents have been used alone or in combination (Fig 3). In cases of AVF, coils are preferred as there is a concern that particles and alcohol may pass into the systemic circulation. In AVMs, the nidus should be obliterated using a liquid agent such as cyanoacrylate (glue) or absolute alcohol. One approach described to prevent inadvertent passage of embolizing agent into the systemic circulation is to block the draining vein while injecting the material[4]. The long term results are excellent in all the series [17, 18]. Although non-target embolization may lead to infarction of greater parts of renal parenchyma than desired[17], it is generally not serious enough to cause a significant derangement of renal function tests[18].

RENAL TRAUMA

Blunt renal trauma may result in simple contusion or renal hematoma (Grade I injury), to complete shattering of the organ or avulsion of the vascular pedicle (Grade V injury). They can be well evaluated with a contrast-enhanced CT of the abdomen, as described earlier. In the vast majority of cases, renal injuries are minor and self-limiting. Conservative management is being increasingly preferred for most renal injuries[19]. Aggressive therapy may become necessary in the presence of massive hemorrhage or continuous hematuria in patients with trauma-induced pseudoaneurysm or fistula. Avulsion of the renal pelvis, vascular pedicle injury and life-threatening hemodynamic instability form the indications for surgery[19].

Embolization techniques are useful in hemodynamically unstable patients with the most severe forms of injury (grade IV and V). Surgery can be avoided with this technique.

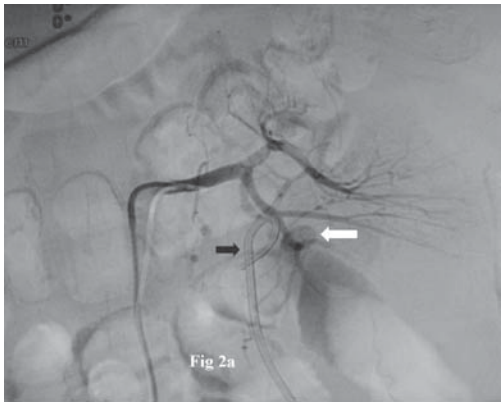
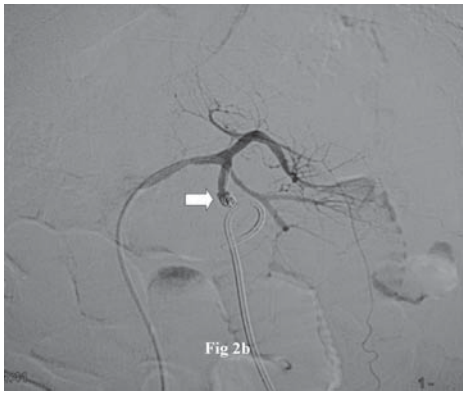


Figure 2. *35-year-old man who developed hematuria following Percutaneous Nephrostomy (PCN) of left kidney.*
A. *DSA of the left renal artery shows a pseudoaneurysm (white arrow) in the lower pole responsible for hematuria. PCN tube is seen in situ (black arrow).*



B. *The artery giving rise to the pseudoaneurysm was embolized with a steel coil. Post-embolization angiogram does not show any pseudoaneurysm. The patient recovered after the procedure and hematuria stopped.*

Injuries like complete vascular pedicle avulsion or blunt renal artery occlusion confer a poor prognosis, even if they are technically amenable to surgery. It is not feasible to perform complete vascular reconstruction within one hour of injury, the critical warm ischemia time for the kidney. With embolization, viable renal tissue can be salvaged even in cases where open revision would often result in total nephrectomy[3]. TAE is the preferred method in the treatment of vascular complications of renal injury with pseudoaneurysm or active bleeding with excellent tissue preservation [3] (Fig 4). Injury to renal allograft has also been tackled with embolization. Other lesions such as uncontained renal ruptures, shattered kidneys, and pedicle avulsions can also be treated with TAE[3]. For embolization of larger arterial branches, gelfoam pledgets and coils are favored, while for smaller vessels, microcoils are ideally suited.

Some of the patients, who remain stable initially after flank trauma, will develop delayed bleeding due to traumatic arterial pseudoaneurysm or AVF and will present late. These patients constitute another group of patients with renal trauma that is well suited for TAE[3].

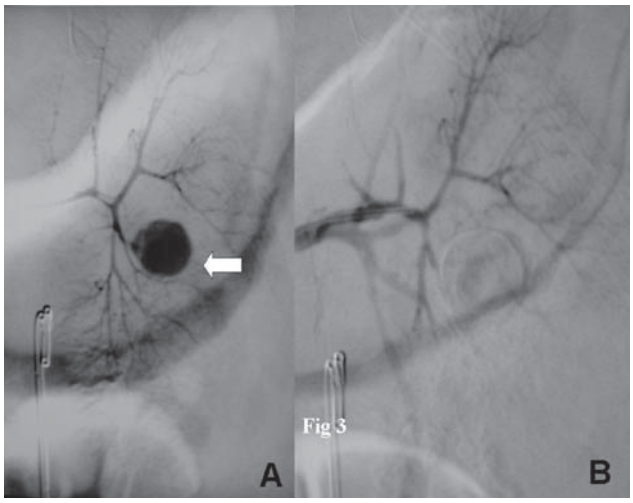


Figure 3. *40 year old man who developed hematuria following Percutaneous Nephrolithotomy (PCNL) in left kidney.*
A.*DSA of the left renal artery shows a pseudoaneurysm (white arrow) from an interpolar artery*
B.*The artery supplying the lesion was selectively cannulated and the lesion was embolized with a silk thread. Post-embolization angiogram shows absence of filling of the pseudoaneurysm.*
The patient recovered after the procedure and hematuria stopped. This case also illustrates the variety of embolizing materials that can be used.

AUTOSOMAL DOMINANT POLYCYSTIC KIDNEY DISEASE (ADPKD)

Patients with ADPKD eventually develop renal failure and require dialysis. Even on dialysis, the renal cysts may keep on enlarging in size and cause gastrointestinal complications. Surgical procedures such as nephrectomy and laproscopic procedures are not satisfactory. TAE has been described in this condition to control macroscopic hematuria and markedly distended abdomen safely and effectively. Kidney size is reduced and hematocrit and levels of insulin-like growth factor-I (an index of nutritional status) significantly increase[20]. Thus, TAE improves the quality of life and nutritional status of patients with ADPKD.

PELVIC TRAUMA

Pelvic fractures may lead to severe hemorrhage and injury to bladder or urethra may lead to hematuria. Pelvic fractures resulting in life threatening hematuria and hemorrhage require embolization if resuscitation measures and external fixation are ineffective. A patient with pelvic fracture should be evaluated with contrast enhanced helical CT. Active contrast extravasation indicating ongoing active hemorrhage and site of bleeding may help the angiographer to target the culprit vessels.

It has been suggested that for patients in shock with pelvic fractures, laprotomy should be preferred over angiography if the fractures are stable, as the bleeding focus is more likely to be intraperitoneal. Angiography and embolization should be offered first to patients with unstable fractures[21]. However, pattern of pelvic fractures may not always correlate with the need for embolization and cannot be used to decide the

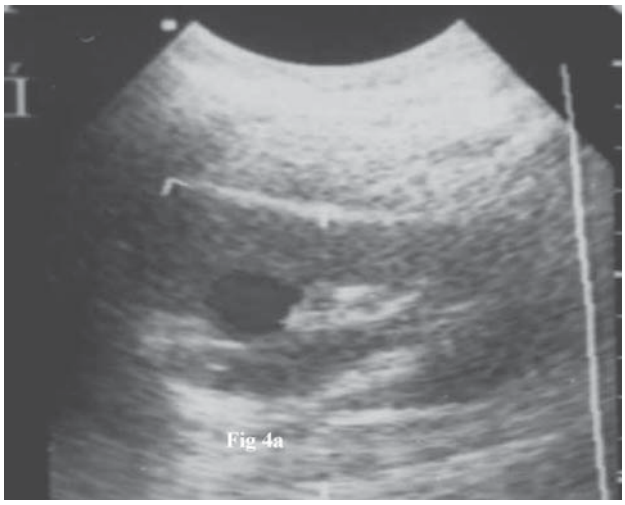
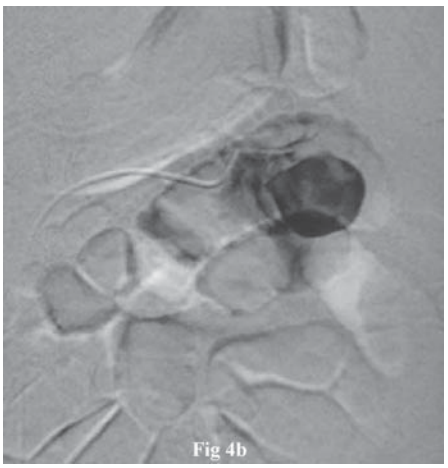
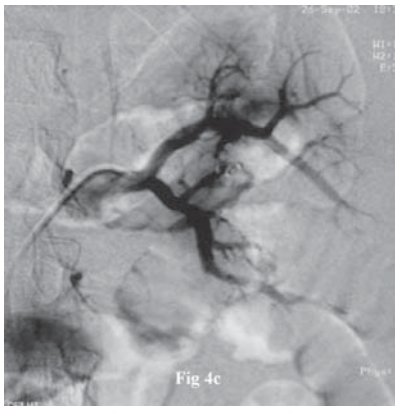


Figure 4. *28-year-old man with hematuria following blunt abdominal trauma in a road accident.*
A. *Color Doppler ultrasound shows a pseudoaneurysm (color fill-in indicated by white arrow) in the mid pole of left kidney.*



B. *Selective injecton of a segmental artery shows the pseudoaneurysm arising from a branch.*



C. *Complete obliteration of the lesion achieved following coil embolization of the branch.*

course of management.
Selective cannulation of bilateral hypogastric arteries should be performed. As there is extensive cross-anastomosis in pelvic vessels, bilateral embolization is performed. If hypogastric arteries are not cannulated, then anterior division of internal iliac arteries can be blocked. Gelfoam pledgets are used as they are effective and also allow for future recanalization. Coils are not preferred as they would block future access in the event of repeat bleeding. Particles of PVA or Gelfoam are not used as they result in distal embolization of small vessels and increase the risk of ischemia of nontarget organs. In patients who have ongoing features of hemorrhage, despite initial embolization or negative angiography, repeat angiography with embolization has been found to be effective[22].
Complications specific to embolization in the setting of pelvic trauma are uncommon, as is non-target embolization. However, gluteal skin necrosis may occur. Embolization does not produce lasting adverse effects on urogenital function. Sexual dysfunction frequently occurs after traumatic pelvic fracture. However it is produced by the injury itself and is not due to embolization procedure per se.

PELVIC MALIGNANCY

Besides bladder and prostate carcinoma, widespread gynecological malignancy can give rise to intractable hematuria. Surgical ligation of both internal iliac arteries for the control of pelvic hemorrhage has a 10% recurrence rate[23]. Internal iliac artery has rich collateral blood supply from several arteries-including gonadal, superior hemorrhoidal, circumflex, and perforating branches of the deep femoral artery, which explains the safety of extensive embolization and the failure of the proximal ligation or embolization (with coils) of this vessel to control bleeding. Hence, particulate matter should be used to achieve distal blockage[24]. Bilateral embolization needs to be performed even if the blood supply is only from one side or bleeding is localized to one part[24].
Efficacy of embolization has been demonstrated in many studies and case series[25]. Relief from hematuria is not only immediate, but also long lasting and may even be life long. Complications are post-embolization syndrome due to tumor necrosis like nausea, vomiting and fever[24]. It can be managed by conservative therapy. Gluteal claudication may also be seen[25].

CONCLUSION

Embolization therapy can play a useful role in the treatment of massive hematuria in various conditions as outlined above. It can be performed under local anesthesia and hence patients who are unfit for surgery can undergo this safely. It can provide permanent relief in conditions like vascular abnormalities, trauma and benign tumors like AML. In cases of wide spread malignancy when curative treatments are not applicable due to the general status of the patient, life expectancy, or advanced tumor stage, it can provide long term palliation and reduces morbidity. It is important to be able to perform the procedure as selectively as possible, to minimize damage to normal structures and avoid complications. Advances in catheter and embolic material design are of advantage in this regard. Helical dynamic contrast enhanced CT of abdomen before the procedure, especially when performed with a multidetector scanner, helps to locate the source of bleeding and also to stage a malignancy.

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