The Role of Renal Artery Embolisation in the Management of Blunt Renal Injuries: A Review

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Abstract

Renal injuries are the most common urinary tract injury secondary to external abdominal trauma. They are caused by blunt, penetrating and iatrogenic mechanisms. Despite the high number of blunt renal injuries, little evidence is available to guide management, especially with the evolution of embolisation as a minimally invasive treatment. Consequently, clinical practice is driven by results of observational studies and anecdote. We have reviewed the current trends in practice when using renal artery embolisation in the management of blunt renal injuries. Three key principles are highlighted. First, high-grade blunt renal injuries can be successfully managed with embolisation. Second, embolisation should be considered when there is radiological evidence of active contrast extravasation, pseudoaneurysm or arteriovenous fistula. Third, embolisation can be used to manage blunt renal injuries in haemodynamically unstable patients. Beyond this, evidence regarding optimal technique, CT indications, clinical status, comorbidities and complications are inconclusive. We discuss the implications for clinical practice and how these findings should define the agenda for future clinical research.

Keywords

Interventional radiology, embolisation, renal, trauma

Renal injuries occur in approximately 1–5% of all patients with trauma and are the most common urinary tract injury secondary to external abdominal trauma.[1] Renal trauma mainly arises from blunt, penetrating and iatrogenic mechanisms.[2,3] Despite how common blunt renal injuries (BRIs) are, little evidence is available to guide management. Patients can undergo operative management or non-operative management and the use of expectant management, embolisation and surgery vary from institution to institution.

We aim to review the current trends concerning renal artery embolisation in the management of BRIs. We examine the evidence for indications for embolisation, outcomes of embolisation and its comparison to surgical and other non-operative adjunctive management, technical considerations, injury characteristics warranting embolisation and complications. Based on the evidence, we propose a treatment algorithm for the management of patients with BRI.

The Evidence
American Association for the Surgery of Trauma Grade

BRIs are usually identified using helical CT.[4] Injuries are graded according to the American Association for the Surgery of Trauma (AAST) grading system. The AAST grading system was first described in 1989 and proposed to classify injury severity and guide management for a particular organ and was revised in 2018.[5] The revised AAST grading for kidney injuries is shown in *Table 1*. Severity is classified according to the depth of parenchymal injury and involvement of ureteric or renal vasculature.

Most BRIs are low-grade (AAST <2) and non-life threatening.[2,3] Renal artery embolisation (RAE) has been used to manage lower-grade BRIs (AAST ≤2), but since most of these injuries are minor and self-limiting, they can be managed conservatively as per the European Association of Urology (EAU) guidelines.[6,7]

For high-grade renal injuries (AAST ≥3), surgery has been traditionally preferred. There are no validated criteria to identify patients with BRIs requiring RAE by AAST grade. One study found that increasing AAST grade was an independent predictor for clinicians performing RAE in patients with BRIs (Grade 1: OR 0.4; Grade 2: OR 1.05; Grade 3: OR 1.49; Grade 4: OR 3.52; Grade 5: not reported).[8] Other studies have grouped patients with both blunt and penetrating mechanisms of injury in their analyses, making it difficult to determine RAE success or failure as it is unclear whether blunt versus penetrating injuries could be confounders. These studies have shown that RAE is likely to be beneficial in patients with high-grade renal trauma (AAST >3).[9–12]

RAE in Grade V BRIs has been reported in the literature.[6,9,13–23] However, the optimal strategy for Grade V kidney trauma remains uncertain as success rates have been variable and repeat embolisation may be necessary.[6,9,15,17,22,24] More promising results show that when used in the

Table 1: American Association for the Surgery of Trauma Renal Injury Scale.

Grade*	CT Findings	Operative Criteria	Pathologic Criteria
I	Subcapsular haematoma and/or parenchymal contusion without laceration	Non-expanding subcapsular haematoma	Subcapsular haematoma or parenchymal contusion without laceration
		Parenchymal contusion without laceration	
II	Peri-renal haematoma confined to Gerota's fascia	Non-expanding peri-renal haematoma confined to Gerota's fascia	Peri-renal haematoma confined to Gerota's fascia
	Renal parenchymal laceration ≤1 cm depth without urinary extravasation	Renal parenchymal laceration ≤1 cm depth without urinary extravasation	Renal parenchymal laceration ≤1 cm depth without urinary extravasation
III	Renal parenchymal laceration >1 cm depth without collecting system rupture or urinary extravasation	Renal parenchymal laceration >1 cm depth without collecting system rupture or urinary extravasation	Renal parenchymal laceration >1 cm depth without collecting system rupture or urinary extravasation
	Any injury in the presence of a vascular kidney injury or active bleeding contained within Gerota's fascia		
IV	Parenchymal laceration extending into urinary collecting system with urinary extravasation	Parenchymal laceration extending into urinary collecting system with urinary extravasation	Parenchymal laceration extending into urinary collecting system with urinary extravasation
	Renal pelvis laceration and/or complete ureteropelvic disruption	Renal pelvis laceration and/or complete ureteropelvic disruption	Renal pelvis laceration and/or complete ureteropelvic disruption
	Segmental renal vein or artery injury	Segmental renal vein or artery injury	Segmental renal vein or artery injury
	Active bleeding beyond Gerota's fascia into retroperitoneum or peritoneum	Segmental or complete kidney infarction(s) due to vessel thrombosis without active bleeding	Segmental or complete kidney infarction(s) due to vessel thrombosis without active bleeding
	Segmental or complete kidney infarction(s) due to vessel thrombosis without active bleeding		
V	Main renal artery or vein laceration or avulsion of hilum	Main renal artery/vein laceration or avulsion of hilum	Main renal artery/vein laceration or avulsion of hilum
	Devascularised kidney with active bleeding Shattered kidney with loss of identifiable parenchymal renal anatomy	Devascularised kidney with active bleeding Shattered kidney with loss of identifiable parenchymal renal anatomy	Devascularised kidney Shattered kidney with loss of identifiable parenchymal renal anatomy

*Advance one grade for bilateral injuries up to Grade III. Source: Kozar et al. 2018.[5] Reproduced with permission from Wolters Kluwer Health Inc.

management of Grade V parenchymal and renovascular lesions, RAE can result in minimal complications and retains an excellent likelihood of preserving the maximal amount of functional renal parenchyma without the need for further intervention, even despite haemodynamic instability.[16–18,22] Vascular injury with shattered kidneys in the presence of no suspicions of a pedicle injury using CT could be an indication for RAE.[17,25]

Grade V renal pedicle avulsion is usually managed with surgery as it is technically demanding, but advances in angioembolisation have likely shifted practice patterns.[26] Renal pedicle avulsions may now be possible with RAE due to vasospasm and the use of various sizes of coils to scaffold and anchor the bleeding vessel.[14] This discrepancy in findings for the use of RAE in Grade V injury could pertain to differences in injury mechanisms, techniques used by interventional radiologists or the lack of uniformity of Grade V renal injuries. Differences in the sample sizes of studies may also account for the variable success rates. Increasing the sample size in future studies will help combat this uncertainty.

CT Criteria

Retrospective studies have identified other findings from CTs in patients sustaining BRIs who were treated with RAE (*Table 2*). Active contrast extravasation, pseudoaneurysm and arteriovenous fistulae were the most reported indications. Of interest is a single-centre American study (n=84) showing that the presence of at least two high-risk criteria on CT (intravascular contrast extravasation, presence of medial laceration, peri-renal haematoma rim distance >3.5 cm) predicted the need for intervention, including angioembolisation, in the management of Grade IV BRIs with haemodynamic instability.[27] The findings from this and other studies have been corroborated by a survey of clinicians regarding the management of BRI, which concluded that CT evidence of active arterial bleeding, pseudoaneurysm and/or arteriovenous fistula (AVF) and discontinuity of Gerota's fascia may be associated with the need for RAE.[28]

Outcomes from Renal Artery Embolisation

Complete control of bleeding using embolisation for BRI was specified in eight studies after the first attempt, and in three studies after multiple attempts.[11,16–19,21,29–32,33] Repeat embolisation was associated with inadequate haemostasis leading to persistent bleeding and higher renal injury grade.[23–25]

In some cases, there was an occasional need for nephrectomy and even exploratory laparotomy following failed embolisation, although these were in older studies.[6,14,22,24,25,34–37] The most common indication for post-embolisation surgery was a failure to control bleeding, regardless of whether embolisation was repeated or not.[22,35,38] Other indications reported include pain, acute coronary syndrome and increased free fluid on CT.[6,38] RAE during a hospital stay may also be more frequent in patients later requiring nephrectomy due to more severe renal injuries.[9] Still, timely nephrectomy remains an important last resort despite advancements in RAE.

Adjunctive endoscopic procedures such as retrograde ureteric stent placement were used in patients with urosepsis, symptomatic ureteral clot obstruction or significant urine extravasation on subsequent CT (3–5 days post-procedure) in patients with high-grade blunt renal trauma.[9,12,22,23,38] The effectiveness of adjunctive stenting is currently

Table 2: Studies with Other CT Evidence For Renal Artery Embolisation In Patients With Blunt Renal Injuries.

	Number of BRI Patients Undergoing RAE	Other CT Characteristics Indicating Need for RAE			
		Pseudoaneurysm	Arteriovenous Fistula	Active Extravasation	Other
Hagiwara et al. 2001[33]	8			Yes	
Dinkel et al. 2002[18]	9	Yes	Yes	Yes	
Hagiwara et al. 2004[54]	6			Yes	
Breyer et al. 2008[15]	10	Yes	Yes	Yes	
Menaker et al. 2010[6]	22			Yes	
Lopera et al. 2011[58]	2			Yes	
McGuire et al. 2011[13]	10	Yes	Yes		
Figler et al. 2013[27]	84			Yes	Presence of medial laceration Peri-renal rim distance >3.5 cm
Lin et al. 2013[34]	22			Yes	
Long et al. 2013[38]	25			Yes	
Burns et al. 2017[21]	6	Yes		Yes	Transected renal artery
Xu et al. 2020[23]	28				Central or expanding haematoma
Baboudjian et al. 2022[22]	170	Yes	Yes	Yes	

BRI = blunt renal injury; RAE = renal artery embolisation.

unknown, but this subgroup of patients may represent those who have more severe injuries and are therefore at higher risk of poor long-term functional renal outcomes. With the current evidence available, patients with radiological markers of urinomas or urinary extravasation, lower urinary tract symptoms or uroseptic features may therefore require more consistent or extended follow-up to rationalise the need for ureteric stenting.

Technical Considerations
Level of Embolisation
Embolisation of renal arteries leads to infarction downstream and eventual parenchymal death. Older direct catheterisation techniques often made sub-selecting smaller segmental branches impossible, leading to proximal embolisation and greater tissue loss.[39,40] Therefore, as much renal parenchyma should be conserved by 'selecting' only the affected arteries at the most distal level to minimise loss of uninjured parenchyma. The preservation of renal parenchyma is an advantage of minimally invasive therapy compared to surgical intervention. Complete RAE of renal arteries was specified in only two studies, but the choice of renal artery total occlusion is usually reserved to achieve haemodynamic stability in polytrauma patients who are not fit for surgery due to associated injury or as an alternative to nephrectomy in cases not requiring surgical exploration.[16,17]

Newer selective and superselective methods allow for more directed localisation and catheterisation, as embolic material is deployed immediately proximal to the bleeding site using coaxial embolisation to preserve a greater proportion of nephrons, although most studies successfully controlled bleeding in a single session without further complications regardless of the level of embolisation (*Table 3*).[29] Most tissue loss is therefore due to the original trauma itself.[18] Neither superselective nor subselective embolisation are usually associated with a significant clinical reduction in renal function, but this depends on pre-procedural renal function, comorbidities and volume of contrast media used for embolisation.[29,31,39–42] Superselective techniques may also limit delayed procedure-related complications, such as infection and post-traumatic hypertension.[33]

For main renal artery injuries, endovascular stenting may present a feasible alternative to embolisation to achieve renal revascularisation.[43–47] Main renal artery dissections and/or luminal stenosis may benefit from endovascular stenting and covered stenting may be considered for proximal arterial rupture.[48–50] Clinical factors to consider would include the presence of concurrent injuries as patients with stents would need to be anticoagulated and the presence of bleeding at other sites may limit stenting as an alternative.[43,44]

Embolic Agent
Multiple embolic agents are available for transcatheter RAE including particulates, sclerosants, glue and coils.

Metallic Coils
Metallic coils are desirable because of their accuracy and radiopacity.[15] They are made of steel, titanium or platinum. The size of the coil must be adjusted to carefully match the vessel diameter to avoid poor placement, which was reported in one older study where there were two cases of extensive parenchymal loss due to incorrectly measured coil size.[35,39]

Metallic coils can be used to treat renal haemorrhage, AVF, pseudoaneurysms and arterio-calyceal fistulas, and multiple coils can be used in the same procedure.[10,17,18] Selective embolisation of subsegmental branches with microcoils has also been used to limit the amount of embolised parenchyma.[18]

There are three main concerns with metallic coils. First, usually more than one coil is needed for adequate occlusion, increasing the time and cost of the procedure.[46–50] Second, coils may be unstable and dislodged.[35] There are two methods reported to ensure stability of the coils. The first and more commonly used method is to release the proximal aspect of the coil outside of the leaking vessel or into a nearby side branch with the remainder of the coil deployed in the vessel. The second method is to slightly oversize the coil to the vessel, relying on the outward radial force of the coil to secure it to the vessel wall so that the larger outer coil or coils act as a scaffolding onto which smaller coils can be deployed to

Table 3: Level of Embolisation Used to Manage Patients with Blunt Renal Injuries and Need for Repeat Embolisation, Surgery or Complications

	Number of Patients with BRI Who Received RAE	Level of Embolisation	Outcomes
Stewart et al. 2010[16]	10	Total embolisation of the main renal artery (n=7) Superselective embolisation (n=3)	One patient receiving complete embolisation of the main renal artery developed hypertension. No other intermediate adverse effects were reported in all patients.
Uflacker et al. 1984[35]	7	Superselective embolisation (n=7)	Bleeding was successfully terminated and no post-procedural complications in all patients
Dinkel et al. 2002[18]	9	Superselective embolisation (n=9)	In all patients bleeding was successfully controlled in a single session
Brewer et al. 2009[17]	9	Total embolisation of the main renal artery (n=7) Selective embolisation (n=2)	All patients showed complete resolution of bleeding on follow-up imaging and all patients did not require further intervention
Burns et al. 2017[21]	6	Selective embolisation (n=6)	All patients did not require repeat embolisation or delayed nephrectomy, no treatment complications were reported
Lin et al. 2013[34]	22	Superselective embolisation (n=22)	5 patients required a repeat embolisation due to re-bleeding. Of these, 1 had subsequent nephrectomy

BRI = blunt renal injury; RAE = renal artery embolisation.

produce the occluding effect.[17] Newer detachable coils provide precision and control leading to accurate embolisation.

Particulate Embolic Agents
Absorbable Gelatine Sponges
Absorbable gelatine sponge embolisation may be useful to occlude small arterial aneurysms but may be related to aneurysm wall rupture owing to increased intra-aneurysmal pressure during embolus injection and passage through the arteriovenous fistula.[35] One case report has illustrated success when using Gelfoam for unselective renal artery embolisation in a haemodynamically unstable patient with delayed partial renal artery canalisation.[51] The authors of this case report attribute this success partially to the rapid haemostasis resulting from the mechanics of Gelfoam and partially due to the patient having small vessel collateralisation to the inferior pole of the kidney. Absorbable gelatine sponge particles may be easily fragmented and inadvertently ablate normal renal parenchyma. The effectiveness of the embolisation is also limited by distal movement of the absorbable gelatine sponge pledgets.[52]

Polyvinyl Alcohol
Polyvinyl alcohol (PVA) is similar to absorbable gelatine sponges in its manipulation, indications and delivery.[35] However, PVA is more difficult to pass through the catheter in large particles and is not reabsorbable. PVA should be avoided in AVF as they can pass into venous circulation, potentially resulting in unintentional pulmonary embolism.[35]

Vascular Plugs
Vascular plugs are versatile and are ideal for embolising high-flow medium-to-large-sized vessels. They are self-expanding and exert adequate radial force to prevent migration even in a high-flow vessel. Vascular plugs can therefore be considered for main renal artery occlusion.[53]

Liquid Embolic Agents
Cyanoacrylates, such as N-butyl cyanoacrylate (NBCA) glue or Onyx® have a low viscosity and can be easily injected through small or tortuous catheters.[46,48–50] NBCA glue may also be used in patients with haemodynamic instability or in patients with underlying coagulopathies as they achieve haemostasis faster than other embolic agents, but this was not specified in any studies using RAE to manage BRI. [40–50]

Injury Characteristics
Mechanism of Injury
The most reported causes of injury were road traffic accidents involving cars, motorcycles or pedestrians.[15–18,22] This was followed by falls and direct trauma.[15–18]

Presence of Concurrent Injuries
Blunt renal trauma can occur as an isolated injury or in a poly-trauma setting with injury to other non-urological organs. The most commonly reported concomitant injuries were to the abdominal viscera and thoracic structures, including the lungs, pleura or ribs, followed by pelvic fracture.[17,18,22,54] Current European Association of Urology guidelines recommend renal exploration for high-grade renal trauma (AAST ≥3) and presence of concomitant intra-abdominal injuries as they can be managed in the same procedure. One study concluded that concomitant liver injury in combination with raised heart rate predicted the need for immediate intraoperative management in patients with high-grade BRI.[7,55]

Haemodynamic Status
RAE has a central role in the non-operative management of haemodynamically stable patients with blunt renal trauma.[9–11,14] Persistent or delayed bleeding in a stable patient can be successfully managed with embolisation in most cases.[2,15,54,56] Yet in patients with haemodynamic instability, defined as a systolic blood pressure of 90 mmHg or less, the role of embolisation is conflicting.[15–17,22] Emergency laparotomy is traditionally favoured as these injuries are usually high grade and accompanied by other severe organ injuries which can also be managed during exploratory laparotomy.[31,32,36]

However, recent experience in Europe suggests that immediate angioembolisation by trained radiologists can be feasible regardless of patients' haemodynamic status.[9,38] Cases of isolated renal injury and haemodynamic instability can be safely managed with embolisation and in one study haemodynamic instability was not found to be a predictor of embolisation failure.[9,10] In other studies, patients with haemodynamic instability were successfully controlled through embolisation and without the need for further surgical or radiological intervention.[6,17,18,33]

An exception may be during a peri-arrest situation, which is the period before or after a cardiac arrest. Clinically, the priority would be on

immediate management of airway, breathing and circulation before proceeding to intervention. Surgical versus minimally invasive management of patients with BRIs would depend on local factors such as logistics and in-house availability of services. We have created a treatment algorithm for the management of BRIs that covers this period *(Figure 1)*.

Anatomic Level of Injury

Knowledge of renal artery anatomy is important to accurately select the injured renal artery and preserve renal function. The renal arteries arise from the abdominal artery at L1–L2. Most patients have one renal artery feeding into each kidney, with the left renal artery being shorter than the right. A minority of patients have variant renal artery anatomy, which is usually an accessory renal artery that usually arise from the aorta but can also arise from any artery between the diaphragm and pelvis.[57] Knowledge of variant anatomy is important as the actual site of contrast extravasation may be missed if arteriography is conducted on the main renal artery alone.

BRI can occur at any level of the renal vasculature. RAE was also used in patients with lesions at the level of the polar arteries, interlobar arteries, lobar branches, segmental branches and at the level of the main renal artery.[15,17-18,21,27, 29-31,38,58]

Complications
Post-embolisation Syndrome

Post-embolisation syndrome (PES) is the most common complication following RAE.[42] Patients usually present with nausea, vomiting, fever and abdominal pain 1–3 days after embolisation.[42] PES is usually self-limiting but prophylactic anti-inflammatories and anti-emetics may be given for symptomatic treatment.[48] PES is more common when using liquid or particulate agents compared to coils, as they are more difficult to control under fluoroscopy.[15] Only one study examined PES as a complication following embolisation for BRI and found that none of the patients experienced PES.[18]

Pain

Post-procedural pain usually lasts between 1–5 days.[47] Patients may report post-procedural pain in the back or flank. The severity depends on the volume of parenchyma involved and is usually self-limiting.[59] Patients should receive appropriate pre-, intra- and post-procedure analgesia.[60]

Arterial Hypertension

Transient increases in arterial blood pressure are a common post-procedural finding and can last for up to 24 hours, after which it resolves spontaneously and should not be a concern if complete occlusion is achieved.[20,61] However, permanent hypertension may result from remnants of ischaemic (but not infarcted) tissue.[47] One possible explanation could involve activation of the renin-angiotensin-aldosterone system secondary to either occlusion of the main renal artery, a branch from the main renal artery or AVF, or external compression of parenchyma by urine or blood.[62]

Renal Function

The risk factors for trauma-related renal impairment include pre-existing renal disease, age, having a single kidney and associated multi-organ failure.[13] Blood clots may also lead to obstructive uropathy and after the resulting haematuria has resolved, renal function may return.[42]

Embolisation, particularly the less selective types, may also infarct healthy renal parenchyma and result in a decrease in renal function.[56] One Chinese study found that RAE for Grade IV and V injuries led to worsened

Figure 1: Proposed Treatment Algorithm for Blunt Renal Injuries at Hull Universities Teaching Hospitals Trust.
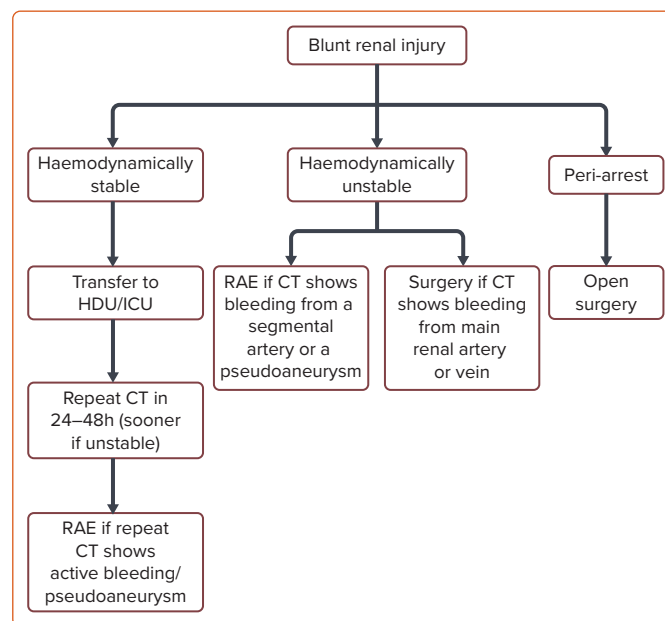
HDU = high dependency unit; ICU = intensive care unit; CT = computed tomography; RAE = renal artery embolisation.

renal function after embolisation, but RAE was significantly more successful in preserving renal function compared to surgery.[23] There was no difference in renal function at 6 months.[23] Several other studies have found that renal function is not affected by RAE when serum creatinine was used as a crude indicator of renal function.[18,23,35] In one study of 52 patients with high-grade renal trauma, RAE was not found to be a significant independent predictor of maximum serum creatinine rise compared to surgical management.[35] Most patients in the study had BRIs, but those with penetrating trauma were also included in this study, which when taken into consideration with the small sample size, it is difficult to comment on whether the conclusions of the study are representative of the true effect.

The effects of iodinated contrast media on worsening renal function, particularly in hypotensive patients sustaining severe injuries, have been a cause for concern.[38,63] The additional contrast needed does not increase the incidence of nephropathy regardless of renal injury grade, but patients should be adequately hydrated before embolisation.[36,64]

Haematuria

Haemorrhagic infarction may result in moderate haematuria following embolisation and usually resolves within 24–48 hours.[20,37,47]

Infection

Infection risk is low but there have been reported cases of post-RAE abscesses requiring percutaneous drainage.[6,19,20,21] Interventional radiologists must be familiar with the patient's past medical history, as reactivation of latent infections may also occur, evidenced by post-procedure CT scans showing air bubbles, although not all air bubbles are indicative of abscess formation.[47] Some may correspond to normal aseptic infarction.[48,49]

Non-target Embolisation

Coil migration is a rare but serious complication of RAE. One study reported a dislodged microcoil into the lumbar artery in a patient due to

catheter instability in an avulsed main renal artery, but no clinical consequences ensued.[18] Endovascular snares can be used to retrieve migrated coils if that vessel cannot be safely killed.[65] Advances in coil design, such as interlocking detachable coils and Guglielmi detachable coils allow for controlled deployment and easy retrieval if it is in an unfavourable position.[18]

Non-target embolisation of spinal arteries, lower extremity or bowel vessels can occur with particulate or liquid embolic agents. Adrenal artery non-target embolisation may lead to self-limiting transient hypertension or adrenal insufficiency and is treated conservatively.[42] Correct catheter positioning, continuous monitoring during delivery of embolic agent and using occlusion balloon catheters can reduce the risk of non-target embolisation.[60]

Other Complications

Other complications that can arise with any endovascular procedure include access site haematoma, arterial thrombosis, arterial dissection, arterial rupture, distal site embolism, anaphylaxis, shock or volume overload.[47]

Discussion

BRIs are a common injury and although the use of embolisation to manage BRIs is becoming more widespread, the evidence base is still weak.

We examined the relevance of AAST grade on the outcomes for patients receiving embolisation. There is evidence to suggest that high-grade renal trauma (AAST ≥3) can be managed with embolisation. This is reflected in the present EAU guidelines which state that when RAE is included in the non-operative management pathways for patients with high-grade renal trauma, it can be successful in managing up to 94.9% of Grade III, 89% in Grade IV and 52% of Grade V injuries.[9,10,25] Close examination of the patient's CT to identify active contrast extravasation, pseudoaneurysm and arteriovenous fistulae may provide an accurate indication for the need for RAE.[6,13,15,18,21,22,27] The patient's CT should also be examined for polytrauma as concurrent intra-abdominal injuries may be managed intraoperatively.[7] The patient's clinical picture should also be considered, particularly their haemodynamic status. EAU guidelines suggest RAE in renal trauma patients who are haemodynamically stable, but there is some evidence to suggest that RAE is successful in patients with a systolic blood pressure <90 mmHg.[7] In either case, the patient's haemodynamic status should be considered with their overall clinical picture.[6,9,10,17,18,33,38] More severe cases are usually accompanied by other severe organ injuries which may be managed concurrently during exploratory laparotomy. The risk of RAE failure should be balanced against the risk of secondary nephrectomy. The provision of 24-hour interventional radiology in major trauma centres may therefore play an integral role.

The choice of embolic agent for the management of BRI was also examined. Coils were the most commonly used embolic agent, probably because greater control can be achieved, particularly with microcoils under fluoroscopy, and the risk of post-embolisation syndrome that has been reported with particulate embolic agents due to reflux and non-target tissue ablation.[15,17,18,20-22,29,31,34,35,39,58] Absorbable gelatine sponges (Gelfoam) were the second most commonly used embolic agent followed by PVA.[17,18,21,31,34,35] These materials can be used as stand-alone agents, but combinations of microcoils with gelatine sponges or PVA have also been documented.[17,18,31,34] As a general rule, Gelfoam is preferred for smaller pseudoaneurysms as it results in peripheral occlusion with minimal

parenchymal loss, while coils in addition to Gelfoam are preferred for larger pseudoaneurysms.[39] The choice of embolisation material depends on vascular anatomy, underlying pathology, size, flow pattern, material availability, experience and preference of the interventional radiologist.[50] At our institution, microcoils are the most often used embolic agent and a combination of coils and gelatin sponges, such as coil/gel or foam/coil, are less commonly used to stop bleeding.

Finally, more common clinical complications are transient and self-limiting, such as post-embolisation syndrome, post-procedural pain, arterial hypertension, haematuria and renal impairment.[18–20,22,23,35,47,50,59] Patients' post-procedural status should be monitored appropriately so these complications can be managed. Appropriate monitoring will also alert clinicians to more serious complications such as intra-abdominal abscess formation, urosepsis, evidence suggestive of non-target embolisation or persistent bleeding which may warrant repeat embolisation or surgery.[21,22,34,35,38,42]

We have proposed a treatment algorithm in the management of patients with BRIs at a UK tertiary centre (*Figure 1*). In our unit, the management of BRIs depends on the haemodynamic stability of the patient and CT findings. Cases are discussed on a case-by-case basis with the on-call surgical team who are often on standby when RAE is performed on unstable patients. Our policy is for embolisation to be as superselective as possible. From our experience, the total procedure duration is approximately 20 minutes from common femoral needle access to successful embolisation, making RAE as quick or quicker than surgery depending on the complexity and number of vessels involved. Naturally for high-grade complex renal lesions with multiple segmental vessels involved procedure duration may increase and the benefits of RAE should be balanced against the benefits of surgical intervention. In the peri-arrest situation, the surgical teams are resident in hospital and so surgery is quicker. The interventional radiology team has a 30-minute call-out time.

This narrative review highlights institutional variation in practice and presents the available evidence surrounding the use of renal artery embolisation in the management of BRIs. While available evidence is promising for the use of RAE in the management of BRIs, this review article is limited in that only a few case series looked at renal artery embolisation in patients with BRIs.[17,18,35] A formal meta-analysis was therefore not conducted because factors such as study design, mechanism of injury, definitions of clinical or technical success, study endpoints, reporting of complications, potential bias and the extent to which investigators controlled for confounding factors were too heterogeneous across the studies to enable comparison.

Conclusion

The evidence for renal artery embolisation in the management of renal trauma is so far promising, particularly with high-grade injuries and advances in embolisation techniques allowing for superselective methods and embolic agents on the order of microns. However, when considering patients with BRIs alone, most answers to the key clinical questions, such as optimal technique, CT indications, clinical status, comorbidities and complications are unknown. Retrospective reviews and case series do not provide robust evidence and sample size in these studies has been small. The question of operative versus non-operative management (including RAE) will remain unknown until the key clinical parameters as defined above, have been addressed by large, rigorous randomised controlled trials. ❑

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