Renal artery embolisation: indications and utilisation at Tygerberg Hospital

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Background: To evaluate the indications, efficacy and outcomes of endovascular renal artery embolisation (RAE) in the management of renal haemorrhage, specifically in cases of non-iatrogenic origin.
Methods: This is a retrospective case note review of 92 patients who underwent RAE in the period from August 1999 to August 2014 at Tygerberg Hospital.
Results: Renal artery embolisation was performed in a total of 92 patients. The indication was traumatic renal injury in 60 patients (65.2%), with mean age 28.2 years. The mechanism of injury was stabbing (55.4%), blunt trauma (7.6%) and gunshot (2.2%). Digital subtraction angiography (DSA) showed pseudo-aneurysm in 32.6%, arteriovenous fistula in 19.6% and segmental artery injury in 13%. Embolisation success: 85% after one, 88.9% after a second attempt, with an overall success rate of 98.3% after two attempts. In 20 of the 92 patients (mean age 50.2 years) the indication was malignancy (21.7%). Other cases included iatrogenic haematuria (4.3%) and angiomyolipoma (3.3%). Embolisation was repeated in 16.3%, with eventual success rate of 93.8%. Post-embolisation syndrome was the most common complication, seen in 9.8% of all cases. Of the 9 patients who returned for follow-up with renogram imaging, 4 had a differential function of > 20% of the embolised kidney.
Conclusion: Renal artery embolisation remains a very successful method of managing renal haemorrhage at this hospital, whether this results from trauma, malignancy, iatrogenic or other causes.
Keywords: renal artery embolisation, pseudo-aneurysm, renal trauma, endovascular management

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Introduction

After the advent of renal artery embolisation (RAE) in the 1970s,[1,2,3] there have been numerous advances and experiences with the method. Indications have broadened from managing renal bleeds due to malignant or benign renal lesions to iatrogenic injury and traumatic renal bleeds. Other indications include pre-nephrectomy and pre-radiation infarction of renal tumours as well as for palliation of unresectable malignancies and/or vascular malformations.[4] Preoperative RAE has the potential to decrease intraoperative blood loss, operative time and transfusion requirements.[5-7]

Due to ever-smaller diameter of endourological catheters and improved imaging techniques, super selective embolisation is possible, reducing the size of the post-embolisation renal infarct, contributing to nephron sparing.[8,9] Infarction of less than 10% of nontarget renal parenchyme (not leading to significant functional reduction) has been reported.[10]

This study comprises the largest review of traumatic renal injuries managed with RAE in modern literature.

Setting

Tygerberg Hospital is a tertiary level training referral hospital in the Western Cape Province of South Africa, coupled to the University of Stellenbosch, Faculty of Medicine and Health Sciences. It also serves as a secondary level hospital to its immediate surrounding suburbs.

Patients and methods

This is a retrospective case note review of 92 patients who underwent RAE in the period from August 1999 to August 2014 at Tygerberg Hospital.

Ethical approval and waiver of informed consent was obtained from hospital management and the University of Stellenbosch. Patient information was gathered from Interventional Radiology (IR) theatre logbooks, the local electronic Enterprise Content Management (ECM) system, patient folders gathered from the hospital archives, as well as

ward summaries and discharge notes compiled by doctors.

All patients who underwent RAE in the above period were included in the study, whether they were referred to IR by urologists, trauma surgeons or oncologists.

The primary imaging modality used to detect renal injuries in stable patients was Computerised Tomography-scans (CT), displaying arterial, portovenous and delayed phases.

A variety of Urological specialists and registrars managed the patients clinically, whilst a senior Radiology registrar, always under the supervision of an IR-Specialist, performed the renal artery embolisation procedure.

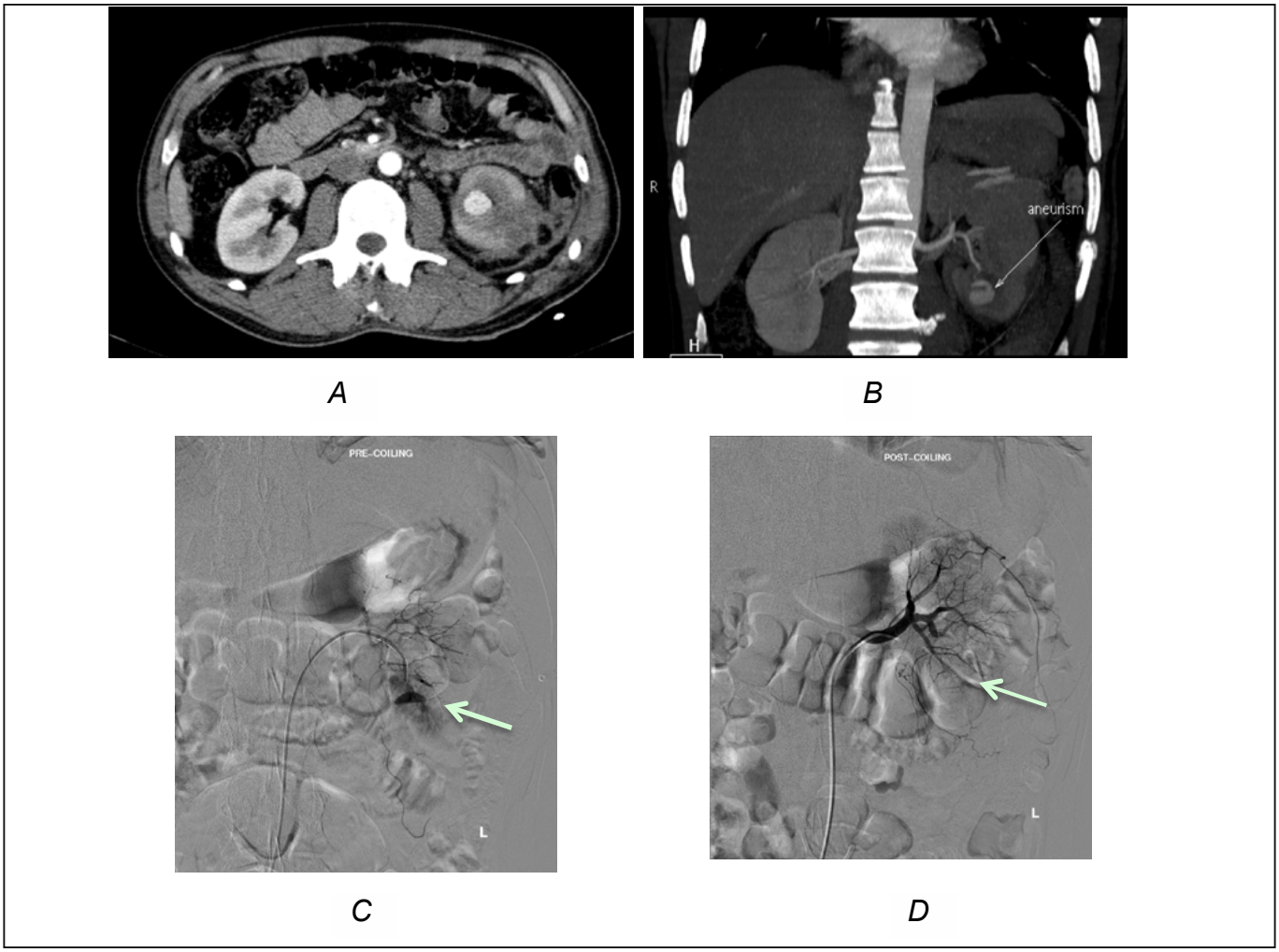

Figure 1. The lower segment of the anterior branch of the left renal artery was injured with a stab wound. A pseudo-aneurysm can be seen on the (A) axial- and (B) coronal views of the arterial phase of the CT IVP. (C-D) Sequential digital subtraction angiograms are seen. Pre-embolisation images delineate exact position. Successful employments of coils to occlude the bleeding vessel are shown, with resolution of the aneurysm and good collateral blood flow.

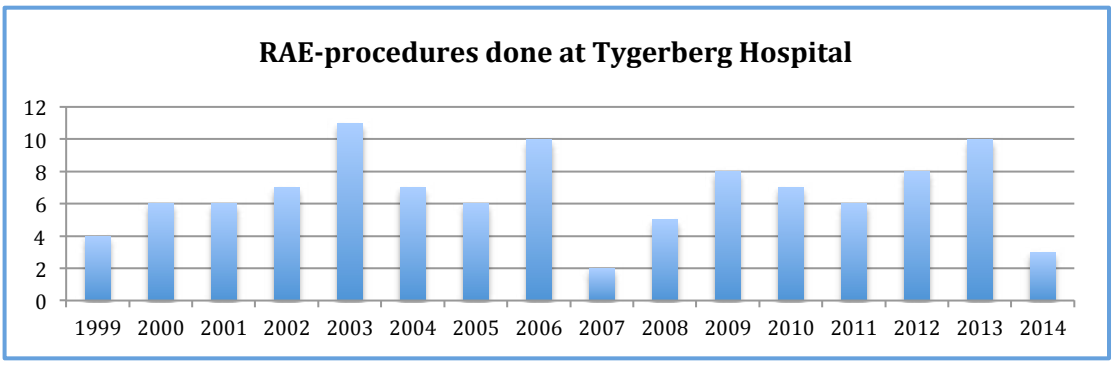

Figure 2. Number of RAE-procedures done at Tygerberg Hospital: August 1999 to August 2014.

Table 1. Results of trauma cases

Trauma cases	
Demographics	
Patient (n)	60
Age (years)	
• Mean	28.2
• Range	11-49
Sex	
• Male	51 (85%)
• Female	9 (15%)
Results	
Affected side	
• Right	31 (52%)
• Left	29 (48%)
Trauma characteristic	
• Stab	51 (85%)
• Gunshot	2 (3.3%)
• Blunt trauma	7 (11.7%)
Angiogram findings	
• Pseudo-aneurysm	29 (48.3%)
• Arteriovenous fistula (AVF)	18 (30%)
• Segmental artery injury	12 (20%)
• AVF and pseudo-aneurysm	1 (1.7%)
RBCs: ‡ Transfusion units required (n)	
• Mean	5.5
• Median	5
• Range	1-21
Hospital stay	
• Mean	12.2
• Range	2-44
Embolisation success	
• After first procedure	51 out of 60 (85%)
• After second procedure	8 out of 9 (88.9%)
• Overall success rate after two attempts	59 out of 60 (98.3%)
Renogram: > 20% differential function	2 out of 2 follow-ups (100%)
Serum creatinine (n) after 6-months follow-up	
• Normal (reference range: 64-104 µmol/l)	45 (only 45 out of 60 followed up)
Complications (n)	
• Post-embolisation syndrome #	3 (5%)
• Incorrect coil placement (into main renal artery)	1 (1.7%)
• Wrong catheter type used – unsuccessful attempt	1 (1.7%)
Analgesic requirements (n)	
• Morphine in hospital	60 (100%)
• Morphine to take home	7 (11.7%)
• Paracetamol ± *others* * to take home	53 (88.3%)

‡ **RBC** - Red blood cells

Post-embolisation syndrome is a self limiting condition characterised by fever, flank pain, nausea and/or vomiting, with onset 24-48 hours after the embolisation procedure.

* *Others* include: NSAIDs, paracetamol alone or paracetamol-codeine combination tablets.

Embolisation technique

If no contra-indication existed, the common femoral artery (CFA) approach was used. Arterial access was gained with an 18-gauge percutaneous entry needle, after which a 5 French sheath was placed and a 0.035 inch guide wire advanced. A 5 French catheter was advanced to the level of T11 and an aortagram and DSA (digital subtraction angiography) were performed and the site of bleeding identified. A 3 French or 5 French catheter was used to deploy the embolisation material. Non-absorbable titanium microcoils (product of Cook Medical®, marketed as Marcus Medical®, Midrand, South Africa) were used, with only a few cases done with alcohol. After each deployment of a coil, a subtraction digital imaging run was done, determining its position, related vascular flow and the need for further coiling. After total occlusion of the severed vessel, a confirmatory subtraction angiogram was done to demonstrate the avascular segment and patency of the remaining vessels.[11,12] (See Figure 1.)

Post-procedure, a dedicated sister applied manual pressure to the groin puncture site for 10 minutes, as standard.

Results

A total of 92 patients underwent renal artery embolisation, with a total of 106 embolisation procedures performed. This population comprised of 60 traumatic (blunt and penetrating) renal bleeds and 32 cases of non-traumatic renal bleeds. (See Table 1 and 2.)

Figure 2 shows the number of RAE-procedures done at Tygerberg Hospital over time.

Of the 60 trauma patients, 51 (85%) had presented with stab injuries, 2 (3.3%) with gunshot wounds and 7 (11.7%) with blunt trauma (including two falls from heights, four assault cases and one high velocity car accident). 51 (85%) of the patients were male. Four (6.7%) patients had undergone negative laparotomies by the trauma surgeons before they were referred for RAE.

Renal arteriography was generally done after a patient required transfusion with two or more (range: 1–21) units of packed red blood cells (RBCs).

One (1.7%) initial diagnostic arteriogram did not show any obvious abnormality. On repeat arteriography a week later, for continual macroscopic haematuria requiring transfusion with a further 2 units RBCs, a bleeding segmental artery was seen and embolised.

The most common arteriographic finding was pseudo-aneurysm (48.3%), followed by arteriovenous fistula (30%) and segmental artery injury (20%).

In the trauma group, the success rate of RAE after one procedure was 85%. Success was defined as cessation of haematuria and no further need for transfusion. After two attempts, success rate was 98.3%. One case was not managed with repeat RAE, as the initial RAE-attempt failed and the patient became haemodynamically unstable. An open repair and ligation of the bleeding vessel was successfully done.

Table 2. Results of non-trauma cases	
Non-trauma cases	
Demographics	
Patient (n)	32
Age (years)	
• Mean	48.7
• Range	19-70
Sex	
• Male	17 (53.1%)
• Female	15 (46.9%)
Results	
Affected side	
• Right	17 (53.1%)
• Left	15 (46.9%)
Condition characteristic	
• Renal cell carcinoma	19 (59.4%)
• Angiomyolipoma	3 (9.4%)
• Renal urothelial carcinoma	1 (3.1%)
• Renal artery aneurysm	2 (6.3%)
• Cervix carcinoma with ureter obstruction	1 (3.1%)
• Rectal carcinoma with ureter obstruction	1 (3.1%)
• Continuous haematuria, unknown cause	1 (3.1%)
• Iatrogenic	**4** (see below) (12.5%)
▫ PCNL	
▪ Segmental artery injury	1 (3.1%)
▪ Arteriovenous fistula	1 (3.1%)
▫ Renal biopsy	
▪ Arteriovenous fistula	1 (3.1%)
▫ "Pigtail drain" insertion by IR	
▪ Pseudo-aneurysm	1 (3.1%)
RBCs ‡ Transfusion units required (n)	
• Mean	4.5
• Median	5
• Range	1-12
Hospital stay	
• Mean	19.5
• Range	2-67
Embolisation success	
• After first procedure	29 out of 32 (90.6%)
• After second procedure	1 out of 3 (33.3%)
• After third procedure	2 out of 2 (100%)
• Overall success rate after three attempts	32 out of 32 (100%)
Renogram: > 20% differential function	2 out of 7 follow-ups (28.6%)
Serum creatinine (n) after 6-months follow-up	
• Normal (reference range: 64-104 µmol/l)	29 (90.6%)
• Increased	3 (9.4%)
Complications (n)	
• Post-embolisation syndrome #	6 (18.8%)
Analgesic requirements (n)	
• Morphine in hospital	28 (87.5%)
• Paracetamol ± *others* * in hospital	4 (12.5%)
• Morphine to take home	17 (53.1%)
• Paracetamol ± *others* * to take home	15 (46.9%)

‡ **RBC** - Red blood cells

Post-embolisation syndrome is a self limiting condition characterised by fever, flank pain, nausea and/or vomiting, with onset 24-48 hours after the embolisation procedure.

* *Others* include: NSAIDs, paracetamol alone or paracetamol-codeine combination tablets.

At 6-month follow-up, documented serum creatinine levels were within normal limits in 60 of the 60 (100%) of patients. The two documented follow-up renogram scans showed differential function of > 20% of the embolised kidney: notably 34% and 24% function.

Of the 32 non-traumatic cases, the most common indication for RAE was renal cell carcinoma in 19 patients (59.4%): 14 patients (43.7%) underwent embolisation for metastatic renal cell carcinoma with haematuria requiring blood transfusion, 2 patients (6.25%) had irresectable tumours with severe pain, 2 kidneys (6.25%) were embolised preoperatively and 1 patient (3.12%) had a demonstratable false aneurysm on CT-scan. The two mentioned follow-up renogram studies were for preoperative embolisation cases. Only four (13.3%) cases were due to iatrogenic renal bleeds, two of these due to percutaneous nephrolithotomy (PCNL)-complications, one due to a renal biopsy and one due to a percutaneous pigtail drain inserted by IR for a perinephric collection.

The mean age of patients in the non-traumatic group was 48.7 years (range 19–70 years), compared to the 28.2 years in the trauma group (range 11–49 years). The mean hospital stay in this group was 19.5 days (range 2–67 days), compared to 12.2 days (range 2–44 days) in the trauma group. 53.1% patients in this group were male.

Of the non-traumatic RAE-cases, the success rate of a single procedure was 90.6%, with an overall success rate of 100% after 3 attempts.

Of the 32 patients 29 (90.6%) showed a normal serum creatinine at 6-month follow-up. Of the other three patients, two were known with chronic renal failure prior to RAE and the last patient defaulted after her 6-month follow-up visit.

Of the 7 non-trauma patients who followed up with renogram studies, only 2 (28.6%) had a differential function of > 20% of the embolised kidney (notably 30% and 37%). Follow-up renograms were noted in 5 patients embolised for renal cancer, 1 patient embolised for iatrogenic renal injury post pigtail insertion and secondary haemorrhage and the last patient was embolised for a large idiopathic renal artery aneurysm. The 2 patients who showed follow-up differential renal function > 20% were in both cases embolised for bleeding renal cell carcinoma, showing that successful selective embolisation is possible in these cases.

Transfusion requirements of the trauma patients revealed a mean of 5.5 units RBCs (range: 1–21), with the non-trauma cases a mean of 4.5 units RBC's (range: 1–12). There was no statistically significant difference in RBC-requirements in patients receiving NSAIDs (nonsteroidal anti-inflammatory drugs) and those not.

Regarding analgesia, all patients received paracetamol as inpatients, with 26/92 (28.3%) patients given a NSAID as additional analgesic. Trauma patients

Table 3. Comparing the Tygerberg experience with the international community

Series	RAE procedures	Success rates	Major complications
Poulakis et al.[4]	Total n = 5	1 RAE: 80% (4/5) 2 RAE: 100% (1/1)	None
Schwartz et al.[5]	Total n = 121	1 RAE: 98.3% (119/121) 2 RAE: 100% (2/2)	None
Jain et al.[13]	Total n = 41	1 RAE: 85.4% (35/41) 2 RAE: 100% (2/2)	None
Saour et al.[15]	Total n = 10	1 RAE: 100% (10/10)	• Urinoma (n = 1) • Delayed nephrectomy (n = 1)
Wang et al.[16]	Total n = 46	1 RAE: 89.1% (41/46) 2 RAE: 80% (4/5) ≥3 RAE: 100% (1/1)	None
Chiramel et al.[17]	Total n = 66	1 RAE: 71.7% (38/53) 2 RAE: 54.5% (6/11) 3 RAE: 100% (2/2)	• Nephrectomy (n = 3)
Sam et al.[18]	Total n = 50	1 RAE: 96% (48/50) 2 RAE: 100% (2/2)	None
Sommer et al.[19]	Total n = 39	1 RAE: 94.9% (37/39) 2 RAE: 100% (4/4)	Accidental embolisation of upper renal pole (n = 1)
Corr and Hacking[21]	Total n = 40	1 RAE: 87.5% (35/40) 2 RAE: 80% (4/5)	Partial nephrectomy (n = 1)
Wang et al.[23]	Total n = 83	1 RAE: 96.4% (80/83)	Nephrectomy (n = 4)
Tygerberg Hosital	Total n = 92	1 RAE: 87% (80/92) 2 RAE: 75% (9/12) 3 RAE: 100% (2/2)	Accidental main renal artery embolisation (n = 1)

showed a higher in-hospital morphine requirement: 100% (all 60 patients) versus 87.5% (28 of 32 patients) of non-trauma patients. However, 53.1% (17 patients) of non-trauma patients and only 11.7% (7 patients) of trauma cases required morphine as discharge analgesic.

The remainder of patients (68 of 92: 73.9%) were discharged on paracetamol-codeine combination therapy, with a NSAID added in 29 of 68 (42.6%) patients.

Post-embolisation syndrome, characterised by usually self-limiting fever, flank pain, nausea and/or vomiting, was present in 9.8% of patients.

In one patient, the non-absorbable coil was incorrectly placed in the main renal artery, with an inability to retrieve this coil endoscopically. Follow-up renogram after 6 months showed a differential function of 24% on the affected side, no hypertension, a normal serum creatinine level and an asymptomatic patient.

Discussion

The kidney is protected in its retroperitoneal position by adjacent vertebrae, musculature, perinephric fat, fascia layers (notably Gerota's fascia), surrounding organs and the peritoneum. A considerable force is required to injure this organ. It has a remarkable capacity to recover from even the worst of injuries. The kidney is, however, the most commonly injured organ in the urogenital tract.[24]

Acute renal haemorrhage is managed conservatively, as far as possible, to preserve renal function. The acronym "SNOM" (selective non-operative management), denoting a conservative management approach in trauma victims, has gained popularity over the past few decades; not only in liver- and splenic injuries, but also in renal injuries.[24-30]

SNOM entails that the patient is admitted for bed rest and observed closely until the macroscopic haematuria clears and the haemoglobin level stabilises. Consistent or large bleeds requiring significant or repeated blood transfusions necessitate intervention.[19-21,23,24]

A variety of factors can cause renal haemorrhage. These include penetrating or blunt trauma, iatrogenic renal insults and malignant or benign renal lesions.[5,8] When the degree of haemorrhage seems out of character to the injury, do not forget about possible medical conditions contributing to the haemorrhage.

Ever since its inception in the 1970s, RAE-procedures have grown in popularity and application. They are less invasive and with less morbidity than surgery and are thus an attractive alternative. The success rate from numerous case series and reviews report success rates between 85.3 and 98%. (See Table 3.)

Haemodynamically unstable patients (due to renal haemorrhage) should be taken for an explorative laparotomy and possible nephrectomy. Most trauma patients can be resuscitated and stabilised well enough to undergo diagnostic imaging.[24] A prior knowledge of the location and extent of the

Table 4. Embolisation technique: A general classification[8]

Embolisation technique	Indication
Partial embolisation	• Pseudo-aneurysm • Arteriovenous fistula / malformation • Segmental artery injury • Renal artery aneurysm • Post procedural / iatrogenic
Total embolisation	• Angiomyolipoma (bleeding or to reduce rupture risk) • Renal cell carcinoma palliation / haemorrhage • Pre-surgery or radiofrequency ablation • Irreversible transplant rejection • End-stage renal disease with severe nephrotic syndrome, hypertension of haematuria • Polycystic kidney disease with intractable pain, severe hydronephrosis, persistent leak from ureterocutaneous fistula or severe hydronephrosis • Prior to endograft placement for AAA-repair

Table 5. Available RAE-coil materials and proposed indications[5,8,16-19,21]

Coil materials	• Metallic coils ▫ Titanium / steel / platinum • Particulate embolisation ▫ PVA (polyvinyl alcohol) particles (permanent) ▫ Gelfoam (biodegradable) • Liquid embolisation ▫ Histoacryl / lipiodol glue ▫ Gelatin ▫ Absolute ethanol
Indication	
Metallic coils	• Large vessels • Lesion flow reduction • Obliteration embolisation
Particulate or liquid	• End-artery embolisation (devascularising a region)
Liquid	• Sclerosis of vascular lesion / vascular bed

injury allows for a faster embolisation procedure, reducing morbidity and theatre time.[19] Our cases underwent CT IVP-scans prior to embolisation.

Selecting the correct embolisation agent for the patient aids in achieving the desired result. Due to the significant trauma burden on our institution and the frequency of embolisation requests, our IR-department uses mostly titanium coils in cases of renal artery embolisation. Familiarity with and frequent use of coils have led to great success rates over a protracted period.

Side effects were minimal and none of previously published major complications, for example renal- or segmental artery dissection[20,21] or ureteric obstruction due to coil migration[22] were observed.

After a failed first embolisation attempt (i.e., clinical failure due to continual haemorrhage), repeat arteriogram and/or repeat embolisation was done, with very high success rates (98–100% in our series). Alternative follow-up investigations could include ultrasound with colour doppler (might show active bleed into a haematoma) or CT-angio to detect the cause of the continual bleed.[17]

Selective RAE will also infarct areas of healthy renal tissue. However, our review did not show a significant loss of global renal function (based on serum creatinine levels). Unfortunately, follow-up renogram studies were only done in selected cases, affecting selection bias. There is currently no set follow-up protocol for these patients in our setting. Poulakis et al. studied five patients who underwent RAE. Their follow-up mean differential renal function on DTPA nuclear renogram was 11.4%.[4]

More research regarding the effect of RAE on the differential function as given by a renogram may be of value, although most studies have shown that a more crude indicator of renal function, serum creatinine, is unaffected by RAE.[8,10,15,18]

Other studies showed an infarcted area of ≤ 10%, with no effect on renal function or blood pressure on follow-up.[4,8,10,15,18]

Embolising a part of the kidney will create an area of ischaemia, causing pain. Attention should be paid to adequate analgesic management. We found a large proportion of our patients (total 88 out of 92: 95.6%) required in-hospital morphine. This complication, although the most common, is usually self-limiting.

Different types of embolisation materials are available. In this review, mostly titanium coils were used, whether for partial- or total embolisation. (See Table 4.)

There are many different coil materials available to be used. (See Table 5.)

The type of material used is based on the indication, physician preference, availability and cost.[8]

The relevance of RAE in modern medicine is worth our focus and study. It aids in relieving pressure on permanently overbooked emergency theatre slates, is less invasive and better tolerated than surgery.

Study limitations

This is a retrospective case note review of a single centre. This might introduce some bias. Tygerberg Hospital employs seasoned professionals and trainees, with some RAE procedures performed by specialists and others by senior registrars.

Mostly titanium coils are used as embolisation material at our institution and the results given above reflect success rates with this method.

Conclusion

Selective renal artery embolisation is an effective and safe means of managing acute renal bleeds at our hospital. The

accompanying infarction of normal renal parenchyme has not been shown to have any clinically significant long-term deleterious effects. This study demonstrates its efficacy in trauma, avoiding the need for open surgical intervention in all but one case. Selective renal artery embolisation should be the first line management in patients presenting with renal trauma and severe haematuria.

Conflict of interest

None

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