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Urological Data

Predictors of renal angioembolization outcome: A retrospective analysis with 148 patients at a tertiary urology institute

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Outcome

Abstract *Objective:* The aim of this study was to evaluate the predictor of unsuccessful outcome of renal angioembolization (RAE). Knowing those predictors may help in avoiding unnecessary RAE procedures and their associated side effects, while helping to prepare for an alternate procedure and improving patient's overall satisfaction.
Methods: A retrospective analysis between January 2006 and December 2018 was performed, and the indications for RAE were classified into post-traumatic, iatrogenic, renal tumors, and spontaneous. Patients who underwent RAE prior to nephrectomy were eliminated. Computed tomography angiography was performed in patients with normal renal function and those who had no contrast allergy, otherwise magnetic resonance angiography was performed. For the purpose of statistical analysis, we stratified patients into two main categories based on the final outcome—successful or failed.
Results: Of 180 patients, 32 with negative angiography were eliminated, leaving 148 patients; 136 (91%) had successful outcomes after one or more trials and 12 had unsuccessful outcomes. The mean age was 45±15 years, and 105 (71%) were male. Neither gender, side of the lesion, presence of hematuria, indication for RAE, nor the type of lesion affected the outcome. On the other hand, renal anatomy with presence of accessory artery was the only predictor to failed RAE ($p=0.001$). Failed RAE trial was a predictor for nephrectomy as a secondary procedure ($p=0.03$).
Conclusion: No pre-procedural predictors could anticipate the RAE outcome, and different indications can be scheduled to RAE, which is equally effective. The presence of accessory renal artery on diagnostic angiography is the only factor that may predict the failure of the procedure.

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1. Introduction

With the increasing use of minimally-invasive surgery of the kidney, hematuria and renal injury have become frequently occurring urologic complications. With the recent advances in imaging, more experience in interventional radiology, and the availability of more refined embolic materials, renal angioembolization (RAE) has been frequently used. The procedure has proved to be effective in treating emergent cases [1] for different indications, such as iatrogenic injury [2], trauma injury [3], and ruptured angiomyolipoma [4]. Moreover, RAE has been recently performed for selected renal tumors as an elective procedure.

Although the literature includes substantial applications of RAE as a safe and effective procedure [5—7], little is known about the incidences and predictors of an unsuccessful outcome of RAE. Knowing those factors may help in avoiding unnecessary procedures and their associated side effects, while helping to prepare for alternate procedures and improving overall patient satisfaction.

We aimed to study the predictors of RAE and correlate all the possible predictors against the final outcome yielding the probability of success or failure of the procedure.

2. Patients and methods

It was a retrospective analysis conducted from January 2006 to December 2018 after obtaining the approval from Mansoura Faculty of Medicine Institutional Research Board (R12/2017). The authors have obtained the permission of using the data for this study from Urology and Nephrology Centre, Mansoura University. As a tertiary care institute, the series included not only our patients, but those who were transferred from other hospitals for immediate intervention.

2.1. Inclusion criteria and indications for RAE

The indications for RAE were classified into three main categories: Post-traumatic, iatrogenic, and renal tumors. Post-traumatic included both blunt and penetrating trauma, and renal trauma was graded on the American Association for the Surgery of Trauma Renal Injury Scale [8]. Iatrogenic included post percutaneous nephrolithotomy, percutaneous nephrostomy, open surgery, and renal biopsy. Renal tumors included angiomyolipoma and renal cell carcinoma (RCC), both before radical surgery and as a palliative therapy. Patients who had severe hematuria of unknown etiology (iatrogenic or trauma) and with no definite lesions on imaging (renal lesions or masses) were referred due to spontaneous bleeding.

2.2. Exclusion criteria

In our institution, the timing for RAE in pre-nephrectomy cases for large RCC was a few hours before the surgery. This group (22 patients) was excluded because the outcome was difficult to accurately determine. In addition, patients who had free angiography without subsequent RAE trials performed were eliminated.

2.3. Laboratory and imaging work-up

As standard throughout medical history, this included a detailed history for the insult (trauma or surgery) and physical examination. All patients had the basic laboratory investigations including serial hemoglobin (Hb) and coagulation profile. Abdominal ultrasound and Doppler ultrasound were used as initial imaging tools.

Enhanced computed tomography (CT) (Philips, Brilliance 64 multidetector, the Netherland) scan was performed for all patients to detect the actual size of the intrarenal or perinephric hematoma and for any other associated abdominal organ injury. For patients who had normal renal function and had no contrast allergy, CT angiography was done after intravenous (i.v.) administration of 1—2 mL/kg of non-ionic contrast media (Omnipaque 350 mg/mL, Schering, Germany). For those with compromised renal function, or in cases in which the administration of contrast media was contraindicated, magnetic resonance (MR) angiography was performed using a 3T magnetic resonance imaging scanner (Philips 3T, Ingenia, veenpluis, the Netherland) after i.v. administration of 0.2 mmol/kg of DOTAREM® (0.5 mmol/mL, Guerbet, Princeton, NJ, USA).

2.4. Management

Stable patients who presented with hematuria were initially managed conservatively: Bed rest, i.v. fluids, and blood transfusion (if required). Serial vital signs and Hb were recorded. If conservative management failed, RAE was the second step. Those who presented in emergency with severe renal bleeding and shock were scheduled urgently to RAE.

2.5. Angiographic technique

In supine position, and under local anesthesia, a vascular access was obtained via the femoral artery puncture. Using the Seldinger technique to obtain safe access to blood vessels, a guide wire was inserted into the aorta under fluoroscopic guidance. In all patients, the renal artery was selectively catheterized via 5 Fr cobra head catheter (Cordis, Santa Clara, CA USA). Non-ionic contrast media (350 mg/mL Omnipaque, Schering, Germany) was used for arteriography in all patients.

In selective angiography, manual injection was used (dose of 8–10 mL of contrast media in each injection). Digital subtraction angiography was carried out using the Toshiba Medical Angiography System (Toshiba, Tokyo, Japan). The runs were finished after the renal vein was clearly visualized, followed by saline of the same amount as contrast media. Diagnostic images were carefully assessed for the presence of vascular pathology. Subselective catheterization of the injured vessel was then performed using either the standard catheter or a microcatheter.

The microcoil (the pushable platinum coil, Boston Scientific, Marlborough, MA, USA) was the most common embolic material used. Microcoils ranged from 3 mm to 5 mm in diameter and from 4 mm to 9 mm in length. Other substances, such as alcohol and gel foam, were used. Post embolization, selective angiography was performed to assess for occlusion of feeding artery by manual injection of contrast media (8–10 mL of contrast media in each injection). All cases were performed by two interventional uro-radiologists.

2.6. The outcome

Success or failure was evident after one or more RAE trials, so we stratified patients into two main categories based on the final outcome—successful or failed. The success was judged both clinically and radiologically, on the stoppage of hematuria, stable vitals and Hb level, and on angiography by complete occlusion of the feeding artery. If not achieved, the procedure was considered a failure.

2.7. Statistical analysis

The data were collected using IBM SPSS version 21® (IBM Corp., Armonk, NY, USA). For univariate analysis, frequency and percentage were used to express nominal and ordinal variables. Mean and standard deviation were used to express the scale variable with normally-distributed data. Median and range were used for non-normally distributed data. For bivariate analysis, Chi-square test was used for nominal variables. For scale variables, paired sample *t*-test was used for normally-distributed data. In all tests, the *p*-value was two-sided, and significance was set at $p<0.05$.

3. Results

Of a total of 180 consecutive patients, 32 patients who had negative renal angiography with no RAE trials performed were eliminated, leaving 148 patients eligible for review. The mean age was 45±15 years, and 105 (71%) were male. The median hospital stay was 4 (range: 2–21) days. The mean±SD of the platelet count was $(280\pm70)\times10^9$/L and three patients had platelet count less than 100×10^9/L. The mean of prothrombin level was 85%±15% and four patients were on low molecular weight heparin. CT with contrast was the primary modality of imaging (91% [135/148]) and MR was used in the other cases. Iatrogenic injuries were the most common indications (60% [89/148]). Fourteen patients after blunt renal trauma were graded on the American Association for the Surgery of Trauma Renal Injury Scale (eight of Grade III, five of Grade IV, and one of Grade V). The left side was more affected (55% [82/148]), and the remaining patients' demographics are shown in Table 1.

Angioembolizations were successful in 136 (92%) cases, the majority (123/136) after only one trial and the remaining with more than one trial. On the other hand, 12 patients ended with failed trial (nine after one trial and three after more than one trial): Seven with Iatrogenic, two traumas, two tumors, and one spontaneous. Pseudoaneurysm was the most common finding on renal angiography (54%). Microcoils alone or/with other embolic materials were the most commonly used material for embolization (85%). Other materials, such as alcohol and gel foam were used in the rest of the patients.

Cross-tabulation, as shown in Table 2, revealed that none of the following, gender, age, body mass index, pre-procedural Hb, side of the lesion, or the type of the lesions, were predictors of the RAE outcome. In addition, the

Table 1 Patients' demographics (N=148).

Parameter	Value[a]
Gender, *n* (%)	
Male	105 (71)
Female	43 (29)
Presentation, *n* (%)	
Hematuria	109 (74)
Pain	34 (23)
Shock	4 (2)
Incidentally-discovered	1 (1)
Indication, *n* (%)	
Iatrogenic	89 (60)
PCNL	62 (42)
Open surgery	19 (13)
PCN and renal biopsy	8 (5)
Trauma	20 (14)
Blunt	14 (9)
Penetrating	6 (4)
Tumor	31 (21)
AML	13 (9)
RCC	18 (12)
Spontaneous	8 (5)
Age[b], year	45±15
BMI[b], kg/m^2	23.0±2.4
Pre-procedural Hb[b], g/dL	10.5±2.5
Prothrombin level[b], %	85±15
Platelet count[b], 10^9/L	280±70
Pre-procedural Cr[c], mg/dL	1.3 (0.6–2.2)
Post-procedural Cr[c], mg/dL	1.8 (1.0–2.7)

PCN, percutaneous; PCNL, percutaneous nephrolithotomy; RCC, renal cell carcinoma; AML, angiomyolipoma; BMI, body mass index; Hb, hemoglobin.

[a] Total percentages may not be 100% due to rounding.

[b] Normally distributed data (values are presented as mean±SD).

[c] Non-normally distributed data (values are presented as median [range]).

Table 2 Bivariate analysis between different predictors and the outcome.

Variable	Outcome (N=148)		p-Value
	Successful (n=136)	Unsuccessful (n=12)	
Gender[a], n (%)			0.7
Male	97 (92)	8 (8)	
Female	39 (91)	4 (9)	
Side of the lesion[a], n (%)			0.9
Right	59 (92)	5 (8)	
Left	75 (91)	7 (9)	
Bilateral	2 (100)	0 (0)	
Heamaturia prior to RAE[a], n (%)			0.7
No	29 (91)	3 (9)	
Yes	107 (92)	9 (8)	
Indication of embolization[a], n (%)			0.9
Trauma	18 (90)	2 (10)	
Iatrogenic	82 (92)	7 (8)	
Tumor	29 (94)	2 (6)	
Spontaneous	7 (88)	1 (12)	
Type of the lesions (by diagnostic angiography)[a], n (%)			0.9
Pseudoaneurysm	74 (92)	6 (8)	
A-V fistula	20 (87)	3 (13)	
Both (pseudoaneurysm and A-V fistula)	17 (94)	1 (6)	
Tumor	15 (88)	2 (12)	
Others	10 (100)	0 (0)	
Renal artery anatomy[a], n (%)			0.001
Single	124 (94)	8 (6)	
With accessory	12 (75)	4 (25)	
Age[b], year	45.5±11.5	44.6±16.7	0.8
Body mass index[b], kg/m^2	24.5±4.4	22.5±4.3	0.1
Pre-procedural Hb[b], g/dL	10.9±2.8	10.4±2.3	0.4

RAE, renal angioembolization; A-V, arterio-venous; Hb, hemoglobin.

[a] Decimals were deleted for simplification and percentages were given for rows.

[b] Values are presented as mean±standard deviation.

indication with different causes (iatrogenic, trauma, tumors, or spontaneous) was not a predictor. On the other hand, renal anatomy with the presence of an accessory artery was the only predictor of failed RAE ($p=0.001$) (Fig. 1).

Failed RAE trial was a predictor for nephrectomy, as a secondary procedure, in 42% (5/12) of patients in the unsuccessful arm versus 9% (12/136) in the successful arm ($p=0.03$).

Readmissions were recorded in 14 cases: Ten underwent repeated RAE procedures and four underwent nephrectomy. Minor complications occurred in 13 patients: Four cases had puncture site hematoma, and two of them were on low molecular weight heparin that was resolved; nine cases had post-embolization syndrome, and all were managed conservatively in the form of bed rest, antibiotics, and analgesics. No major complications related to RAE were recorded. Nephrectomy was carried out for 14 patients (due to failed RAE): Four of traumas, three of iatrogenic, six of angiomyolipoma, and one of spontaneous hematuria.

4. Discussion

We reported our experience with 148 RAE procedures. The incidence of failed RAE was 8% after one or more unsuccessful trails. No pre-procedural predictors could anticipate the RAE outcome, and different indications can be scheduled to RAE, which are equally effective. Therefore, the results of RAE cannot be predicted, however, the presence of an accessory artery can be considered as the only predictor of failed RAE.

With the increasing use of minimally-invasive surgery of the kidney, hematuria and renal injury have become frequently occurring urologic complications. Fortunately, most patients respond to conservative managements that include bed rest, correction of the underlying causes and bleeding disorders, i.v. fluids, and blood transfusion (if required). However, if the conservative measures fail, or if the patient presents with severe hematuria or concealed renal hemorrhage, RAE is the optimal method not only to stop bleeding, but to preserve renal parenchyma and renal function [9].

RAE is generally regarded as a safe and effective method for diverse applications and is considered as an evolving method in the field of endoluminal therapy [5]. With the advances in imaging techniques, greater experience, and newly refined embolic materials [6], RAE indications have expanded from emergent to elective cases [4]. As a minimally-invasive procedure, it carries low morbidly, with the advantage of short hospital stays and an early return to work. More importantly, it saves the kidney [10] with a minimal complication rate [11]. Despite all the advantages of RAE, it is not free of complications. This includes the complications of the procedure as well as the side effects of the contrast media in the kidney. More studies have been recommended to predict when a failed outcome precludes the procedure.

4.1. Negative results of catheter renal angiography

We have to mention that diagnostic angiography does not always reveal pathological findings and in our series with 180 patients, 32 (18%) had no lesions (negative results of catheter renal angiography) despite being clinically symptomatic. Also, Huber et al. [10] reported 10% of his series with free angiography.

4.2. The successful outcome

In our series, 136 out of 148 patients (92%) had successful outcomes; most of them were successfully embolized after one trial (90% [123/136]), and we recommend a second trial in the presence of lesions on angiography because 13 cases had successful outcomes after more than a trial. This also was suggested by Huber et al. [10] who reported 4/6 of their patients subjected to repeated procedures had successful outcomes. Similarly, Hotaling et al. [1] reported 29%

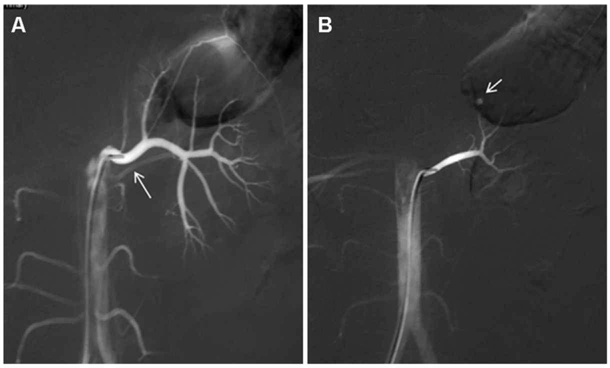

Figure 1 Left renal angioembolization in a 13-year-old male patient with recurrent attacks of hematuria after accidental renal trauma. (A) Selective left main renal artery angiography by cobra head catheter showed normal intra renal arteries with no evidence of vascular abnormalities. There was an accessory renal artery seen arising from aorta below the main renal artery (arrow). (B) Selective angiography of the accessory left renal artery showed small upper polar contrast filled cavity representing pseudoaneurysm (arrow).

of his patients who had repeated trials ended with successful outcomes.

4.3. The unsuccessful outcome

The remaining patients in our series (8% [12/148]) had failed trials and this incidence was reported differently in the literature: six percent by Rao et al. [12] and 5% by Jain et al. [13], with an even higher percentage (30%) that has been reported [10]. The difference in reporting could be attributed to the different indications enrolled to RAE (traumatic, iatrogenic, or neoplastic), major lesions that could not be controlled by RAE, or different experience. Those patients did not get the benefit and had adverse effects from the procedure. It would be better if we anticipated those patients, a matter that has not been studied nor reported in the literature.

4.4. The predictors of the RAE outcome

In our study, no pre-procedure factors, such as age, gender, BMI, Hb, side of the lesion, or even the indication for RAE, could predict the outcome. Anatomical variants in the renal artery were the only predictor for failed RAE and the presence of accessory artery was the only predictor of failed RAE trails; 25% (4/16) of the study population in the failed arm had accessory renal artery versus only 6% (8/132) in the successful arm (p=0.001). The presence of an accessory artery cannot be identified accurately by CT/MR angiography, but only at the time of angiography.

4.5. Accessory renal artery

Accessory renal arteries are common and reported in about 20%—30% of individuals, and usually arise from the aorta above or below the main renal artery to the renal hilum [14]. If present, the accessory artery enters the renal hilum to perfuse the upper or lower renal poles. The most common type of accessory artery perfuses the lower pole [15].

4.6. Literature review on accessory renal artery

Aberrant/accessory renal arteries provide an important predictor of initial selective RAE failure. In a study of Mao et al. [2], they found that the vascular aberration was a significant risk factor for the failure of initial selective RAE (p=0.004). They reported that the vascular aberration would add time, complexity, and risk to the intervention procedure.

4.7. The effects of the other predictors on the outcome

As our data showed, the types of lesions on angiography (pseudoaneurysm, A-V fistula, or others) were not predictors for RAE, regardless of the indication (p=0.9). This means that RAE is effective in different indications, and our results are in agreement with the published series on angiomyolipoma [16], renal cell carcinoma [17], post renal trauma [13], and post iatrogenic renal injuries [18].

4.8. Embolic materials and the outcome

We did not include the embolic materials on the bivariate analysis because microcoils were used for the vast majority of our patients (85%), either alone or in combination, leaving a small number in which the other embolic materials were used. Similarly, Schwartz et al. [6] used microcoils for most of their series with more than 100 patients with good results.

4.9. The limitations of our study

Our study is a retrospective one that adds to its limitations. However, our study reported on a topic that has not been addressed in the previous research and included a larger number of patients at a tertiary urology institute with experienced interventional uro-radiologists.

5. Conclusion

No pre-procedural predictors could anticipate the RAE outcome, and different indications can be scheduled to RAE which is equally effective. The presence of an accessory renal artery on diagnostic renal angiography is the only factor that may predict the failure of the procedure.

Author contributions

Study concept and design: Mohamed Mohamed Elawdy.
Data acquisition: Tarek Mohsen, Karim Ali Soliman, Mohamed Ali Badawy, Ali Elsorougy, Abdalla Abdelhamid.
Data analysis: Mohamed Mohamed Elawdy.

Drafting of manuscript: Mohamed Mohamed Elawdy, Hashim Mohamed Farg.
Critical revision of the manuscript: Mohamed Mohamed Elawdy,Tarek El-Diasty.

Conflicts of interest

The authors declare no conflict of interest.

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