International Journal of Surgery Case Reports 100 (2022) 107724

Contents lists available at ScienceDirect

International Journal of Surgery Case Reports

journal homepage: www.elsevier.com/locate/ijscr

Case series

Technical aspect in renal artery embolization in renal tumors: A case series

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ARTICLE INFO

Keywords:
Renal artery embolization
Renal malignancy
Renal vascularization
Vascular plug
Polyvinyl alcohol
Case report

ABSTRACT

Introduction: Renal artery embolization aims to reduce blood loss during surgery. Various embolizing agents are available, each of which has its own indications appropriate for various vascular anatomy and renal pathology.
Presentation of case: We report three cases of renal artery embolization prior to surgical nephrectomy using vascular plug and other embolizing agents. In two cases, complete blood flow occlusion was achieved with minimal blood loss during the subsequent surgery. One case only achieved reduced blood flow, but subsequent nephrectomy and patient recovery was successful.
Discussion: Renal artery embolization prior to malignant mass resection is a well-known, potentially beneficial procedure. The rationale that supports this procedure is clear, but its reported outcome in the literature is still inconclusive. It is important to understand its benefits, complications, and pitfalls to achieve better outcome.
Conclusion: In our cases, renal artery embolization provided satisfactory reduction in bleeding during nephrectomy, and therefore has the potential to be employed as a standard procedure for future surgeries.

1. Introduction

Arterial embolization constitutes a reliable procedure in reducing blood loss during surgery. Its current application in renal pathology has no clinical guidelines, although potentially valid. Various embolizing agents have been introduced over the years. Vascular plug is one of well-established embolizing agent, which use in peripheral vascular pathology is recently proposed. We present three retrospective consecutive cases of renal arterial embolization utilizing vascular plug, with the combination of non-spherical polyvinyl alcohol (ns-PVA) and Gel Foam, prior to surgical nephrectomy during 2021. All endovascular procedures were done by a cardiothoracic and vascular surgeon in a public teaching hospital. This work has been reported in line with the PROCESS criteria [1].

2. Presentation of case

2.1. Case 1

A 37-year-old female presented with a palpable mass on the left flank which rapidly grew in size within 6 months accompanied by history of gross hematuria and noticeable weight loss. Abdominal ultrasonography indicated a left renal mass which was further confirmed by abdominal MSCT scan. There was an enhancing malignant solid mass with necrotic and calcified components, around 14,2 × 26,6 × 19 cm with peritumoral lymphadenopathy and suspicion of inferior vena cava thrombus. The patient was then planned for renal artery embolization prior to radical nephrectomy.

We used a 7-Fr angiographic sheath through the right common femoral artery percutaneously. Aortography was obtained using a 5-Fr pigtail catheter and an autoinjector (Medrad® Mark 7 Arterion, Bayer Pharmaceuticals) to inject 20 ml of contrast in 4 s. One main renal artery and one accessory artery were identified arising from the left side of the aorta. The main renal artery was sized using calibrated two-point measurement which revealed 6 mm in size. An Amplatzer Vascular Plug (AVP) 1 sized 10 × 7 mm was deployed through a 7-Fr guiding catheter into the main renal artery. After 10 min, arteriography showed complete blood flow interruption. The accessory renal artery was then embolized with Gel foam (Lyostypt®, B. Braun), which was dissolved using contrast media. Confirmatory arteriography exhibited complete occlusion of the left renal artery and reduced flow of the accessory artery (Fig. 1). Postoperative blood urea nitrogen (BUN) and serum creatinine values were normal. The patient underwent left radical nephrectomy the following day. The urologist confirmed clear field during surgery with

Abbreviations: AVP, Amplatzer Vascular Plug; BUN, blood urea nitrogen; nsPVA, non-spherical polyvinyl alcohol; PVA, polyvinyl alcohol.

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https://doi.org/10.1016/j.ijscr.2022.107724
Received 10 September 2022; Received in revised form 26 September 2022; Accepted 29 September 2022
Available online 5 October 2022

minimal blood loss.

2.2. Case 2

A 63-year-old male was previously hospitalized due to hematuria with blood clot retention in the bladder. Palpable mass was present on the left flank. Ultrasound examination showed upper left renal mass and right renal cyst. CT scan findings suggested left renal cell carcinoma with arteriovenous (AV) fistulation on the left renal artery and IVC thrombus. Peritumoral lymph node and left hydroureter were also noted. Arteriography revealed one main left renal artery, 8 mm in diameter, without visible accessory arteries. A 12 × 8 mm AVP was then deployed into the left renal artery. Arteriography within the next 15 min after deployment showed significant reduced flow of the left renal artery (Fig. 2). However, complete blood flow interruption was not achieved. The following day, the patient underwent successful nephrectomy with little blood loss and uneventful recovery.

2.3. Case 3

A 56-year-old male was referred by a urologist with left renal tumor. A solid mass was palpable on the left hypochondrium extended to the flank area with unclear border. Diagnostic ultrasonography and abdominal CT confirmed the presence of a large mass, around 19,9 × 13,1 × 17,8 cm in size, infiltrating the upper-mid renal lobe, compressing adjacent organs, and encasing the abdominal aorta and inferior vena cava. No other organ infiltration was reported. Aortography showed one left renal artery sized 4 mm and one accessory artery sized 2 mm. A 6 × 7 mm AVP 1 was deployed into the main left renal artery. Within the next 10 min, blood flow distal to the plug subsided. The accessory artery was embolized using non-spherical PVA (Contour® Boston Scientific) size 355–500 μm and followed by Gel Foam, achieving total flow occlusion (Fig. 3).

3. Discussion

The goal of vascular embolization is to interrupt blood flow or induce inflammatory reaction to the vessel wall [2]. Since its development in the 1970s, renal artery embolization has been used to treat various kidney conditions, ranging from symptomatic hematuria to palliative measures in renal malignancies. It is also commonly used in preoperative preparation for renal tumors, arteriovenous fistulas and other renal vascular malformations, complications following biopsy, and traumatic renal bleeding. The literature provides various results regarding the outcome of vascular embolization prior to the surgery. This is partly because the available reports regarding its use and benefits are mainly from retrospective studies, which yielded mixed outcomes [3]. In renal malignancy, some authors reported no survival benefit and no difference in intraoperative blood loss [4,5], while others noted significantly reduced intraoperative blood loss and postoperative blood transfusion in preoperatively embolized group [4]. The definite role of preoperative embolization is thus still unclear. Overall, patients with huge, gravely vascularized renal mass may benefit from this procedure.

Selective embolization is performed in cases where preservation of functional parts of the kidney is desired. Nonselective embolization is typically used in diffuse abnormalities that require obliteration of the entire renal function or its blood flow, such as preoperative nephrectomy or palliative therapy [5]. In palliative therapy, the goal is to debulk the mass, alleviate symptoms and complications.

The kidneys are typically supplied by one renal artery for each kidney. Anatomical variations are very common, ranging from 11 to 61 % [6]. Accessory renal arteries, which typically arise from the lateral aspect of the abdominal aorta, can be located either above or below the main artery. They are noteworthy elements in two of our three cases. The literature advises obtaining preoperative imaging studies prior to embolization, such as CT scan or MRI, to better identify the unique anatomy and plan the intervention. Laboratory tests comprising of hemoglobin level, renal, cardiac, and hepatic function, and coagulation indexes are also essential [7].

Various embolic agents are available. Fibrin glue, coils, microspheres are commonly used. Amplatzer Vascular Plug (AVP) is a more recent innovation by St. Jude Medical. Its use as peripheral embolic agent has been approved by the United States Food and Drug Administration (FDA) in 2004 and reported to be successful in a study published within the same year [8]. The structure is nitinol-based braids which allow self-expansion on the targeted vascular bed. After released, it is still possible for the plugs to be recaptured and repositioned. It is mandatory to choose 30–50 % larger device to perfectly occlude the vessel and prevent distal, unintended embolization. The recommended vessel size and device size comparison as well as the delivery catheter are recorded in Table 1.

Polyvinyl alcohol (PVA) has been frequently used as an embolization agent in small caliber vessels with success. PVA particles induce inflammatory response of the vessel wall, leading to angionecrosis, which may support the permanence of its occlusion [9]. Non-spherical PVA (ns-PVA) is commercially available in radiolucent particles between 50 and 1200 μm in diameter. Duvnjak et al. (2015) [10] described lower reintervention rate with ns-PVA compared to its spherical counterpart, however, comparison studies in the literature is limited. The use of appropriate delivery catheter size also needs to be taken into account; it has to be small enough to reach the desired vessel, yet large enough to allow passing of the particles. PVAs take longer to be metabolized, thus favoring the formation of thrombi.

Gel Foam is another commonly-used agent. It is available as blocks of sponge or powder which are typically suspended in contrast to form thick, paste-like consistency prior to injection. They have no hemostasis

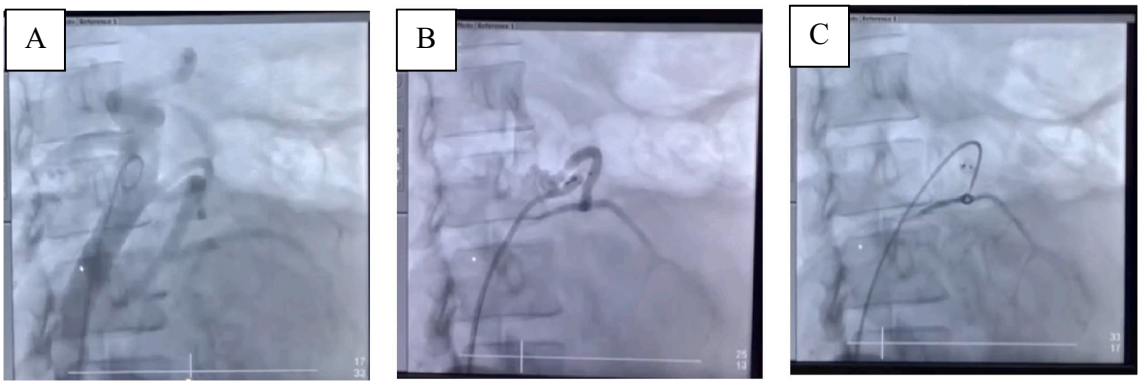

Fig. 1. Arteriography of the first patient. A: Prior to AVP deployment, showing rich vascularization by the left renal artery. B: 10 min after AVP deployment. C: After injection of Gel Foam to the feeding artery, superior to the left renal artery. Complete flow occlusion was achieved.

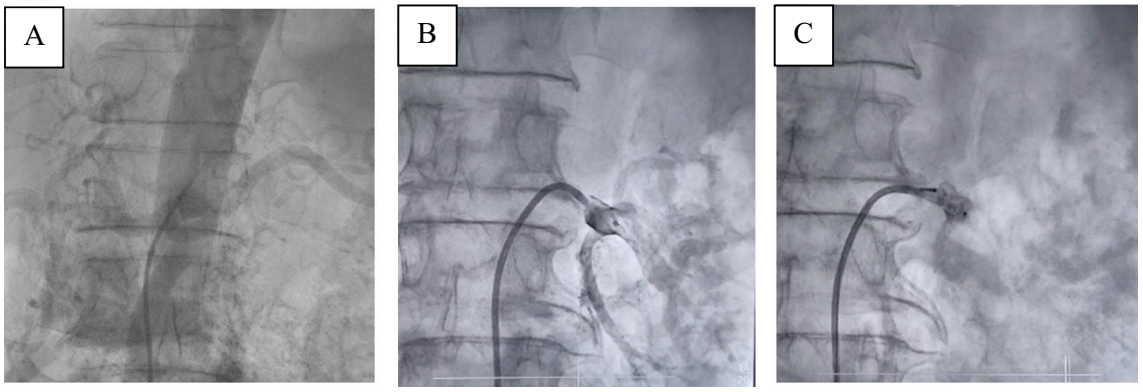

Fig. 2. Arteriography of the second patient. A: Initial aortography, showing patent flow to the left renal artery. B: Arteriography prior to AVP deployment, showing rich vascularization by the left renal artery. B: 10 min after AVP deployment, showing reduced flow on the left renal artery.

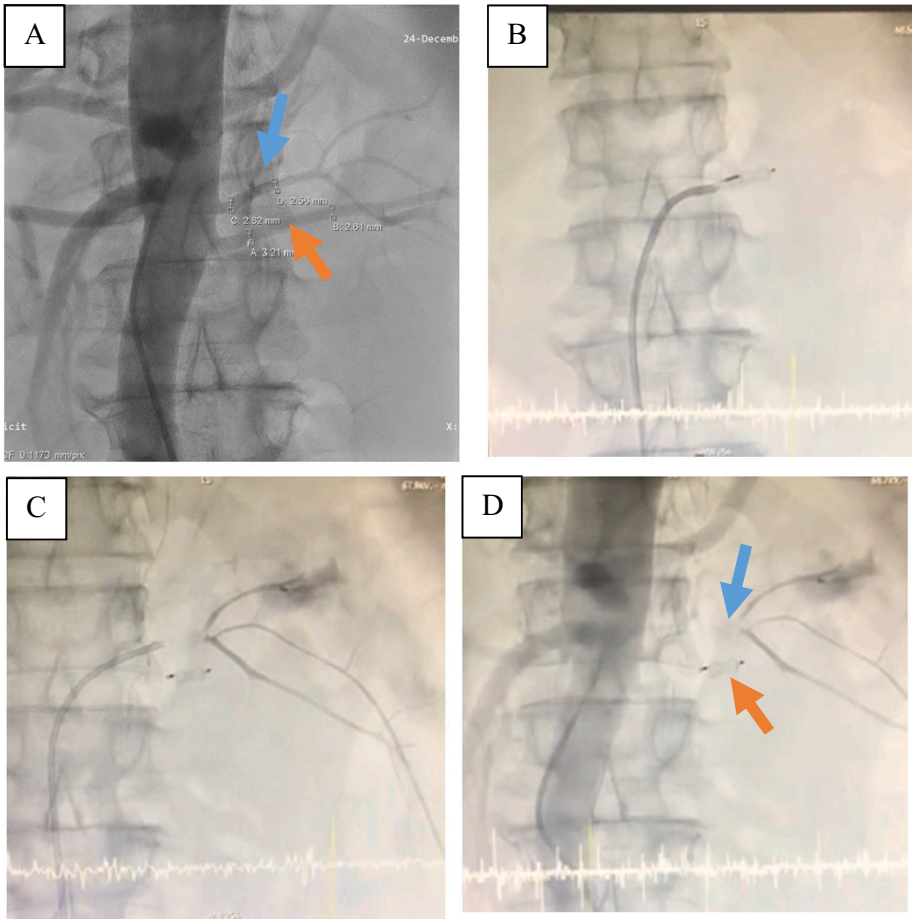

Fig. 3. Presentation of the third patient. A: initial aortography indicated accessory renal artery (blue arrow) above the left main renal artery (red arrow). B: 10 min after AVP deployment to the inferior branch, showing complete occlusion. C: confirmatory arteriography after injection of contour embolization (355–500 μm) and Gel Foam to the accessory artery superior to the left renal artery. D: aortography of the final result, no flow was observed distal to the AVP (red arrow) with minor residual blood distal to the Gel Foam (blue arrow). (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

capability on its own; rather, it occludes blood flow by direct mechanical obstruction. Compared to PVAs, Gel Foam has less frictional drag through the catheter, allowing smoother delivery. However, they are metabolized relatively quicker, resulting in higher risk of recanalization. PVA particles can be combined with Gel Foam to achieve longer period of occlusion.

The goal of intervention in our cases is to maximize blood flow occlusion. Appropriate use of embolization material, including plug sizing according to the size of the target vessel, is therefore crucial. Pre-intervention imaging was done to fulfill this requirement and to discover the presence of accessory arteries. In our first case, the main artery was occluded by AVP while the smaller-caliber accessory artery was occluded by Gel Foam, resulting in complete embolization. The similar method was used in our third case, with the accessory artery embolized using a mixture of nsPVA and Gel Foam. Both cases achieved complete embolization and successful nephrectomy with minimal intraoperative bleeding. In the second case, the size of artery was 8 mm and 50 % larger AVP sized 12 mm in diameter was properly deployed with good apposition. The blood flow was significantly reduced in 15 mins evaluation, but not occluded. We decided not to wait for another fifteen minutes (to evaluate occlusion) as recommended because the patient was agitated so that we needed to conclude the procedure. Intraoperative nephrectomy during the next 24 h was successful nevertheless.

Table 1
Equipment used on each patients.

Patient	Artery identified	Embolic agent for main artery	Delivery catheter for main artery	Embolic agent for accessory artery	Delivery catheter for accessory artery
Case 1	1 main, 1 accessory	AVP 10x7mm	Guiding Catheter Judgkin Right 4.0 7fr	Gel Foam	MPA 5fr
Case 2	1 main	AVP I 12 × 8 mm	Guiding Catheter Judgkin Right 4.0 7fr	–	–
Case 3	1 main, 1 accessory	AVP I 6 × 7 mm	Guiding Catheter Judgkin Right 3.5 7fr	ns-PVA + Gel Foam	MPA 5fr

AVP: Amplatzer Vascular Plug; MPA: Multipurpose angiographic catheter; ns-PVA: non-spherical polyvinyl alcohol.

4. Conclusion

Renal arterial embolization is a widely-practiced procedure. The available embolization material varies with its own characteristics. Pre-intervention laboratory and imaging studies are mandatory, as well as careful consideration regarding the goal of intervention, choice of material and its availability, operator preference, and case-to-case variation to achieve satisfactory results. In our experience, embolization using AVP in main renal artery and combination ns-PVA Gel-foam in accessory renal artery provide good surgical outcome and also cost-effective. Further research with more uniformed population is still needed to better define the benefit of preoperative embolization.

Funding

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

Ethical approval

Exemption for this study has been given by our institution.

Consent

Written informed consent was obtained from the patients for publication of this case report and accompanying images. A copy of the written consent is available for review by the Editor-in-Chief of this journal on request.

Registration of research studies

1. Name of the registry: -
2. Unique identifying number or registration ID: -
3. Hyperlink to your specific registration (must be publicly accessible and will be checked): -

Guarantor

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Provenance and peer review

Not commissioned, externally peer-reveiwed.

CRediT authorship contribution statement

Amy Rosalie Sukamto: data collection, writing – original draft & editing.
Yan Efrata Sembiring: surgeon, conceptualization, supervision.
Erdyanto Akbar: conceptualization, data collection, supervision.
Danang Himawan Limanto: surgeon, conceptualization, supervision.

Declaration of competing interest

None.

Acknowledgements

None.

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