Journal of Medical Imaging & Case Reports

https://doi.org/10.17756/micr.2022-73

Case Report

Open Access

Dilemmas in the Management of Pseudoaneurysms, Treatment Approaches, and Clinical Outcomes

Gurjeet Dulku* **and Ross Vander Wal**

Department of Medical Imaging and Interventional Radiology, Fiona Stanley and Fremantle Group of Hospitals, Murdoch 6150, Western Australia

***Correspondence to:**
Gurjeet Dulku
Department of Medical Imaging and Interventional Radiology, Fiona Stanley and Fremantle Group of Hospitals, Murdoch 6150
Western Australia
Tel: +618 6152 3334
E-mail: gsdulku@hotmail.com

Received: March 03, 2022
Accepted: March 23, 2022
Published: March 25, 2022

Citation: Dulku G, Vander Wal R. 2022. Dilemmas in the Management of Pseudoaneurysms, Treatment Approaches, and Clinical Outcomes. *J Med Imaging Case Rep* 6(1): 4-10.

Published by United Scientific Group

Abstract

A review was conducted of all patients who were investigated for pseudoaneurysms, including those who were treated with ultrasound guided percutaneous thrombin injection(s) – (UGTI) in the medical imaging department since 2014. Our institute's electronic database was searched and data was extracted using the keywords "thrombin" and "pseudoaneurysm". A total of 87 cases were identified. Out of these, we present a series of six interesting pseudoaneurysms cases, its associated management dilemmas, treatment approaches, and clinical outcomes. Key learning point for each case is discussed.

Keywords

Pseudoaneurysm, Ultrasound guided compression, Thrombin injection, Endovascular balloon occlusion, Related complications, Interventional radiology

Introduction

Pseudoaneurysms occur following a defect in the arterial vessel wall leading to leakage of blood into the surrounding soft tissue, bounded only by the tunica adventitia. The extra-vascular haematoma freely communicates with the intravascular space [1].

Whilst iatrogenic-related pseudoaneurysms occur more commonly, other aetiologies include trauma, infection, malignancy, and vasculitis/inflammation [2]. We present six-interesting and note-worthy pseudoaneurysm cases that were treated in our department, the associated management predicaments, and discuss the key learning points for each.

Case 1

A 67-year-old male, clinically septic at day nine post-reversal of an end ileostomy. The procedure was complicated by the development of intra-abdominal collections, each measuring 31 x 152 x 158 mm, and 26 x 65 x 43 mm respectively which were identified on the subsequently performed CT abdomen (Figure 1). The patient had an intra-abdominal drainage catheter placed in the right upper quadrant to drain the collections. The drainage catheter was removed two weeks later.

Case 2

A 57-year-old female, sustained a traumatic left knee injury with a crowbar. The patient developed a tender swelling around the left knee which was

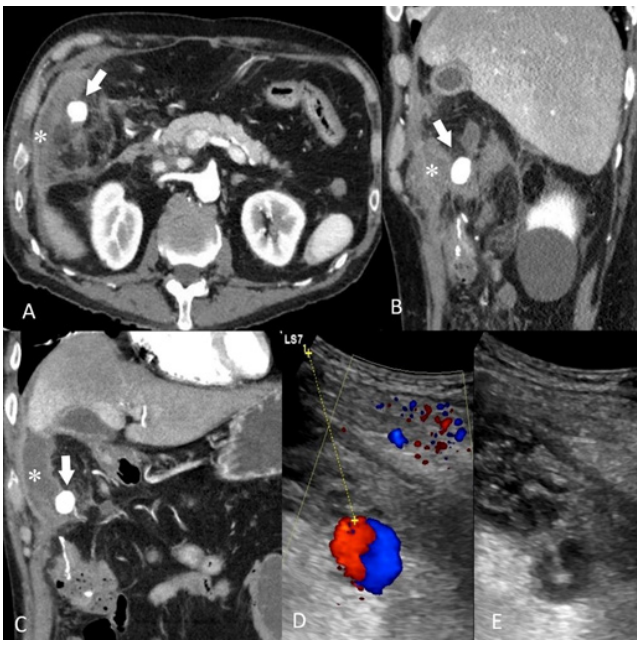

Figure 1: CT angiogram of the abdomen [A (axial), B (sagittal), and C (coronal)] demonstrates a superficial intra-abdominal pseudoaneurysm (arrows) which measures 16 x 16 x 15 mm with an indefinable neck arising from a terminal middle colic artery. No collateral blood supply was identified. The pseudoaneurysm is located in the vicinity of the intra-abdominal collections (asterisks) which had occurred as a complication of the laparotomy and reversal of end-ileostomy procedure. With the patient in the lateral decubitus position, UGTI with 800 International Units (IU) was performed until successful cessation of luminal flow was noted (Ultrasound images D and E). The pseudoaneurysm remains thrombosed on follow-up imaging.

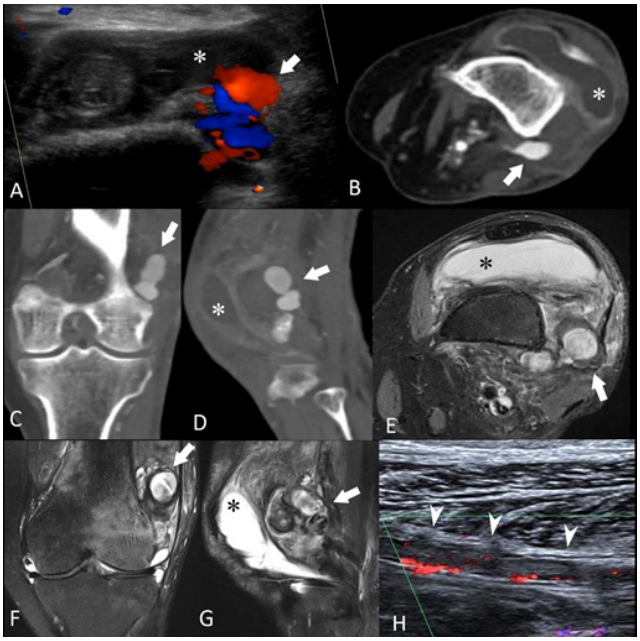

Figure 2: Targeted ultrasound of the left knee demonstrates a pseudoaneurysm (arrows) which measures 63 x 31 x 44 mm, with a neck of 1 x 2 mm (width x length) arising from a lateral geniculate arterial branch (Image A). The pseudoaneurysm sac is largely thrombosed with minimal flow seen within. The popliteal artery is patent and three-vessel run off into the calf is noted. CT angiogram of the left knee delineated the anatomy, confirmed the presence of an actively bleeding lateral genicular artery pseudoaneurysm, a large traumatic knee joint effusion (asterisks), and excluded an arterio-venous fistula [Images B (axial), C (coronal), and D (sagittal)]. The patient declined to have a thrombin injection at this juncture. A left knee MRI was subsequently performed due to concerns for collateral ligament injury, although no ligamentous defects or meniscal injuries were identified [Images E (axial), F (coronal), and G (sagittal)]. The patient eventually agreed to undergo UGTI the following day. Approximately 1500 IU thrombin was slowly and carefully injected into the pseudoaneurysm until clotting ensued and thrombosis achieved. Post-procedure, real-time ultrasound demonstrates propagation of arterial thrombus into the left popliteal artery and calf arteries, extending caudally until the ankle level [Image H – (arrow heads)]. The patient was asymptomatic and the foot remained warm post-procedure. An urgent left popliteal arterial thrombectomy, and vein patch angioplasty was performed, removing a large volume of thrombus from the popliteal artery, tibial-peroneal trunk, and all three run-off vessels in the calf. Patient recovered well post-procedure.

subsequently interrogated with ultrasound, CT angiogram, and MRI of the knee (Figure 2).

Case 3

A 62-year-old female, sustained a traumatic injury to the inflow brachial artery of her above elbow left brachio-basilic arterio-venous fistula (Figure 3) whilst being needled at haemodialysis.

Case 4

A 66-year-old female with a background of non-alcoholic steatohepatitis cirrhosis presented with large volume ascites. Given that the patient was symptomatic, she underwent an abdominal paracentesis (Figure 4) to drain the ascitic fluid. The patient developed intractable pain at the drainage site post-procedure.

Case 5

A 25-year-old male, sustained a traumatic glass injury to both upper limbs. The patient developed a painful and throbbing right axillary swelling following self-removal of a glass shard in the same location (Figure 5).

Case 6

A 61-year-old male who developed central chest pain, underwent percutaneous coronary intervention via right common femoral artery access which was complicated by the development of a painful right groin swelling (Figure 6).

Discussion

Pseudoaneurysms or false aneursyms occur as a result of arterial wall injury resulting in extravasation of blood into the surrounding soft tissue which is contained only by the tunica adventitia [1].

Pseudoaneurysm characterisation, localisation, and treatment approaches

All symptomatic pseudoaneurysms require treatment due to the high risk of rupture with incidences ranging from 2-80%, and mortality rates approaching 100%. There is a paradigm shift in the treatment of pseudoaneurysms moving

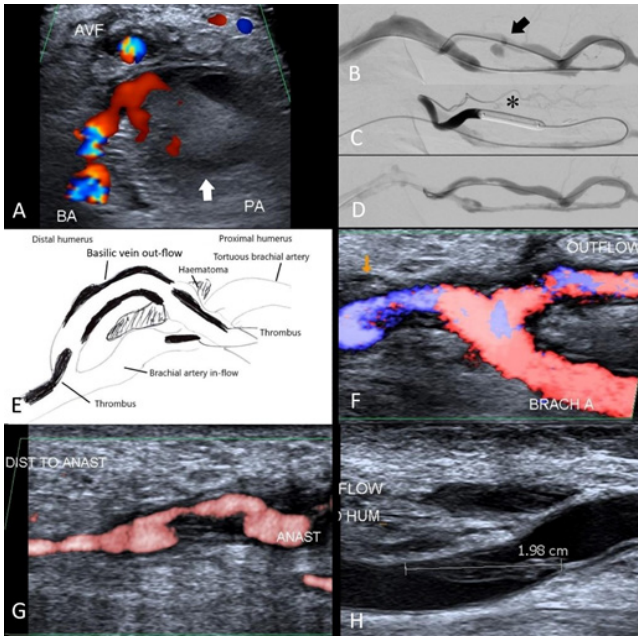

Figure 3: A targeted ultrasound of a left brachio-basilic arteriovenous fistula demonstrates an in-flow brachial artery pseudoaneurysm (arrow) which measures 78 x 25 x 48 mm with a neck of 2.5 x 9 mm (width x length) [Image A (AVF: arteriovenous fistula, BA: brachial artery, PA: pseudoaneurysm)]. There was also a large soft tissue haematoma measuring 136 x 17 mm seen in the vicinity of the pseudoaneurysm, which was exerting mass effect onto the adjacent AVF (Image E). The pseudoaneurysm was subsequently treated with UGTI of 400 IU. On follow-up ultrasound the following-day, there was persistent residual flow at the pseudoaneurysm neck, although the sac was largely thrombosed. It was deemed too high a risk to further inject thrombin under ultrasound guidance alone. Under interventional radiology, the left internal jugular vein (IJV) was punctured and access was secured with a 6-French sheath. Retrograde navigation of the guide wire and catheter into the left subclavian and basilic veins was achieved, the anastomosis traversed, and the catheter secured in the in-flow brachial artery. The subsequent fistulogram not only demonstrates the pseudoaneurysm once again (arrow), but also severe stenosis of the basilic venous outflow over a length of approximately 150 mm, cranial to the anastomosis (Image B). The stenosis was treated with a 6 x 100 mm percutaneous transluminal angioplasty (PTA) Boston Scientific Mustang™ balloon with improvement of the post-plasty angiographic appearance. Subsequently, a 6 x 40 mm PTA Abbott Armada™ balloon was inflated across the in-flow brachial artery [Image C – (asterisk)] to occlude the pseudoaneurysm neck before a further UGTI of 3000 IU into the pseudoaneurysm was performed until cessation of flow was demonstrated (Image D). Following UGTI, several filling defects involving the juxta-anastomotic in-flow brachial artery and out-flow basilic vein were noted (Image E). There was also a tongue of non-occlusive, unstable thrombus measuring approximately 2 cm in length, in the mid-brachial artery, close to the pseudoaneurysm site (Image F, G, and H). Anti-coagulation with therapeutic dose of intra-venous heparin was commenced. Serial follow-up ultrasound imaging demonstrated stable appearance of the thrombosed pseudoaneurysm, reduced volume of the clot burden, whilst the anastomosis and outflow venous limb remain patent.

from surgical repair to minimally invasive procedures which include ultrasound-guided compression and/or -thrombin injection (UGTI), and endovascular management, due to its reduced rates in overall mortality and morbidity. Surgical repair is reserved for selected cases.

Pseudoaneurysm characterisation not only include the sac and neck sizes, but also the complexity (multi-lobulated/multi-compartmental), parent arterial supply, and location. Superficial

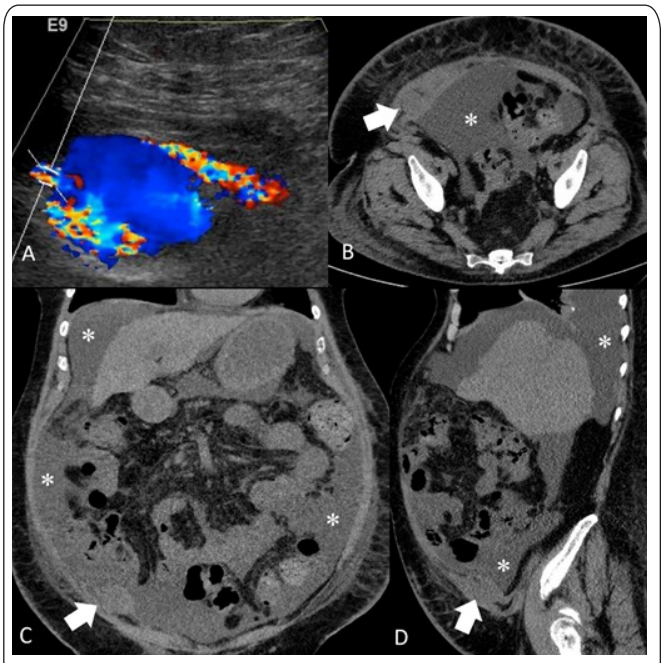

Figure 4: An ultrasound targeting the right lower quadrant of the abdomen was performed. This corresponds to the puncture site, where the abdominal paracentesis was performed the day earlier. A 23 x 20 x 35 mm pseudoaneurysm (arrows) was identified arising from the right inferior epigastric artery (Image A). Due to the patient's poor renal function, a non-contrast CT abdomen was subsequently performed which demonstrated large volume ascites (asterisks) and a rounded hematoma in the anterior abdominal wall, right inferior-lateral aspect, localized to the site of the pseudoaneurysm seen on the targeted ultrasound [Images B (axial), C (coronal), and D (sagittal) – arrows]. Successful thrombosis of the pseudoaneurysm was achieved following UGTI of 300 IU without immediate complications encountered.

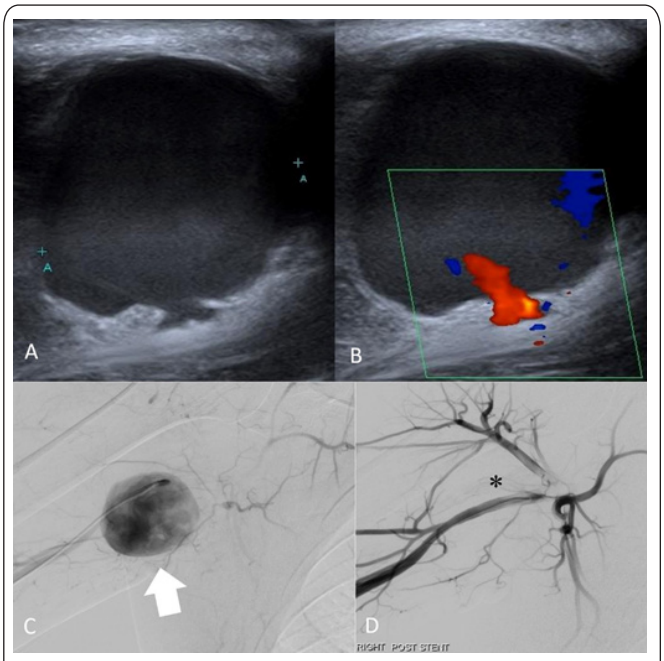

Figure 5: Targeted ultrasound interrogation of the right axilla demonstrates a right brachial artery pseudoaneurysm which measures 45 x 30 x 35 mm, and devoid of a neck (Images A and B). The pseudoaneurysm abuts and exerts mass effect onto the adjacent brachial nerve. The intra-operative angiogram demonstrates the pseudoaneurysm [Image C – (arrow)] and a covered stent was subsequently deployed across the pseudoaneurysm neck [Image D – (asterisk)]. This aided the subsequently performed wound exploration and washout.

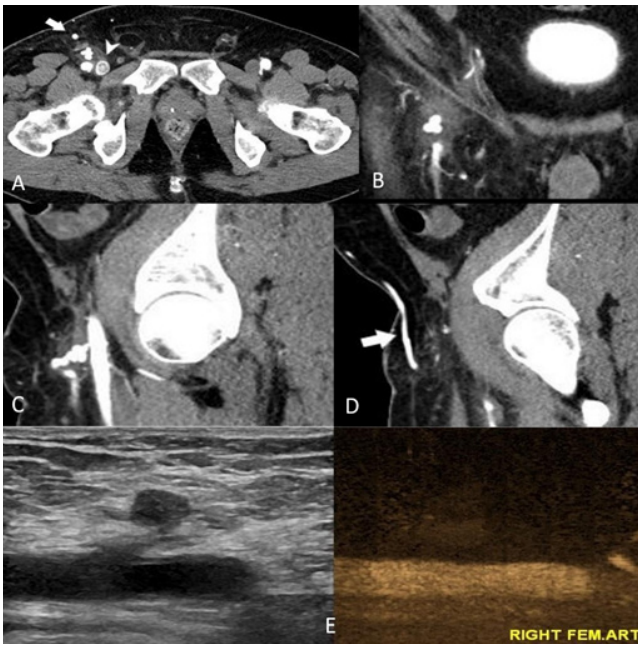

Figure 6: A CT angiogram of the abdomen demonstrates a pseudoaneurysm which measures 13 x 10 x 13 mm with a narrow and long neck, approximately 7 mm in length, arising from the right CFA [Images A (axial), B (coronal), C (sagittal). The pseudoaneurysm communicates with a cluster of blood-filled sacs and was complicated by fistulisation to the right inferior epigastric vein (Images A and D – arrow). Contrast drainage is also identified in the right common femoral vein (Images A – arrow head). Manual compression of the pseudoaneurysm was performed and the follow-up ultrasound the following-day demonstrates complete thrombosis of the pseudoaneurysm (Image E).

post-catheterisation pseudoaneurysms should be treated with UGTI [1]. For the treatment of all other pseudoaneurysms, it is then important to determine endoluminal accessibility. An algorithmic approach (Figure 7) towards direct percutaneous management can be considered as seen with case 1, when the pseudoaneurysm is deemed inaccessible via the preferred and widely used endovascular approach [1, 3].

When the decision is made to treat visceral pseudoaneurysms via the percutaneous method, it is not only crucial to determine the pseudoaneurysm characteristics, but also prudent to determine the anatomical blood supply of the parent vessel, the presence of anatomical variants, location of the pseudoaneurysm in relation to collateral vascular network particularly when involving the splenic artery (60%), hepatic arteries (20%), superior mesenteric artery (5.5%), coeliac trunk (4%), gastric and gastroepiploic arteries (4%), pancreaticoduodenal arteries (2%), gastroduodenal (1.5%), and inferior mesenteric arteries (1%). This can simply be determined with CT angiography. Absence of collateral pathways would be favourable for percutaneous approach [3, 4].

Peripheral pseudoaneurysms most frequently involve the common femoral artery and is often iatrogenic-related, as this is the most common vascular access site for diagnostic and therapeutic interventional procedures [2].

In contrary, pseudoaneurysms around the knee are often trauma-related as seen with case 2, but also known to occur as a complication of orthopaedics intervention [5], with <1% occurring following knee arthroscopy, and between 0.3-1.6%

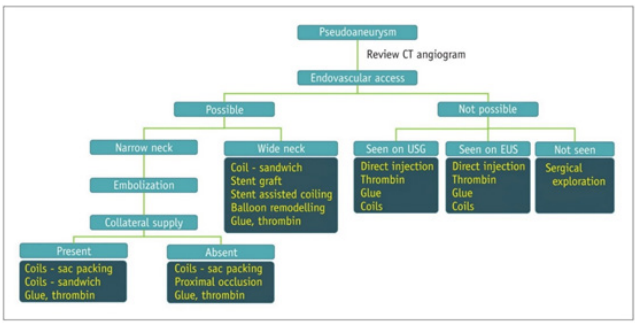

Figure 7: Algorithm for the management of visceral artery pseudoaneurysm. EUS = endoscopic ultrasonography, USG = ultrasonography [3].

of total knee replacements [6]. The most frequently treated culprit vessel around the knee is the superior lateral genicular artery [7]. Endovascular approach remains the treatment of choice [5, 6], although percutaneous thrombin injection has also been reported [8].

Thrombin injection, technique, contraindications, complications, and dosing protocols

Thrombin injection consist of either bovine or human formulations. These usually come as dehydrated powder which is then reconstituted with sterile saline to form preparations in concentrations of 100 to 1,000 International Units (IU) per mL [9].

The technique is performed under sterile conditions, and following local anaesthesia, a 22- or 25-gauge needle is utilized to puncture the pseudoaneurysm sac, with its tip directed clear from the pseudoaneurysm neck [10]. When injecting a complex multi-lobular pseudoaneurysm, the lobe furthest from the neck is treated first [11].

Additional thrombin injection is ceased once no flow is identified in the pseudoaneurysm. Manual or ultrasound-guided compression of the pseudoaneurysm neck can also be applied to further aid thrombosis and also prevent reflux of thrombin. These maneuvers are aimed to avoid non-target embolization [11, 12].

Contraindications for thrombin injection include history of allergic reaction to thrombin, local infection, distal limb ischemia, large pseudoaneurysm (>5cm), wide (>1cm) and short or indefinable neck, direct adjacency of the pseudoaneurysm to vessels, and presence of concomitant arteriovenous fistula [11, 13, 14].

Complication rates of thrombin injection is recorded at 1-4% which comprise of thromboembolic phenomena including clot propagation, venous thrombosis, allergic reactions, pseudoaneurysm rupture, and recurrence [1, 3, 11].

Till date, there is no established optimal dosing protocol for thrombin injection. Successful thrombosis of pseudoaneurysms utilising low dose protocols, as low as 40 IU [12, 15] have been described. Slow-injection techniques have also shown equivocal success for pseudoaneurysm thrombosis when compared to bolus administration [16]. The

complications associated with the low dose protocol [12] and slow-injection techniques are also lower, with the incidence of silent microembolization phenomena appearing marginally higher with the bolus-technique [16].

We found the use of a small-syringe 1 ml enabled controlled-delivery of smaller aliquots of thrombin, and when injected intermittently over longer intervals, commencement of thrombosis can be clearly visualized without excess thrombin needing to be delivered, which in turn reduces the risk for clot propagation. Distal clot propagation can be managed with intravenous administration of heparin, thrombolysis with recombinant tissue plasminogen activator (r-tPA), and surgical thrombectomy as seen with case 2 [17].

Haemodialysis-related pseudoaneurysms and treatment options

The management of pseudoaneurysms arising from haemodialysis arterio-venous fistulas can be difficult and complex. Repeated punctures and adjuvant heparinization increase the risk of developing pseudoaneurysms in these patients. Although applying manual compression directly on either the pseudoaneurysm neck [18] or sac [19] can result in thrombosis of the pseudoaneurysms, these may not always be feasible, especially when the neck is short or indefinable, tortuosity of the AVF limbs, peculiar location of the pseudoaneurysm in relation to the anastomosis, and mass effect exerted by the pseudoaneurysm onto the adjacent AVF, all of which were seen with case 3. In this case, manual compression with view to preserve shunt flow would not be possible. In these high-risk pseudoaneurysms, balloon catheter-assisted UGTI technique is an invaluable treatment option offering protection to the AVF by occluding the pseudoaneurysm neck. This prevents reflux of the injected thrombin into the native parent artery [20-22]. Additionally, the transvenous approach also enabled us to treat stenotic segments of the draining venous limb and improve angiographic appearance post-thrombin injection in the same setting. Alternatively, if thrombin is contraindicated, prolonged balloon-occlusion can be attempted to achieve thrombosis of the pseudoaneurysm.

Abdominal paracentesis-related pseudoaneurysms and current guidelines in the management of peri-procedural bleeding risks

Even common and low risk procedures such as abdominal paracentesis can result in pseudoaneurysm formation. Two-thirds of pseudoaneurysms arise from the inferior epigastric artery which is more prone to injury when the procedure is performed without imaging guidance. Performing abdominal paracentesis under ultrasound guidance may reduce the likelihood of this complication from occurring. The most common procedure-related complication is ascitic fluid leakage. Although haemorrhage, infection, and bowel perforation are less common, these complications confer more serious implications with mortality rates approaching 50%. Haemorrhagic complications can be stratified into abdominal wall hematomas (52%), hemoperitoneum (41%), and pseudoaneurysms (7%), which are often associated with coagulopathy and/or thrombocytopenia, and a higher Child-Pugh score [23].

The current guidelines suggests that a pre-procedural laboratory threshold of a platelet count of >20 x 10^9/L and fibrinogen >100 mg/dL are required to perform low risk procedures such as abdominal paracentesis in patients with chronic liver disease, whilst transfusion can be considered if laboratory results are below the threshold values. International Normalized Ratio (INR) is not routinely performed unless there are other clinical indications to do so, and slow intravenous infusion of vitamin K, 10 mg is recommended if the INR >2.5 [24].

Extremity pseudoaneurysms and combined treatment approaches

Traumatic pseudoaneurysms involving the upper and lower limbs most commonly arise from the axillary-brachial (22%) and femoral-popliteal (16%) arteries [25]. Endovascular intervention with bare-metal stent or stent-graft placement can be utilized as first-line management options in the treatment of upper-limb arterial injuries involving the subclavian and axillary arteries [26]. Open surgical exploration and repair is often required in the setting of penetrating, or extensive blunt-traumatic injuries [25]. A combined surgical and endovascular intervention is an alternative approach to treatment as seen in case 5.

Pseudoaneurysms and concomitant arterio-venous fistula

The incidence of femoral puncture site-related pseudoaneurysms account for 1% following diagnostic, and up to 8% of therapeutic interventional procedures. The presence of a concomitant arterio-venous fistula is a contraindication for thrombin injection due to the concerns for venous thromboembolism [14]. However, the cautious use of UGTI has been reported in selected cases, with favourable outcomes identified in patients who were on oral anticoagulation, and with small AVFs which is determined by end-diastolic arterial-flow-velocities ≤25 cm/second. Combined treatment with manual compression can aid partially thrombosed complex multicompartmental pseudoaneurysms [27]. Given the benign natural course and outcome of small pseudoaneurysms and AVFs which often resolves spontaneously, a trial of watchful management [28], or prolonged compression either manually or under ultrasound-guidance can be offered as alternative treatment to UGTI or surgery. As with case 6, manual compression was sufficient to result in complete thrombosis of the pseudoaneurysm. When contemplating manual compression, it would be prudent to determine the patient's anticoagulation status, complexity of the pseudoaneurysm including neck width and length, and the age of the pseudoaneurysm. Failure rates of this technique approaches 40% with 30% recurrence rates when patients have received

anti-coagulation. Therefore, to improve the procedural success, temporary discontinuation of anti-coagulation therapy prior to manual compression is critical [1].

Conclusion

In the management of pseudoaneurysms, apart from determining if endoluminal accessibility is possible, pseudoaneurysm characteristics, anatomical blood supply, and pseudoaneurysm location are crucial. Complications related to thrombin injection needs to be actively watched for and it is critical to recognise silent microembolisation phenomena which can have devastating outcomes. Balloon catheter-assisted UGTI technique is an invaluable treatment option that can be readily utilised concurrently particularly in the management of haemodialysis fistula-related pseudoaneurysms. Although the presence of a concomitant AVF is a contraindication for thrombin injection, combined manual compression with watchful management can aid thrombosis and should be considered in these cases.

References

1. Saad NEA, Saad WEA, Davies MG, Waldman DL, Fultz PJ, et al. 2005. Pseudoaneurysms and the role of minimally invasive techniques in their management. *RadioGraphics* 25: S173-S189. https://doi.org/10.1148/rg.25si055503
2. Sueyoshi E, Sakamoto I, Nakashima K, Minami K, Hayashi K. 2005. Visceral and peripheral arterial pseudoaneurysms. *AJR Am J Roentgenol* 185(3): 741-749. https://doi.org/10.2214/ajr.185.3.01850741
3. Madhusudhan KS, Venkatesh HA, Gamanagatti S, Garg P, Srivastava DN. 2016. Interventional radiology in the management of visceral artery pseudoaneurysms: a review of techniques and embolic materials. *Korean J Radiol* 17(3): 351-363. https://doi.org/10.3348/kjr.2016.17.3.351
4. Abdelgabar A, d'Archambeau O, Maes J, Van den Brande F, Cools P, et al. 2017. Visceral artery pseudoaneurysms: two case reports and a review of the literature. *J Med Case Rep* 11(1): 126. https://doi.org/10.1186/s13256-017-1291-6
5. Sadat U, Naik J, Verma P, See TC, Cousins C, et al. 2008. Endovascular management of pseudoaneurysms following lower limb orthopedic surgery. *Am J Orthop (Belle Mead NJ)* 37(5): E99-E102.
6. Giurazza F, Corvino F, Silvestre M, Corvino A, Niola R. 2019. The role of interventional radiology in the treatment of lower limb vascular injuries after orthopaedic surgery. *Pol J Radiol* 84: e504-e510. https://doi.org/10.5114/pjr.2019.91204
7. Cornman-Homonoff J, Kishore SA, Waddell BS, Kesler J, Mandl LA, et al. 2021. Genicular artery embolization for refractory hemarthrosis following total knee arthroplasty: technique, safety, efficacy, and patient-reported outcomes. *J Vasc Interv Radiol* 32(8):1128-1135. https://doi.org/10.1016/j.jvir.2021.04.020
8. Rachakonda A, Qato K, Khaddash T, Carroccio A, Pamoukian V, et al. 2015. Ultrasound-guided thrombin injection of genicular artery pseudoaneurysm. *Ann Vasc Surg* 29(5): 1017.e1011-1017.e1013. https://doi.org/10.1016/j.avsg.2014.12.037
9. Kandarpa K, Machan L, Durham J. Section 1: Vascular Access and Catheter Directed Angiography, 4 - Management of Vascular Complications. In. Handbook of Interventional Radiologic Procedures, 5th ed: Lippincott Williams & Wilkins (LWW), 2016. ISBN 9781496302076
10. Kang SS, Labropoulos N, Mansour MA, Baker WH. 1998. Percutaneous ultrasound guided thrombin injection: a new method for treating postcatheterization femoral pseudoaneurysms. *J Vasc Surg* 27(6): 1032-1038. https://doi.org/10.1016/s0741-5214(98)70006-0
11. Dzijan-Horn M, Langwieser N, Groha P, Bradaric C, Linhardt M, et al. 2014. Safety and efficacy of a potential treatment algorithm by using manual compression repair and ultrasound-guided thrombin injection for the management of iatrogenic femoral artery pseudoaneurysm in a large patient cohort. *Circ Cardiovasc Interv* 7(2): 207-215. https://doi.org/10.1161/CIRCINTERVENTIONS.113.000836
12. Reeder SB, Widlus DM, Lazinger M. 2001. Low-dose thrombin injection to treat iatrogenic femoral artery pseudoaneurysms. *AJR Am J Roentgenol* 177(3): 595-598. https://doi.org/10.2214/ajr.177.3.1770595
13. Kurzawski J, Sadowski M, Janion-Sadowska A. 2016. Complications of percutaneous thrombin injection in patients with postcatheterization femoral pseudoaneurysm. *J Clin Ultrasound* 44(3): 188-195. https://doi.org/10.1002/jcu.22274
14. Sizemore G, Ayubi F, Clark B, Kellicut D. 2018. Ultrasound-guided percutaneous thrombin injection following iatrogenic femoral artery pseudoaneurysm: patient selection and perspectives. *J Vasc Diagn Interv* 6: 1-5. https://doi.org/10.2147/JVD.S127255
15. Kurzawski J, Janion-Sadowska A, Zandecki L, Sadowski M. 2020. Comparison of the efficacy and safety of two dosing protocols for ultrasound guided thrombin injection in patients with iatrogenic femoral pseudoaneurysms. *Eur J Vasc Endovasc Surg* 59(6): 1019-1025. https://doi.org/10.1016/j.ejvs.2020.01.009
16. Lewandowski P, Maciejewski P, Wąsek W, Pasierski T, Budaj A. 2011. Efficacy and safety of closing postcatheterisation pseudoaneurysms with ultrasound-guided thrombin injections using two approaches: bolus versus slow injection. a prospective randomised trial. *Kardiol Pol* 69(9): 898-905.
17. Sadiq S, Ibrahim W. 2001. Thromboembolism complicating thrombin injection of femoral artery pseudoaneurysm: management with intraarterial thrombolysis. *J Vasc Interv Radiol* 12(5): 633-636. https://doi.org/10.1093/ndt/15.9.1453
18. Witz M, Werner M, Bernheim J, Shnaker A, Lehmann J, et al. 2000. Ultrasound-guided compression repair of pseudoaneurysms complicating a forearm dialysis arteriovenous fistula. *Nephrol Dial Transplant* 15(9): 1453-1454. https://doi.org/10.1093/ndt/15.9.1453
19. Rahil MA. 2019. Successful treatment of a venous pseudoaneurysm in a brachiobasilic fistula using ultrasound-guided manual compression: two case reports. *J Ultrasound* 22: 345-347. https://doi.org/10.1007/s40477-018-0280-y
20. Clark TWI, Abraham RJ. 2000. Thrombin injection for treatment of brachial artery pseudoaneurysm at the site of a hemodialysis fistula: report of two patients. *Cardiovasc Intervent Radiol* 23(5): 396-400. https://doi.org/10.1007/s002700010091
21. Lin MS, Drucker C, Tolaymat B, Jinwala F, Nagarsheth K. 2020. Salvage of autogenous dialysis access with balloon-assisted thrombin injection. *J Vasc Surg Cases Innov Tech* 6(4): 686-689. https://doi.org/10.1016/j.jvscit.2020.09.013
22. Mark G, Mike G, Islam A, Kate S. 2021. Balloon assisted, ultrasound guided percutaneous thrombin injection of a large radial artery pseudoaneurysm using a trans-venous approach via an ipsilateral arteriovenous fistula. *CVIR Endovascular* 4(1): 67. https://doi.org/10.1186/s42155-021-00253-3
23. Sharzehi K, Jain V, Naveed A, Schreibman I. 2014. Hemorrhagic complications of paracentesis: a systematic review of the literature. *Gastroenterol Res Pract* 2014: 985141. https://doi.org/10.1155/2014/985141
24. Patel IJ, Rahim S, Davidson JC, Hanks SE, Tam AL, et al. 2019. Society of interventional radiology consensus guidelines for the periprocedural management of thrombotic and bleeding risk in patients undergoing percutaneous image-guided interventions - Part II: Recommendations: endorsed by the canadian association for interventional radiology and the cardiovascular and interventional radiological society of Europe. *J Vasc Interv Radiol* 30: 1168-1184.e1161.
25. Raherinantenaina F, Rajaonanahary TMA, Rakoto Ratsimba HN. 2016. Management of traumatic arterial pseudoaneurysms as a result of limb trauma. *Formos J Surg* 49: 89-100. https://doi.org/10.1016/j.fjs.2016.04.001

26. Carrafiello G, Laganà D, Mangini M, Fontana F, Recaldini C, et al. 2011. Percutaneous treatment of traumatic upper-extremity arterial injuries: a single-center experience. 22(1): 34-39. https://doi.org/10.1016/j.jvir.2010.09.015

27. Steppich B, Schürmann F, Bruskina O, Hadamitzky M, Kastrati A, et al. 2018. Ultrasound-guided thrombin injection for treatment of femoral artery pseudoaneurysm with concomitant AV-fistula - a retrospective single centre experience. *Vasa* 47: 507-512. https://doi.org/10.1024/0301-1526/a000732

28. Toursarkissian B, Allen BT, Petrinec D, Thompson RW, Rubin BG, et al. 1997. Spontaneous closure of selected iatrogenic pseudoaneurysms and arteriovenous fistulae. *J Vasc Surg* 25(5): 803-808. https://doi.org/10.1016/s0741-5214(97)70209-x position and renal artery stenosis: a case report and review of literature. *Rom J Morphol Embryol* 56(2): 557-562.