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Original Article

CASE REPORT: EMBOLIZATION OF TRAUMATIC PULMONARY ARTERIOVENOUS MALFORMATION DUE TO INFERIOR PHRENIC ARTERY SUPPLY

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ABSTRACT

Pulmonary arteriovenous malformations (PAVMs) can arise from various underlying conditions and can present with hemoptysis, necessitating prompt emergency medical intervention. Systemic pulmonary arteriovenous malformation is regarded as an uncommon vascular anomaly. Imaging modalities such as computed tomography (CT), computed tomography angiography (CTA), and conventional angiography are instrumental in evaluating the anatomical characteristics of the malformation. Endovascular arterial embolization is a well-established and effective treatment option for this condition. Our case is a traumatic systemic pulmonary arteriovenous malformation treated with coil embolization.

الملخص

من حالات مرضية (PAVMs) يمكن أن تنشأ التشوهات الشريانية الوريدية الشريانية الرئوية مختلفة ويمكن أن تظهر مع نفث الدم، مما يستلزم التدخل الطبي الطارئ الفوري. يعتبر التشوه الشرياني الوريدي الرئوي الجهازي تشوهًا وعائيًا وعائيًا غير شائع. تُعد طرائق التصوير مثل التصوير وتصوير الأوعية (CTA) والتصوير المقطعي المحوسب للأوعية الدموية (CT) المقطعي المحوسب الدموية التقليدي مفيدة في تقييم الخصائص التشريحية للتشوه. يُعد الانصمام الشرياني داخل الأوعية الدموية خياراً علاجياً راسخاً وفعالاً لهذه الحالة. يناقش تقرير الحالة هذا تشوهًا شريانيًا وريديًا رئويًا رئويًا رضحيًا تم علاجه بنجاح من خلال الانصمام اللولبي

Keywords: Pulmonary Arteriovenous Malformations (PAVMs), Systemic Pulmonary Arteriovenous Malformations (SPAVMs), Computed Tomography (CT) Imaging, Computed Tomography Angiography (CTA) Imaging, PAVM Catheter Angiography, PAVM Arteriography, Systemic-to-Pulmonary Shunt, Left-to-Left Shunt, Left-to-Right Shunt, Right-to-Left Shunt, Traumatic SPAVM, Arterial Coil Embolization, Hemoptysis

1. INTRODUCTION

Several terms are used for Pulmonary Arteriovenous Malformations (PAVMs), such as Pulmonary Arterio-Venous Aneurysms (PAVA), pulmonary arteriovenous fistulas, pulmonary angiomas, and cavernous hemangiomas [1] [2][3]. Contrast-enhanced computed tomography (CT), computed tomography angiography (CTA), and conventional angiography are the imaging modalities that can assess the size, hemodynamic significance, and the need for intervention [4][5]. Systemic artery to pulmonary artery fistula or malformation is a rare vascular anomaly that could be identified on chest CT [5] [6]. CT is an accurate imaging modality to determine the feasibility of arterial embolization in these cases [7] [8]

The treatment options are surgical resection, endovascular embolization, a combined surgical and endovascular approach, and a conservative approach. One of the early reports of traumatic SPAVM was treated surgically[9] [10] [11]

[12] [13]. We describe the imaging findings and embolization procedure of a rare traumatic SPAVM supplied by the right inferior phrenic artery originating from the accessory left renal artery. All required approvals from the hospital's ethical committee have been duly obtained.

2. CASE REPORT

A 39-year-old non-smoker male presented with hemoptysis for nine months (1 to 2 episodes every month). He had a history of stabbing injury to his right hemithorax about ten years earlier, resulting in hemopneumothorax, managed conservatively with chest drain insertion. Fig 1

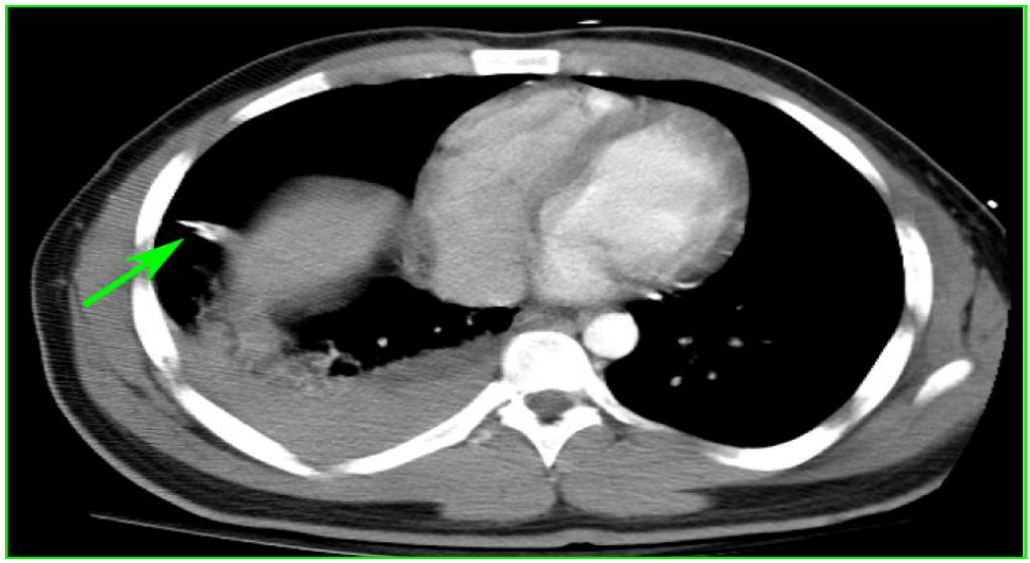

Figure 1.

Note. *Contrast-enhanced CT thorax post-treatment with chest drain insertion 10 years ago. There was no evidence of Pulmonary Arteriovenous Malformations (PAVMs). (green arrow) chest draining tube.*

Computed Tomography Angiogram (CTA) of the chest and abdomen showed a right lower lobe lung Arteriovenous Malformation (1.3cm nodule) supplied by a systemic branch (right inferior phrenic artery) originating from an accessory left renal artery. Crossing the midline to supply the right diaphragmatic cupola and the right lung pulmonary arteriovenous malformation. The venous drainage is to the right lower pulmonary vein. Fig 2.

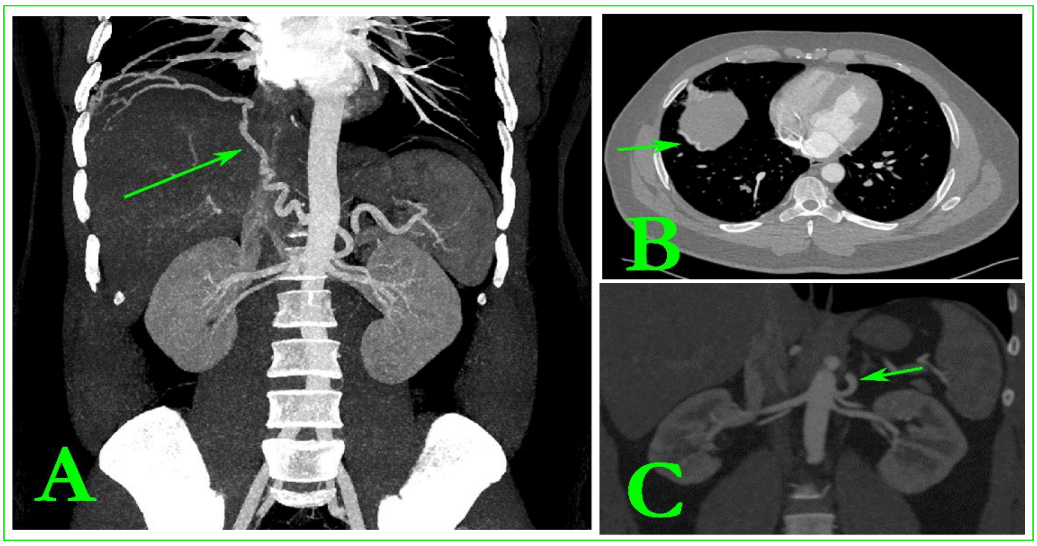

Figure 2. A:

Note. CT angiogram, Maximum Intensity Projection (MPI), (Green arrow) the right inferior phrenic artery originating from an accessory left renal artery crossing over the celiac axis to the right posterior subdiaphragm. B: axial CT angiogram image (green arrow), complex arteriovenous malformation in the lower lobe of the right lung, C: CT angiogram coronal image (Green arrow), the right inferior phrenic artery originating from the accessory left renal artery.

After written informed consent, arterial embolization was performed through a 5Fr Sheath (Cordis, 14201 Northwest 60th Avenue, Miami Lakes, FL 33014) in the right common femoral artery, and a 5Fr Cobra catheter (Cook Medical LLC, PO Box 4195, Bloomington, IN 47402-4195 USA) was used for selective catheterization of the left superior renal artery. The right phrenic artery shows multiple enlarged arterial branches supplying a complex arteriovenous malformation in the lower lobe of the right lung, draining into the right lower lobe pulmonary vein. Renegade STC microcatheter (Boston Scientific Way. Marlborough, MA 01752-1234) was advanced into the right inferior phrenic artery and multiple detachable micro-coils (Boston Scientific Way. Marlborough, MA 01752-1234, Cook Medical LLC PO Box 4195 Bloomington IN 47402-4195 USA, and Medtronic Parkway Minneapolis, MN 55432-5604 USA) were used

for embolization. The patient had no hemoptysis after embolization. Fig. 3, and Table 1.

Table 1: The coils' technical details, coil sizes: diameter in millimeters (mm), length in centimeters (cm), the brand, the quantities, and type (Detachable or non-detachable)

Size diameters X length	Brand	Guidewire System (inch)	Quantity	Type
6mmx14cm	cook	0.018	2	Non detachable
10mmx14cm	cook	0.018	10	Non detachable
14mmx30cm	Medtronic	0.014	1	detachable
16mmx40cm	Medtronic	0.014	1	detachable
20mmx50cm	Medtronic	0.014	1	detachable
5mmx20cm	Medtronic	0.014	2	detachable
6mmx20cm	Medtronic	0.014	1	detachable
7mmx20cm	Boston	0.021	1	detachable
9mmx20cm	Boston	0.021	1	detachable
8mmx20cm	Boston	0.021	1	detachable
6mmx10cm	Boston	0.021	2	Detachable

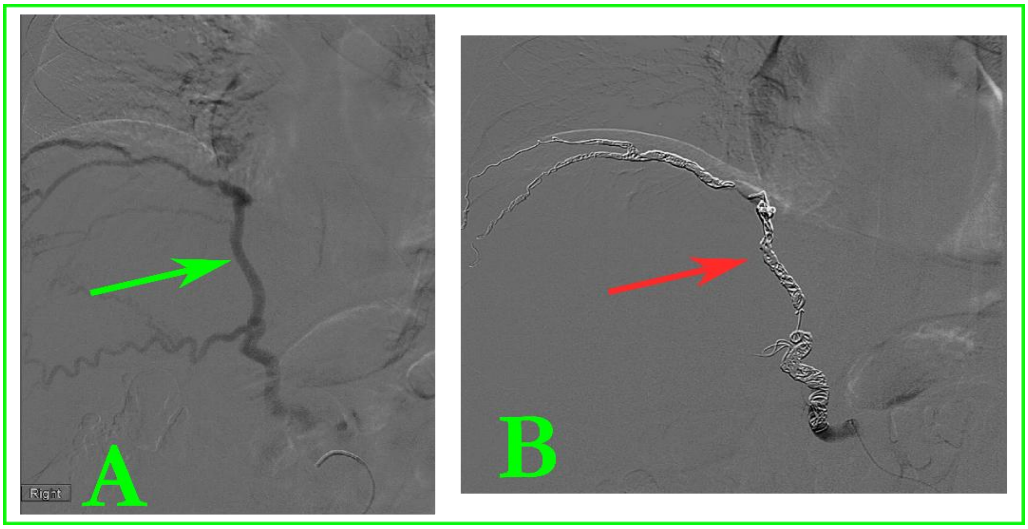

Figure 3.

Note. *A 5Fr sheath was inserted (retrograde approach) into the right common femoral artery; selective catheterization of the left superior renal artery and the right phrenic artery showed multiple enlarged arterial branches supplying a complex arteriovenous malformation in the lower lobe of the right lung draining into the right lower lobe pulmonary vein. Multiple coils are used to embolize those arteries.* ***A****: conventional subtracted angiogram (green arrow), the supplying artery pre-embolization.* ***B****: conventional subtracted angiogram post-embolization (red arrow), embolization coils.*

3. DISCUSSION

Churton 1897 identified and reported Multiple bilateral Pulmonary Arteriovenous Malformations (PAVM) in an autopsy for a 12-year-old boy [14]. White et al. 1983 classified the PAVM-based analysis of intraarterial digital subtraction as simple and complex; the simple term describes the single artery and single draining vein and can appear in CT imaging as a well-defined, rounded or lobulated peripheral nodule; the complex is described when there are more than two arteries and draining veins Chamarthy et al. 2018 also classified PAVM as simple and complex according to CTA imagingYakushiji et al. 2017 emphasized performing chest and upper abdomen CTA for hemoptysis before embolization to identify the culprit lesion that causes the bleeding [6] [15] [16] [17]. Gwon et al. 2007 and Yakushiji et al. 2017 emphasized the significance of investigating the inferior phrenic artery in hemoptysis cases when the abnormality involves the base of the lung Systemic Pulmonary Arteriovenous Malformation (SPAVM) is uncommon compared to pulmonary artery to pulmonary vein malformation [6] [18] [19] [20] [21] [22] [23] [24] [25]. Few cases reported PAVM after sustaining chest trauma or penetrating shrapnel injury [26] [27] [28]. SPAVM tends to grow and rupture because of the systemic. The SPAVM can also develop as a reperfusion post-embolization [17] [20] [29] [30]. Although all PAVMs require intervention treatment, the symptoms, location, size, and type of the PAVM influence the treatment options.

Regarding extracardiac shunts, there are several types of circular shunts to consider. The most common are right-to-left shunts, which often include post-traumatic fistulas. On the other hand, left-to-right extracardiac shunts are less frequent. Meanwhile, left-to-left shunts (do not pass through the systemic capillary bed) and right-to-right shunts (do not pass through the pulmonary capillary bed) are quite rare [3]. Our case is a left-to-left circulation shunt. The availability of treatment options also influences the selection of treatment methods. Surgical resection of the lesion itself is an invasive treatment option for traumatic PAVM [9] [27] [28] [31]. Geyik et al. 2006 reported endovascular embolization of an incidental asymptomatic SPAVM of a 52-year-old woman with angiography who had a significantly hypertrophied left phrenic artery with a tangle of vessels in the inferolateral aspect of the left chest. Endovascular embolization is less invasive and can be repeated compared to the surgical option. It has been performed to treat asymptomatic SPAVM to prevent potential hemorrhage or pulmonary hypertension in the future [32]. Hsu et al. 2011 reported a left lower lobe lobectomy after two weeks of endovascular embolization of a 42-year-old man with massive hemoptysis, where angiography showed anastomosis between the left inferior phrenic artery and the left pulmonary artery at the left lower lung [33]. Lee et al. 2013 reported embolization of the left inferior phrenic artery of a 51-year-old man who presented with massive hemoptysis because of congenital SPAVM. Yakushiji et al. 2017 reported embolization of the right inferior phrenic artery for an 82-year-old woman with massive hemoptysis secondary to abnormal vascular anastomosis between the right inferior phrenic artery and right pulmonary artery around focal bronchiectasis in the middle lobe, Livingston et al. 2019 reported a 59-year-old woman with asymptomatic non-traumatic SPAVM with hypertrophied right inferior phrenic artery that was treated conservatively D'Angelo et al. 2024 reported a 79-year-old patient with traumatic SPAVM post 8-11 rib fractures, and angiography showed the right inferior phrenic artery communicating with a branch of the right pulmonary artery; this was treated with endovascular coiling [5] [6] [34]. Dobson et al. in 2021 reported asymptomatic SPAVM in a 60-year-

old male with a hypertrophied right inferior phrenic artery supplying the right basal lung juxta-diaphragmatic PAVM treated conservatively. Our case is a traumatic symptomatic SPAVM. Supplied by the right phrenic artery originating from the accessory left renal artery, treated successfully with coil embolization.

4. CONCLUSION

Traumatic pulmonary arteriovenous malformation with circular shunting due to systemic arterial supply from the inferior phrenic artery is a rare condition that might present with hemoptysis and can be successfully and safely treated by embolization.

5. CONFLICT OF INTEREST

The authors declare that they have no conflict of interest.

6. ACKNOWLEDGMENT

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7. REFERENCES

[1] Burke C, Safi C, Nelson P, Raffin T. Pulmonary arteriovenous malformations: a critical update. The American Review of Respiratory Disease. 1986;

[2] Gill SS, Roddie ME, Shovlin CL, Jackson JE. Pulmonary arteriovenous malformations and their mimics. Clinical Radiology. 2015 Jan;70(1):96–110.

[3] Dobson JW, Barnor-Ahiaku E, Puppala S, McPherson SJ. A Rare Pulmonary Arterio-venous Malformation with Circular Shunting Due to Inferior Phrenic Artery Supply with Pulmonary Venous Drainage: a Case Report. SN Compr Clin Med. 2021 Feb;3(2):688–91.

[4] Danyalian A, Hernandez F. Pulmonary Arteriovenous Malformation. In: StatPearls [Internet]. Treasure Island (FL): StatPearls Publishing; 2024 [cited

2024 Feb 3]. Available from: http://www.ncbi.nlm.nih.gov/books/NBK560696/

[5] Livingston D, Grove M, Grage R, McKinney JM. Systemic Artery-to-Pulmonary Artery Fistula Mimics Pulmonary Embolus. JCIS [Internet]. 2019 Sept 20 [cited 2024 Feb 2];9. Available from: https://clinicalimagingscience.org/systemic-artery-to-pulmonary-artery-fistula-mimics-pulmonary-embolus/

[6] Yakushiji E, Ota S, Komatsu T, Ayaori M, Ikewaki K. Massive Hemoptysis due to Right Inferior Phrenic Artery-to-Right Pulmonary Artery Fistula in the Right Middle Lobe of the Lung. Intern Med. 2017 Mar 15;56(6):687–9.

[7] Lin Y, Chen Z, Yang X, Zhong Q, Zhang H, Yang L, et al. Bronchial and non-bronchial systemic arteries: Value of multidetector CT angiography in diagnosis and angiographic embolisation feasibility analysis. J Med Imag Rad Onc. 2013 Dec;57(6):644–51.

[8] Hemoptisis recurrente por anastomosis sistemicopulmonar de la arteria frénica inferior derecha. Tratamiento mediante embolización percutánea [Internet]. [cited 2024 Feb 16]. Available from: https://www.archbronconeumol.org/es-pdf-S0300289602751600

[9] Arom KV, Lyons GW. Traumatic pulmonary arteriovenous fistula. The Journal of Thoracic and Cardiovascular Surgery. 1975 Nov;70(5):918–20.

[10] Loebl EC, Platt MR, Mills LJ, Estrera AS. Pulmonary resection for a traumatic pulmonary arteriovenous fistula. The Journal of Thoracic and Cardiovascular Surgery. 1979 May;77(5):674–6.

[11] Cox PA, Keshishian JM, Blades BB. Traumatic arteriovenous fistula of the chest wall and lung. The Journal of Thoracic and Cardiovascular Surgery. 1967 July;54(1):109–12.

[12] Creech O, Gantt J, Wren H. Traumatic Arteriovenous Fistula at Unusual Sites. Ann Surg. 1965 June;161(6):908–20.

[13] Moyer JH, Glantz G, Brest AN. Pulmonary arteriovenous fistulas. The American Journal of Medicine. 1962 Mar;32(3):417–35.

[14] Churton T. MULTIPLE ANEURYSM OF PULMONARY ARTERY.

British Medical Journal. 1897;1:1223.

[15] White R, Mitchell S, Barth K, Kaufman S, Kadir S, Chang R, et al. Angioarchitecture of pulmonary arteriovenous malformations: an important consideration before embolotherapy. American Journal of Roentgenology. 1983 Apr;140(4):681–6.

[16] Saboo SS, Chamarthy M, Bhalla S, Park H, Sutphin P, Kay F, et al. Pulmonary arteriovenous malformations: diagnosis. Cardiovasc Diagn Ther. 2018 June;8(3):325–37.

[17] Chamarthy MR, Park H, Sutphin P, Kumar G, Lamus D, Saboo S, et al. Pulmonary arteriovenous malformations: endovascular therapy. Cardiovasc Diagn Ther. 2018 June;8(3):338–49.

[18] Gwon DI, Ko GY, Yoon HK, Sung KB, Lee JM, Ryu SJ, et al. Inferior Phrenic Artery: Anatomy, Variations, Pathologic Conditions, and Interventional Management. RadioGraphics. 2007 May;27(3):687–705.

[19] Dobson JW, Barnor-Ahiaku E, Puppala S, McPherson SJ. A Rare Pulmonary Arterio-venous Malformation with Circular Shunting Due to Inferior Phrenic Artery Supply with Pulmonary Venous Drainage: a Case Report. SN Compr Clin Med. 2021 Feb;3(2):688–91.

[20] Pouwels H, Janevski B, Penn O, Sie H, Ten Velde G. Systemic to pulmonary vascular malformation. Eur Respir J. 1992 Nov 1;5(10):1288–91.

[21] Currarino G, Willis K, Miller W. Congenital fistula between an aberrant systemic artery and a pulmonary vein without seqquestration. The Journal of Pediatrics. 1975 Oct;87(4):554–7.

[22] Jariwala P, Ramesh G, Sarat Chandra K. Congenital anomalous/aberrant systemic artery to pulmonary venous fistula: Closure with vascular plugs & coil embolization. Indian Heart J. 2014;66(1):95–103.

[23] Ernst SMPG, Bruschke AVG. An Aberrant Systemic Artery to the Right Lung with Normal Pulmonary Tissue. Chest. 1971 Dec;60(6):606–8.

[24] Scott LP, Perry LW. Systemic artery—pulmonary vein fistulas. The American Journal of Cardiology. 1969 June;23(6):872–6.

[25] Varma KK, Clarke CP. Congenital Systemic-to-Pulmonary Arteriovenous

Fistula: Report of a Case. Australian and New Zealand Journal of Surgery. 1971 May;40(4):360–2.

[26] Manganas C, Iliopoulos J, Pang L, Grant PW. Traumatic pulmonary arteriovenous malformation presenting with massive hemoptysis 30 years after penetrating chest injury. The Annals of Thoracic Surgery. 2003 Sept;76(3):942–4.

[27] Symbas PN, Goldman M, Erbesfeld MH, Vlasis SE. Pulmonary arteriovenous fistula, pulmonary artery aneurysm, and other vascular changes of the lung from penetrating trauma. Ann Surg. 1980 Mar;191(3):336–40.

[28] Azimi-Ghomi O, Ramirez M, Brummund D, Gibber M, Mawad MR. Traumatic Pulmonary Arteriovenous Malformation Presenting as Spontaneous Hemothorax. Cureus [Internet]. 2021 June 30 [cited 2024 Feb 2]; Available from: https://www.cureus.com/articles/59874-traumatic-pulmonary-arteriovenous-malformation-presenting-as-spontaneous-hemothorax

[29] Woodward CS, Pyeritz RE, Chittams JL, Trerotola SO. Treated Pulmonary Arteriovenous Malformations: Patterns of Persistence and Associated Retreatment Success. Radiology. 2013 Dec;269(3):919–26.

[30] Pollak JS, Saluja S, Thabet A, Henderson KJ, Denbow N, White RI. Clinical and Anatomic Outcomes after Embolotherapy of Pulmonary Arteriovenous Malformations. Journal of Vascular and Interventional Radiology. 2006 Jan;17(1):35–45.

[31] Transpleural abdominal systemic artery-pulmonary artery anastomosis in patients with chronic pulmonary infection [Internet]. [cited 2024 June 14]. Available from: https://www.ajronline.org/doi/epdf/10.2214/ajr.129.2.233

[32] Geyik S, Yavuz K, Keller FS. Unusual Systemic Artery to Pulmonary Artery Malformation Without Evidence of Systemic Disease, Trauma or Surgery. Cardiovasc Intervent Radiol. 2006 Oct;29(5):897–901.

[33] Hsu SJ, Luo YH, Lee YC, Yang KY. Life-threatening hemoptysis due to left inferior phrenic artery to pulmonary artery fistula rescued by

extracorporeal membrane oxygenation therapy. Interactive CardioVascular and Thoracic Surgery. 2011 Feb 1;12(2):337–8.

[34] D'Angelo A, Khan H, Coleman G, Masood I. Right inferior phrenic artery to right pulmonary artery fistula causing hemothorax: A case report. Radiology Case Reports. 2024 Aug 1;19(8):3273–5.